LONG-TERM CHANGES IN THE BIOMASS AND COMPOSITION OF FODDER ZOOPLANKTON IN COASTAL REGIONS OF THE BLACK SEA DURING THE PERIOD 1957-1996

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Abstract. Results of long-term research carried out on the of fodder zooplankton (mesozooplankton excluding jelly organisms) in coastal regions and shelf areas of the Black Sea (Sevastopol area, northwestern shelf, Turkish shelf) are compared. In all regions similar changes in the composition of this economically important group of zooplankton were obvious. During the period under investigation the total biomass of the fodder zooplankton has decreased and some species have disappeared (*Oithona nana* and other species of genus *Pontellidae)*. In terms of biomass *Acartia clausi* became the most dominant copepod during the last 2 decades. The most significant changes have taken place in coastal zones with maximum depths of about 40-50 m, and in bays, especially in regions influenced by river run-offs, near to ports and industrial regions. The changes in the abundance of fodder zooplankton coincide with the increase of the biomass of gelatinous predators. The strengthening of anthropogenic impact on the ecosystem of the Black Sea is, besides natural fluctuation, obviously the main reason of the changes in the coastal regions.

1. Introduction

The coastal zone of the Black Sea, like many other regions of the world's oceans, is characterised by considerable spatial and temporal variability. This variability occurs not only naturally but there is also an important influence of anthropogenic factors as well, which have notably increased over the last 2-3 decades. The constant strengthening of the anthropogenic impact, especially in the estuarine areas of large rivers and near large seaports, had a significant influence on the planktonic community [1]. In the northern area influenced by the Danube flow, the eutrophication of waters during the period 1970-1990's caused more than a 10 fold increase in phytoplankton biomass. Due to this, the

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abundance of zooplanktonic organisms increased approximately 3 fold and biomass by 5 fold. Two species, namely the heterotrophic dinoflagellate *Noctiluca scintillans (= N. miliaris)* Suriray and the copepod *Acartia clausi* Giesbrecht displayed the highest increases amongst the zooplankton in this area [2]. In more southern Bulgarian coastal waters with a marked influence of the Danube water, the zooplankton biomass was 10 fold higher than 30 miles offshore [3]. In the eastern regions of the Black Sea these differences were either minimal or absent [1].

During the same period between 1970-1990`s, the abundance of many species especially those inhabiting upper the surface layer has decreased by 1-2 orders of magnitude. Many authors have associated this with the toxic influence of some pollutants [1,4,5]. Areas with the most considerable changes were the bays and gulfs of large seaports and industrial towns.

The coastal regions are valuable feeding and breeding grounds for fishes and are important for the fishery of all riparian countries of the Black Sea and have therefore a large economical importance. Changes of the spawning grounds and the spawning intensity of anchovy (*Engraulis encrasicolus*) were already obvious [5,6]. Thus, the long-term changes in the structure and distribution of the fodder zooplankton (*Copepoda, Cladocera, Chaetognatha, Appendicularia* and other small species, except gelatinous organisms) may influence the abundance and composition of fish stocks and fishery.

The aim of this study is to compile and compare multi-institutional data from riparian countries on the long-term changes of fodder zooplankton in coastal regions (with a water depth lower than 200 m) of the Black Sea exposed to different environmental conditions and anthropogenic influence. Analyses were performed to determine changes in composition, abundance and biomass of fodder zooplankton (especially copepods, being the main component of fodder zooplankton). The roles of natural and anthropogenic factors in relation to quantitative changes in community structure are also discussed.

1.1 AREA UNDER INVESTIGATION

The northwestern Black Sea differs from the deep-water region on account of its physico-geographical aspects. This shallow shelf area of the Black Sea accepts about 90 % of total river run-off (about 260 km^3) which amounts to about 14% of the total water volume in that region. Such large river run-off has resulted in strong pollution and eutrophication due to the industrial and agricultural activities in the regions of Danube, Dnestr and Dniepr, which had a large impact upon the fauna and flora of this region [5,7]. The influence of the river run-off decreases in accordance with distance from the coast.

The composition of the zooplankton of the northwestern shelf differs from that of the deep-water regions of the Black Sea. Moreover, differences in zooplankton composition are obvious in different areas of the shelf, i.e. in the narrow coastal regions, in the bays and in the central part of the shelf. In coastal waters (down to 25 m) the zooplankton is

dominated by *Oikopleura dioica* and other bentho-planktonic species as larvae of molluscs and polychaetes. The high amount of mollusc larvae occurring in shallow areas decreases with increasing water depth and therefore distance from the coast. For example *Lamellibranchia* larvae account for 59 % of the total zooplankton biomass in the Jebriyan Bay (near Odessa, summer 1993; [8]). Whereas, in the northwestern shelf they averaged about 0.7 % of the total zooplankton biomass (during 1960-1974) and in the deeper areas only 0.1 % of the total [9].

Cold-water species, such as *Calanus euxinus, Pseudocalanus elongatus* and *Oithona similis* are very rare, especially in summer. Both total biomasses and numbers of zooplanktonic species and fishes are much higher in coastal regions, than in either the central part of the shelf or in the deep regions of the Black Sea.

The Turkish shelf compared to the northern shelf is very narrow, with steep edges and is not as eutrophicated and polluted as the north western shelf . Due to such a sharp transition, cold water species such as *Calanus euxinus* are more frequent in near shore regions off the Turkish coast, than in the north western shelf.

2. Material and Methods

This evaluation is based on the data of long-term studies carried out in the shallow area off Sevastopol at 3 locations (Kamish Bay, Sevastopol Bay and Vasilev Bay), on the north western shelf and the Turkish shelf of the Black Sea during 1957 -1996 .The sampling areas and the position of the stations are indicated in Figure 1 and the sampling period and the number of stations surveyed are summarised in Table 1. The investigations were carried out by the Institute of Biology of the Southern Seas of the National Academy of Sciences of Ukraine (IBSS-NASU), the Southern Institute of Marine Fisheries and Oceanography (YuGNIRO), and the Institute of Marine Sciences, Middle East Technical University (IMS-METU). Within the frame work of the TU-Black Sea project and the NATO Linkage Grant (ENVIR.LG. 951569) the original data were evaluated and stored in the database established during the TU-Black Sea project.

At the selected locations, sampling was performed using different nets and sampling methods. In the Kamish Bay (maximum depth 50 m) the samples were taken by the IBSS over a 10 mile transect at four stations at depths of 0-40 m, 2-3 times per month during 1960-1969 (Fig 1). More than 800 samples were collected from Kamish Bay. The horizontally towed Greze net (opening 158 cm^2, mesh-size 100 x 70 micron with a flow meter) was used [10]. The samples were taken at 40 m, 30m, 20m, and 10 m depth. At each depth sampling continued for two minutes, after which the net was repositioned in the next layer. In total the net was towed for about 15 minutes. The total filtered volume of water varied between 4-9 m^3. Method of identification, counting and biomass estimation were the same as used at the northwestern shelf area. Large and rare species were identified and counted for the whole sample. Mass species were estimated by subsampling whereby duplicate subsamples of one or two millilitres were removed with a stempel pipette. The biomass was calculated by taking in account the abundance and individual weight of the species in accordance with the tables of Petipa (1959, summarized in [11]). The average annual biomass was calculated for species, taxonomic groups and for the total zooplankton.

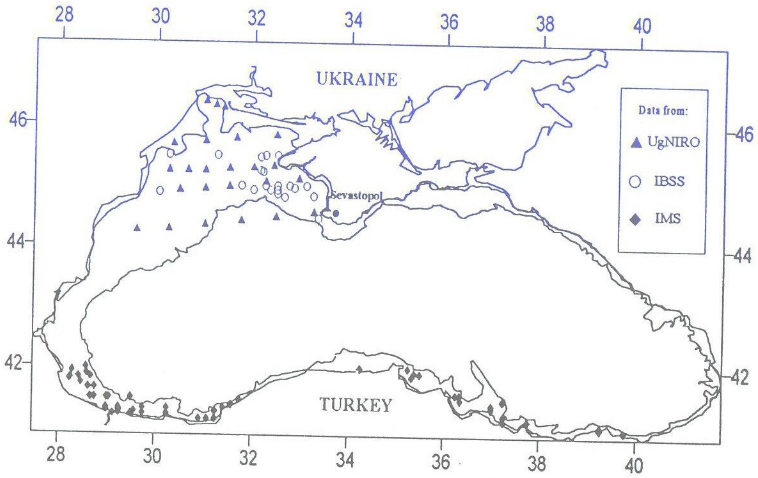

Figure 1. Distribution of stations in the coastal regions of the Black Sea

In Sevastopol Bay with a maximum depth of 12 -17 m, zooplankton samples were taken twice monthly at one permanent station during different time periods from January 1976 till May 1996 (1976: January to December; 22 samples; 1979/80: December-November, 22 samples; 5 stations in 1981-1983, 150 samples; 1989/90: October to September, 18 samples; 1995/96: June to May, 9 samples). These samples were collected with a vertically towed Juday net (opening: 0.1 m^2, mesh size: 145 micron). The hauls were performed from 10 m to the surface. The samples were fixed in 4 % formaldehyde. For the whole transect, the monthly and annual average biomass was calculated as outlined above.

In Vasilev Bay (Balaklava area) zooplankton samples were taken by the IBSS during 1981-1994 [12]. The samples were collected with a Juday net three times a year (spring, summer, autumn), at 5 permanent stations in an area of about 0,5 km^2, with a bottom depth of 10-50 m. The net and the methods used were the same as those in Sevastopol Bay.

At the northwestern shelf samples were taken in the layer 0-100 m (bottom depth < 200m) at 24 fixed stations in March, May, June, July and August during 1959-1988 (data of YuGNIRO; [13]). The data of 1957, 1985, 1988-1994 were collected by the IBSS. The samples were collected with a vertically towed Juday net (opening: 0,1m^2, mesh-size 168 micron). The net and the methods used were the same as those in the Sevastopol Bay.

TABLE 1. Sampling information for the coastal zooplankton data of the Black Sea. T=Turkey, U=Ukraine; Regions: NW Northwestern Black Sea, S near Sevastopol, SB Sevastopol Bay, TC Turkish Coast, WCC Western Crimaen Coast.

Year	Region	Country	Month	Total Number of Stations
1957	NW	U	5;8	15
1960	S; NW	U	3;5;6;7;8;9	28
1961	S; NW	U	3;4;5;6;7;8;9	28
1962	S; NW	U	3;4;5;6;7;8;9	28
1963	S; NW	U	3;4;5;6;7;8	28
1964	S; NW	U	3;5;6;7;8;9	28
1965	S; NW	U	3;4;5;6;7;8;9	28
1966	S; NW	U	3;4;5;6;7;8;9	28
1967	S; NW	U	3;4;5;6;7;8;9	28
1968	S; NW	U	3;4;5;6;7;8;9	28
1969	S; NW	U	3;4;5;6;7;8;9	28
1970	S; NW	U	3;5;6;7;8	24
1971	NW	U	3;5;6;7;8	24
1972	NW	U	3;5;6;7;8	24
1973	NW	U	3;5;6;7;8	24
1974	NW	U	3;5;6;7;8	24
1975	NW	U	3;5;6;7;8	24
1976	NW; SB	U	3;5;6;7;8; 1-12	24; 1
1977	NW	U	3;5;6;7;8	24
1978	NW	U	3;5;6;7;8	24
1979	NW	U	3;5;6;7;8	24
1979-80	SB	U	12; 1-11	24; 1
1980	NW	U	3;5;6;7;8	24
1981	NW; WCC	U	3;5;6;7;8; seasonally	24; 5
1982	NW; WCC	U	3;5;6;7;8; seasonally	24; 5
1983	NW; WCC	U	3;5;6;7;8; 9; seasonally	24; 5
1984	NW; WCC	U	3;5;6;7;8; seasonally	24; 5
1985	NW;WCC	U	3;5;6;7;8; seasonally	30; 5
1986	NW;WCC	U	3;5;6;7;8; seasonally	28; 5
1987	NW; WCC	U	3;5;6;7;8; seasonally	24; 5
1988	NW; WCC	U	3;5;6;7;8; seasonally	27; 5
1989	NW; WCC	U	7; seasonally	3; 5
1989-90	SB	U	10;1-9	1
1990	NW; WCC	U	7; seasonally	12; 5
1991	NW; WCC; TC	U; T	6 ; seasonally; 6	11; 5; 6
1992	NW; TC	U; T	7; 7	9; 15
1993	NW; WCC; TC	U; T	9; seasonally; 8	24; 5; 20
1994	NW; WCC; TC	U; T	9; seasonally; 4	16; 5; 3
1995	NW; TC	U; T	3; 4	17; 5
1996	TC	T	6; 7	6
1995-96	SB	U	6-12;1-5	1

The shelf regions of the Turkish coast with a depth between 45-200 m were sampled by the Institute of Marine Sciences, Middle East Technical University (IMS-METU).

The zooplankton samples were collected by a vertically towed Hensen net (opening: 0.380 m^2; mesh size: 300 micron) from the bottom layer to the surface during spring and summer 1991-1996 (62 stations). The methods used for sorting, identification, and biomass calculation were the same as used by the IBSS.

3. Results

3.1 SEVASTOPOL AREA

Kamish Bay. For the period 1960 - 1969, the Kamish Bay can be considered a typical shallow coastal region with weak pollution and only minor anthropogenic influence. During this period the seasonal and annual variability of zooplankton was studied by Greze *et al.* [10]. The zooplankton community, observed by Greze *et al.* could be stated as a typical Black Sea zooplankton community of coastal regions. The biomass varied between 2 and 5 g wet weight m^{-2} (Fig. 2A). During this period the total biomass of fodder zooplankton displayed a decreasing trend. The decade observed can be separated into two divisions whereby the zooplankton biomass was generally high during 1960-1964 (> 3.5 g wet weight m^{-2} and was low from 1965 -1969 (< 3.0 g wet weight m^{-2}, Fig. 2A).

During both time periods the species *Oithona nana* was the dominant species of the copepod community in terms of biomass representing about 47-48 % of the total biomass (Fig. 3a; A,B). Other dominant species were *Calanus euxinus, Pseudocalanus elongatus, Acartia clausi* an *Oithona similis*. A remarkable increase in the biomass of *Acartia clausi* by about 9 % was obvious in the second period of observation (1965-1979), while the biomass of *P. elongatus* decreased by about 13 % (Fig. 3a; A,B).

Sevastopol and Vasilev Bays. In the more eutrophic Sevastopol and Vasilev Bays the biomass of fodder zooplankton was higher than in Kamish Bay with maximum levels of about 18 g wet weight m^{-2} with an average biomass of about 8 g wet weight m^{-2} (Fig. 2B).

In Sevastopol Bay, high biomass levels were recorded until 1980 but after 1983 the biomass decreased to values of about 2.5 g wet weight m^{-2}. A similar trend in biomass was obvious for Vasilev Bay whereby the biomass decreased after 1984, reached another peak in 1987 and then declined sharply during 1988 and 1989. Since 1990 the zooplankton biomass of both Vasilev and Sevastopol Bay have fluctuated at a low level of about 2.5 g wet weight m^{-2}.

In Kamish Bay, a similar increase in the biomass of *A. clausi* occurred. The biomass of this species increased from the period 1981-1985 (Fig. 3a; C) when it represented from 30 % of the total biomass of the copepod community to 85 % for the period 1990-1994 (Fig. 3a; D). In Sevastopol Bay the same increase was seen for of *A. clausi* from 30 % before 1989 to 75 % after 1990 (Fig. 3a; E). In both areas *Paracalanus parvus* and especially *Oithona similis* decreased and *Oithona nana* was not found.

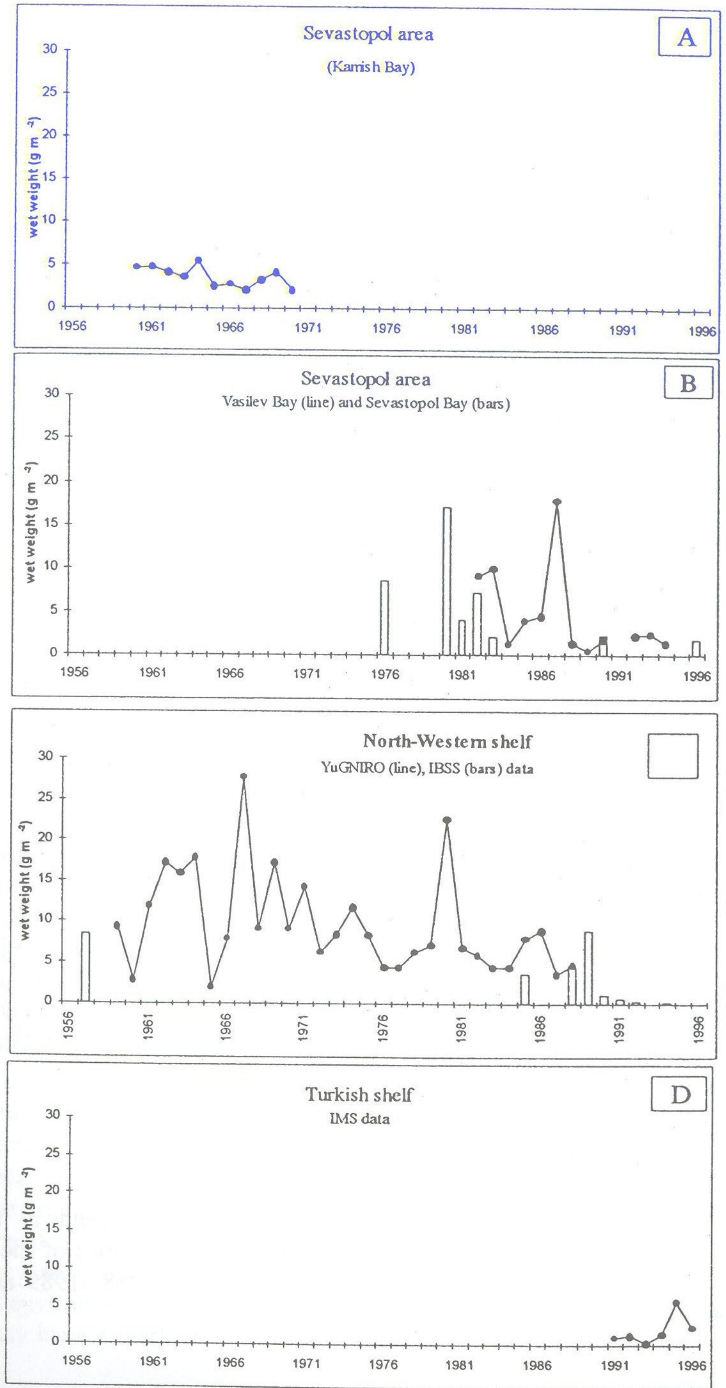

Figure 2. Annual fluctuations in the biomass of fodder zooplankton in different coastal regions of the Black Sea.

3.2 NORTH WESTERN SHELF

Compared to the Sevastopol areas the biomass of the fodder zooplankton of the deeper northwestern shelf was found to be higher with average values of about 5-15 g wet weight m^{-2} (Fig. 2c) The total fodder zooplankton biomass in this area displays similar fluctuations as seen for the more coastal Sevastopol area: an overall decrease trend in biomass from 1957 to the mid eighties, a slight increase during 1985 -1986, and then a drastic decline during 1988 - 1989 followed by a gradual increase during 1990-1994 (Fig. 2c).

Similar changes in the copepod community as observed for the Sevastopol area were obvious in the northwestern shelf. Due to the deeper waters of the shelf region, the cold water species *Pseudocalanus elongatus* and *Calanus euxinus* were more frequent. As in the shallow Sevastopol area the overall increase of *Acartia clausi* from 6 % in 1957 and 1985 to 56 % in the period 1991-94 is striking Fig. 3b: A-B). *P. elongatus*, *C. euxinus*, which were present in high amounts during the 1980's, decreased after 1989. *Oithona nana* and *O. similis* also decreased from 1957 to 1989. While *O. nana* disappeared during the period 1991-1994, *O. similis* again increased constituting up to 20 % of the copepod biomass. (Fig. 3 b: A,D).

3.3 TURKISH SHELF

The fodder zooplankton biomass for the Turkish shelf is available only since 1991 when it was low which is in accordance with the trend observed for the other analysed regions. The biomass was in the range of about 2.5 g wet weight m^{-2} during this period (Fig. 2d). However the biomass increased sharply reaching a peak of about 10 g wet weight m^{-2} in 1995 (Fig. 2d).

As in the other areas, after 1990 the copepod community was dominated by *Acartia clausi* comprising about 67 % of the total copepod biomass in areas <100 m deep. *Pseudocalanus elongatus* and *Calanus euxinus* made up 19% and 14% of total copepod biomass respectively. The genus *Oithona* was not recorded, because the mesh size of the Hensen net (300 microns) was too large to catch this species. The composition of the copepod community changed rapidly, if the total shelf area down to 200 m is included. Then the deep water species *Calanus euxinus* (70%) and *Pseudocalanus elongatus* (12%) were dominant whereas *A. clausi* accounted for only 10 % of total zooplankton biomass (Fig. 3b, E).

4. Discussion

Despite the different sampling methods used, the long-term trend in the fodder zooplankton biomass was found to be the similar for different regions of the Black Sea during the 1970's and 1980`s, with a sharp decrease during 1988 -1989 and a slight recovery since 1994.

Similar changes were also obvious in the composition of the copepod community. While *Acartia clausi* became the most dominant copepod during the 1990's forming up to 85 % of total biomass in the shelf areas of the Black Sea, the biomass of other copepod species such as *Oithona nana* has decreased since the mid 1960's (Fig. 3 a,b) and indeed some have disappeared completely from the zooplankton community [14]. In Sevastopol Bay the increase in *Acartia clausi* was so strong that this species was the only copepod there found in the summer months during June-August 1990-1994. The same was true for the shallow coastal area, close to the river Dniepr, where *A. clausi* was the single species occurring in this area [12].

In 1976, 11 of the 13 marine copepod species known for the Black Sea were present in Sevastopol Bay. By the 1990's only 6 species remained in this area. The disappearing species included the hyponeustonic copepods *Pontella mediterranea* Claus and *Labidocera brunescens* Czern., which had not been recorded in the bay since 1976. In 1982-1983, the copepods *Anomalocera pattersoni* Templ. and *Paracartia latisetosa* Crisz. were found for the last time [15]. During 1989/1990 the species *Oithona nana* Giesbr. and the small form of *Acartia clausi* Giesbr. also disappeared [14].

Similar changes were observed in copepod composition of Vasilev Bay. *Paracalanus parvus* and *Centropages ponticus* have decreased drastically since 1987. *Pontella mediterranea* and *Oithona nana* had not been recorded in samples as in Sevastopol Bay while *A. clausi* constituted up to 90 % of the total copepod biomass in the summer of 1990 [12]. Similar changes were also reported for the Rumanian coast [2].

These remarkable changes did not only occur in the copepod community, but also in the composition of the total fodder zooplankton in the Sevastopol area. In Kamish Bay the copepods constituted about 73% of the average total zooplankton biomass during 1960-1970, however, their biomass decreased to 67% in Sevastopol Bay in 1976 and was only 14% in 1990.

Despite the decrease in the biomass of fodder zooplankton, the total zooplankton biomass of the Black Sea has increased during the period of increasing anthropogenically induced eutrophication of the Black Sea [5,13,15]. This increase has mainly occurred due to the increase in the biomass of gelatinous organisms such as *Noctiluca scintillans, Pleurobrachia pileus Aurelia aurita* and later *Mnemiopsis leidyi* [16,18]. Since these animals consume fodder zooplankton, the increased predation has led to changes in the composition of the fodder zooplankton and a marked decrease in their biomass. The decrease in the fodder zooplankton biomass seen in the 1970's-1980's corresponds with the increase in the biomass of *Aurelia aurita* [18,19,20] and the peak in the *Mnemiopsis leidyi* biomass after 1988 [16,21]. Especially after the mass occurrence of *M. leidyi* the abundance of fodder zooplankton decreased dramatically [22].

The negative effect of the gelatinous species on the fodder zooplankton was probably strengthened by the influence of pollution, which has gradually increased over the last few decades, because both abundance and biomass of the fodder zooplankton had already started to decrease before the outburst of *Aurelia aurita* [5,16].

Natural environmental factors, in particular water temperature, and long-term climatic changes may have a marked influence on the zooplankton biomass [21]. Changes in the abundance of fodder zooplankton are also caused by trophic relationships, in particular by predator-prey associations. Zaitsev [5] considers the most important reason for the increase in the *A. aurita* biomass to be the disappearance of the mackerel *Scomber scombrus* which consumed juvenile medusae in the 1970's. The discovery that fishes are consumers of gelatinous organisms was found by Petipa *et al.* [23]. They discovered in the stomachs of *Sprattus sprattus* and other fish species shapeless white-rose substances, which probably were the remains *of P. pileus, A. aurita* and *N. scintillans.* A. Konsulov (pers. comm.) found in the stomachs of the mackerel *Scomber scombrus* the remains of *M. leidyi.* According to Petipa *et al.* [23], gelatinous organisms are consumed when the food resources of fishes are low.

Thus, questions about the decrease in the fodder zooplankton biomass and the increase in the jellyfish biomass have great importance for understanding food-web relationships in the Black Sea ecosystem.

5. Conclusions.

In the period of observation from the 1960's until 1996 the biomass of fodder zooplankton decreased in different regions of the Black Sea. This is a result of increasing eutrophication and increase in the biomass of gelatinous organisms. The most dramatic changes in abundance and biomass of fodder zooplankton have occurred in bays where anthropogenic impact has been the most significant.

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References

1. Kovalev, A.V. (1991) *Structure of zooplankton communities of the Atlantic ocean and the Mediterranean basin*, Naukova dumka-Kiev, 141 pp. (in Russian).
2. Porumb, F. (1992) Evolution du zooplankton des eaux du plateau continental Roumain de la mer Noire au cours de trois decennies. *Rap. proc.- verb. Reun. Comm. Int. explor. Sci. Mediterr. Monaco, 33,* 266.
3. Konsulov, A. (1992) Zooplankton structure and distribution in the Bulgarian Black Sea coastal eutrophicated zone in summer 1991. *Rap. proc.- verb. Reun. Comm. Int. explor. Sci. Mediterr. Monaco, 33,* 266.
4. Polischuk, L.N., Nastenko, E.V., and Garkavaja, G.P. (1984) Some peculiarities of modern state of pelagic and neustonic zoocoenosis of the Black Sea. *Ecologiya Morya (Marine Ecology) 18,* 25-34 (in Russian).
5. Zaitsev, Yu.P. (1992) Recent changes in the trophic structure of the Black Sea. *Fisheries Oceanography 1,* 180-189 .

6. Niermann, U., Bingel, F., Gorban, A., Gordina, A.D., Gьсь, A.C., Kideys, A.E., Konsulov, A., Radu, G., Subbotin, A.A., and Zaika, V.E. (1994) Distribution of anchovy eggs and larvae (*Engraulis encrasicolus* Cuv.) in the Black Sea in 1991-1992. *ICES J. of Marine Science 51*: 395-406.
7. Zaitsev, Yu.P. (1983) The effect of anthropogenic factors on the biology of the north-western Black Sea shelf. System analysis and modeling of processes on the Black Sea shelf. *NASU, Marine Hydrophysical Institute, Sevastopol,* pp. 19-28 (in Russian).
8. Vorob'eova, L.V., Garkavaya, G.P., Nesterova, D.A., Polischuk, L.N., Sinegub, I.A., and Teplinskaya, N.G. (1995) The Zhebriaskaya Bay as a model for the evolution of ecological processes in the north-western Black Sea impact zones. *Investigations of the shelf zone of the Azov-Black Basin. NASU, Marine Hydrophysical Institute. Sevastopol,* pp. 44-54 (in Russian).
9. Fedorina, A.I. (1978) Dynamics of the Black Sea zooplankton development and the reasons its causing. *VNIRO, Moscow, DSP in TSNIITECHRH. 11.05.78, N 149,* 49 p. (in Russian).
10. Greze, V.N., Baldina, E.P., and Bileva, O.K. (1971) Dynamics of abundance and production of the basic zooplankton components in the Black Sea neritic zone. *Biologiya moria (Sevastopol) 24,* 12-49 (in Russian).
11. Niermann, U., and Kideys, A.E. (1995) *An assessment of recent phyto- and zooplankton investigations in the Black Sea and planning for future.* Report on the meeting of Marine Biologists in Erdemli, Turkey, 20 February-3 March 1995, Institute of Marine Sciences, 100 pp.
12. Zagorodnyaya, Yu.A., and Skryabin, V.A. (1995) Current trends in the zooplankton evolution in the Black Sea coastal areas investigations of the shelf zone of the Azov-Black Sea Basin. *NAS of Ukraine, MHI, Sevastopol,.* 87-95 (in Russian).
13. Anon., (1992) Project "Sea of the USSR". *Hydrometheorology and hydrochemistry of seas of the USSR, v. 4: The Black Sea,.* N 2. S.-Petersburg: Hydrometheoizdat, 219 p. (in Russian).
14. Kovalev, A.V., and Gubanova, A.D. (1995) Long-term dynamics of the Sevastopol Bay zooplankton investigations of the shelf zone of the Azov-Black Sea Basin. *NAS of Ukraine, MHI, Sevastopol,* 96-99 (in Russian).
15. Belyaeva, N.V., and Zagorodnyaya, Yu.A., (1988) Zooplankton of the Sevastopol Bay in 1981-1983. *Ecologiya Morya (Marine Ecology) 29,* 77-84 (in Russian).
16. Anon., (1990) *Applied ecology of sea regions: The Black Sea*, Kiev, Naukova Dumka, 251 p.
17. Mashtakova, G.P., (1985) Long-term dynamics of plankton community in the eastern part of the Black Sea, in, *Oceanological and fisheries researches of the Black Sea*, Moscow, Nauka, 55-61 (in Russian).
18. Zaitsev, Yu.P., and Polischuk, L.N. (1984) Outburst of *Aurelia aurita* in the Black Sea. *Marine Ecology, 17,.* 35-46 (in Russian).
19. Gomoiu, M.T., and Kupriyanov, S.S. (1980) Estimation of *Aurelia aurita* abundance and distribution in the eastern part of the Black Sea, in, *Ecosystem of the Black Sea pelagial.*-Moscow: Nauka, pp.191-198 (in Russian).
20. Vinogradov, M.E., and Flint, M.V. (1985) Researches on the pelagic ecosystem of the Black Sea: 6th cruise of R/V "Vityaz" (April, 19- June, 3 1984). *Oceanology 1,* 168-171. (in Russian).
21. Kovalev, A., Niermann, U., Melnikov, V., Belokopitov, V., Uysal, Z., Kideys, A.E., Unsal, M., and Altukhov, D. (1998). Long-term changes in the Black Sea zooplankton: The role of natural and anthropogenic factors, in *NATO TU-Black Sea project: Symposium on Scientific results.* Crimea, Ukraine, June 15-19, 1997.
22. Kovalev, A.V., Melnikov, V.V., Ostrovskaya, N.A., and Prusova, I.Yu. (1993) Zooplankton: Macroplankton, in, *Plankton of the Black Sea.*-Kiev: Naukova dumka,: pp. 183-193 (in Russian).
23. Petipa, T.S., Sazhina, L.I., and Delalo, E.P. (1965) Fodder base of warm water and cold water fishes in the Black Sea, in, *Researches on plankton of the Black and Azov Seas.* Kiev, Naukova Dumka, pp. 69-84 (in Russian).