CHANGES IN SPECIES DIVERSITY AND ABUNDANCE OF THE MAIN COMPONENTS OF THE BLACK SEA PELAGIC COMMUNITY DURING THE LAST DECADE

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Abstract. The changes in species diversity and abundance of ichthyo- and zooplankton in the northern (mainly in the north-eastern) and southern regions of the Black Sea were analysed prior to and after the *Mnemiopsis leidyi* invasion. In addition, long-term changes in species diversity and abundance of gelatinous animals were briefly considered for understanding the extent of their influence on the pelagic community.

Since the explosive development of *Mnemiopsis leidyi*, the ichthyo- and mesozooplankton abundance and species diversity declined for the entire Black Sea. Analysis of data collected during the years (1992-1996) following the explosion showed the number of fish eggs, larvae and fodder zooplankton to display negative correlation with the *Mnemiopsis* abundance. With the recent decrease of *Mnemiopsis* in 1995-1996 the abundance of fish eggs, larvae, fodder zooplankton and particularly their species diversity rose, even more considerably than in the years following the initial plummet in the biomass of *M. leidyi*._This indicates that the ecosystem began to adapted to a new invader.

Comparison of abundance and species diversity in zooplankton, ichthyoplankton and fish catches between the northern and southern Black Sea showed the southern region to be richer in abundance and species diversity of these pelagic groups. The southern Black Sea became one of the most important areas for the spawning of a great number of commercial species, many of which had not previously recorded there. The changes in spawning locations may be attributed to favourable environmental conditions and food availability (fodder zooplankton) in the southern Black Sea in contrast to the northern part in particular the barren north-eastern area.

L.I. Ivanov and T. Oguz (eds.), Ecosystem Modeling as a Management Tool for the Black Sea, Vol. 1, 171-188.

1. Introduction

The ecosystem of the Black Sea which was characterised during the 1960s-1970s by its high productivity at all trophic levels has now been degraded to an ecosystem of low biodiversity ecosystem dominated by gelatinous organisms controlling the food-web. Anthropogenic impacts such as manipulation of river discharge [1, 2, 3], a rise in eutrophication and pollution, selective and over fishing, [1, 4, 5, 6] , climatic and inter-annual natural fluctuations resulted in the great structural changes of the food web. The pelagic community first responded to those changes.

This study concerns the changes in species diversity and density of ichthyoplankton and mesozooplankton under the influence of the ctenophore *Mnemiopsis leidyi* and jellyfish *Aurelia aurita* in the north-eastern and the southern Black Sea during the 1990s. Interrelation and competition between gelatinous carnivores are also assessed.

2. Materials and Methods

Material was collected during joint international cruises carried out according to the programs COMSBlack and NATO TU Black Sea. The present study is based on ichthyoplankton, mesozooplankton, gelatinous species data from Russian (SIO-RAN; Table 1) and Turkish cruises (IMS; Table 2). Literature (Table 3) and unpublished data (from T.A. Shiganova) were also utilised.

Russian data obtained between 1992 to 1995 were collected during 9 cruises (Table 1) and coastal investigations (July 1993,1996 - Blue Bay off Gelendtzik). Turkish IMS data were collected mainly in the southern Black Sea during 8 cruises (Table 2).

During surveys of SIO-RAS, the samples of ichthyoplankton and gelatinous animals were collected with the Bogorov-Rass (BR) net and mesozooplankton with the Juday net . In 1996 the Hensen net was used in addition to the BR net. Data of the IMS were obtained with the Hensen net. The comparative catchability of these nets was tested in 1993 and 1996. For comparison purposes the numbers were converted to m^{-2} for both nets. Correction factor for insufficient catchability was used for the BR Net for all organisms, according to the method employed by the Institute of Oceanology [7]. After correction the numbers of zooplankton and ichthyoplankton caught did not significantly differ for both nets. For gelatinous animals estimated coefficients were used. The species diversity analysis was carried out with Margalef's equation [17].

3. Results

3.1. GELATINOUS ZOOPLANKTON

At the present time in the Black Sea gelatinous animals comprise four species namely two indigenous scyphozoan medusae (*Rhizostoma pulmo* and *Aurelia aurita*) and two ctenophores (the indigenous *Pleurobrachia pileus* and the invader *Mnemiopsis leidyi*).

Rhizostoma pulmo mainly inhabits contaminated coastal areas of the Black Sea and rarely penetrates into the open sea. They are generally encountered in single numbers although it was a rather abundant species in the 1960's - early 1970's [18].

Aurelia aurita occurs throughout the sea but mostly in inshore waters. Since the 1970's the population of *Aurelia aurita* grew explosively and reached its peak at the beginning of the 1980's when its average biomass was 0.6-1.0 kg m^{-2} and total biomass for the total sea area comprised 300-500 million tons [19]. The abundance of fodder zooplankton began to decrease due to grazing by *A. aurita*. But the most drastic changes in the structure of the Black Sea ecosystem have been occurring since 1988 in connection with development of a new invader, the ctenophore *Mnemiopsis leidyi*.

TABLE 1. Cruises of SIO-RAS.

Date	Number of stations	Area
July 1992	112	north-eastern, north-western
July-August 1993	86	north-eastern, central, southern
November 1993	12	central, north-eastern
August 1994	18	north-eastern
September 1994	42	north-eastern, central
March 1995	17	north-eastern
August 1995	12	north-eastern
September 1995	21	north-eastern
June-July 1996	25	north-eastern, eastern

TABLE 2. Cruises of the IMS.

Date	Number of stations	Area
June 1991	65	southern
July 1992	143	southern
April 1993	34	south-western, north-western
August 1993	153	southern, central
February 1994	73	southern
May 1994	85	south-western
September-October 1995	72	southern
June-July 1996	72	southern

TABLE 3. Published data used in the present assessment.

Year	Authors
1988	Vinogradov et al. [7]
1989	Shushkina and Musaeva [8, 9], Khoroshilov [10]
1990	Shushkina and Vinogradov [11], Shushkina et al. [12], Vinogradov [13]
1991	Vinogradov [14], Khoroshilov [10]
1992	Vinogradov et al. [15], Vinogradov [14, 16]

In the open sea, the peak biomass (4.6 kg m^{-2}) and abundance (7600 ind.m^{-2}) of *M. leidyi* were obtained in October and November 1989, respectively [7]. In 1990 and 1991 the density of *M. leidyi* started to decrease. In 1992 the *M. leidyi* abundance remained low [15]. In 1993 spring, the *M. leidyi* density decreased to its lowest value(50 g m^{-2})

since the beginning of its outbreak. During summer and autumn of the same year *Mnemiopsis* biomass was higher than that in spring with 0.82 kg m^{-2} in August and 1.1 kg m^{-2} in November [20]. In 1994 the abundance of *M. leidyi* continued to increase reaching a peak biomass (2.7 kg.m-2) in the open sea in August-September. This peak of abundance corresponded to a second explosion like that in 1989 although average abundance in the whole sea was lower than in 1989. In 1995 the density of *M. leidyi* gradually began to decrease whereas in August 1995 the biomass was approximately the same as in 1994, by September it had already fallen two-fold times less [21]. In 1996 this decline continued (Fig.1).

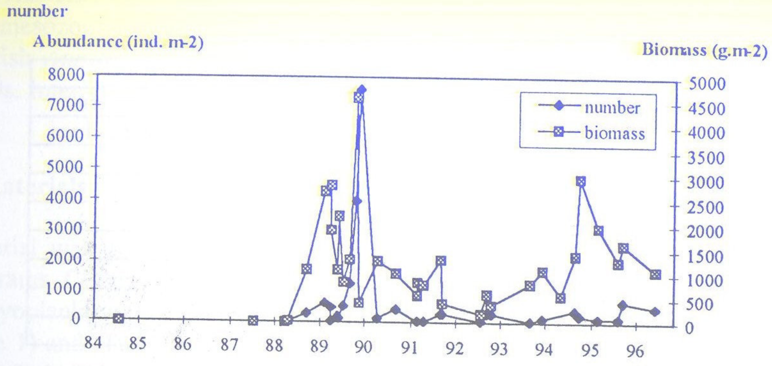

Figure 1. Long-term fluctuations in *Mnemiopsis leidyi* biomass and abundance.

After the explosive development of *M. leidyi* in 1989, the abundance of *A. aurita* dropped (Fig. 2). Analysis of data collected during the following years showed a significant negative correlation between the number of *M. leidyi* and the biomass of *A. aurita* (n=14, r= -0,80, p=0.005) (Fig. 3). It indicates intense competition between these species whereby *M. leidyi* proved to be a successful competitor with *A. aurita*. The density of *A. aurita* again rose in 1992-1993 corresponding with a decreasing in *M. leidyi* biomass and then dropped during August-September 1994. Following the decrease of *M. leidyi* in 1995-1996 (Fig. 2), the *A. aurita* biomass again started to rise.

The fourth gelatinous species is the ctenophore *Pleurobrachia pileus*. This species inhabits the interzonal layer and no correlation between the abundance of *M. leidyi* and *P. pileus* was found. Nevertheless during recent years the biomass of *P. pileus* has increased. Only in the summer-autumn period of 1993 the biomass of *P. pileus* was very low according to our data (Fig. 4).

Thus during the 1980's-1990's the abundance or biomass of gelatinous animals increased in the Black Sea. Particularly harmful for the pelagic ecosystem was the increase in the inhabitants of the upper layer, namely the indigenous *A. aurita* and the invader *M. leidyi*.

A comparison of the spatial distribution of *M. leidyi* and *A. aurita* revealed that there were many more *M. leidyi* and *A. aurita* in the highly polluted inshore waters of the northeastern Black Sea than in its southern region (Fig. 5).

3.2. ICHTHYOPLANKTON

According to Dekhnik [22] 56 species and subspecies of Black Sea marine fish display pelagic development: 28 species producing pelagic eggs and larvae with 28 species having pelagic larvae only. The fish fauna of the Black Sea is diverse due to its origin. It includes the summer-spawning warm-water species of Mediterranean origin and the winter spawning cold-water boreal species. The spawning of warm water species begins in late spring lasting until July-August or August-September.

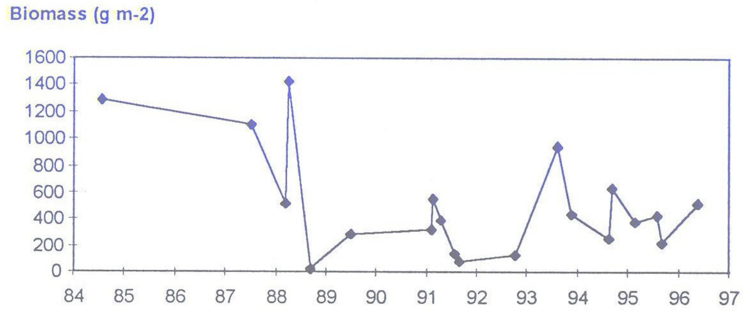

Figure 2. Long-term fluctuations in *Aurelia aurita* biomass.

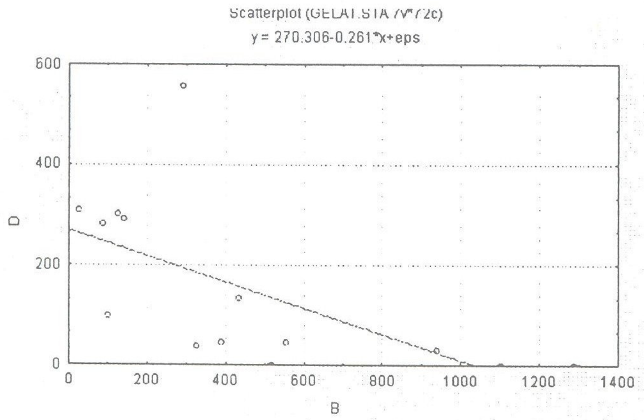

Figure 3. Correlation between *M. leidyi* biomass (B, g m^{-2}) and *A. aurita* number (D, ind. m^{-2}).

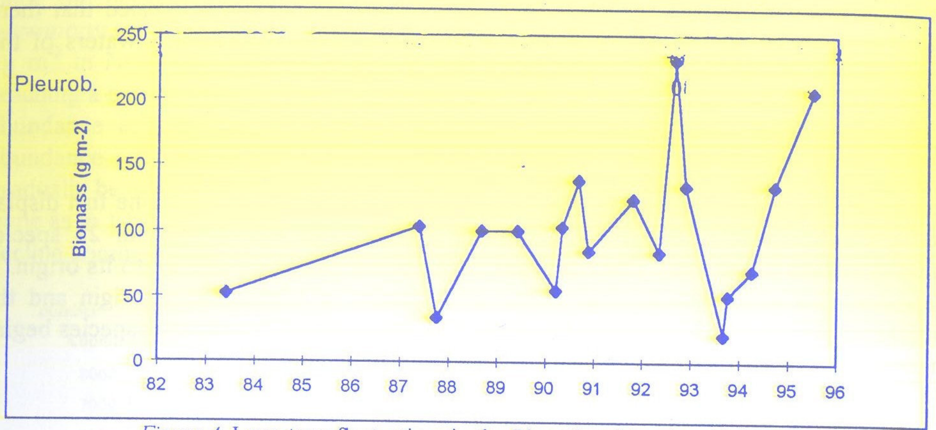

Figure 4. Long-term fluctuations in the *Pleurobrachia pileus* biomass.

During the 1980's the species diversity of summer ichthyoplankton decreased. The eggs and larvae of the mainly planktivorous species *Engraulis encrasicolus* (anchovy), *Trachurus mediterraneus* (horse-mackerel) became the most abundant. But after the explosive development of *M. leidyi* in 1989 their numbers greatly decreased. In 1991 the number of anchovy eggs and larvae was still low, particularly in the northern Black Sea though the *M. leidyi* abundance had decreased. In 1992 anchovy eggs and larvae numbers began to rise, however, their total density was still low in the northern Black Sea despite favourable conditions in June-July [23, 24]. Their abundance was significantly greater in the southern Black Sea, particularly in its south-western region [23]. Eggs of anchovy of the Sea of Marmara also was found to contribute to the ichthyoplankton of this region in 1992 [25]. In 1993 the number of anchovy eggs and larvae also apparently increased in offshore waters. However the total number of eggs and species were less than in1992 which may be due to the sampling month August being the end of spawning. The spatial distribution was the same: the density was much higher in the southern and particularly in the south-western region of the sea, while in the north-eastern area the number of eggs and larvae was very scarce [20]. In 1994 the density of anchovy eggs and larvae again decreased simultaneously with a new rise in *Mnemiopsis leidyi* abundance. In 1995 and particularly in 1996 numbers rose again in the northern area concurrent a decrease in *M. leidyi* abundance (Figs. 6, 7). In the southern area the number of anchovy was very high in 1996, at a level of 89.5 ind. m^{-2} [26]. This value was seven times greater than the density in the north-eastern Black Sea (12 ind. m^{-2}) for the same year. However for the north-eastern area it was also the highest value seen there in recent years (Figs. 6, 7).

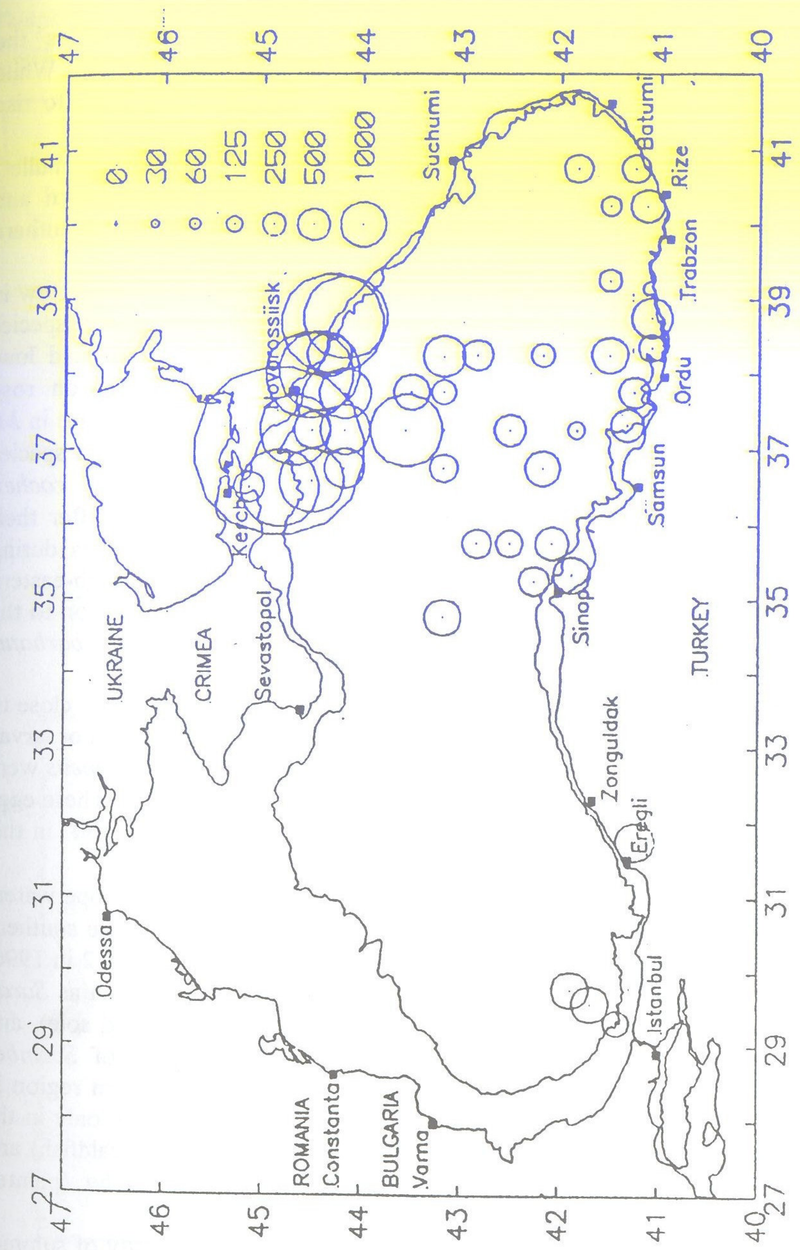

Figure 5. Spatial distribution *M. leidyi* biomass (g m^{-2}) in September-October 1995 (In the north-eastern Black Sea data were obtained with the BR-net, recalculated using the catchability coefficient. Data from the southern area were obtained with the Hensen net).

The second most abundant species on account of egg and larval numbers was the Mediterranean horse mackerel for both the northern and the southern Black Sea. While its egg and larval numbers were extremely low during 1991-1993, they began to rise after 1995.

The third most abundant species was *Mullus barbatus ponticus* (striped mullet) with the fourth being *Diplodus annularis* (annular gilthead), in both northern and southern areas. The density of eggs and larvae of both species was higher in the southern area during the 1990's.

The total numbers of eggs and larvae of summer spawning species were very low in samples taken in the north-eastern Black Sea between 1992-1994. The index of species diversity was 0.7. The number of species was 4-6. However in August 1995 and June 1996 their abundance began to increase . The species diversity of ichthyoplankton rose to 1.9 (Fig. 7) and the number of species increased to 15, although the decrease in *M. leidyi* abundance was not so great during 1995-1996 (Fig. 1). The eggs of such species as *Mugil cephalus* (flathead grey mullet), *Ctenolabris rupestris, Ophidion rochei, Scorpena porcus* (black scorpion fish) again appeared in samples in 1996 after their complete disappearance from samples obtained in the north-eastern Black Sea during 1992-1995. Eggs of the species *Mugil soiuy* were very abundant in the north-eastern area in 1996. This species was brought from the Sea of Japan for acclimatisation to the Sea of Azov and the Black Sea. The egg numbers of such species as *Mullus barbatus ponticus, Trachurus mediterraneus, Diplodus annularis* also rose.

Total egg numbers and species diversity were highest in the offshore waters close to the inner edge of the frontal zone of the rim current. In inshore waters no eggs or larvae were recorded in the north-eastern area. Only the eggs of *Trachurus mediterraneus* were recorded in significant numbers in the coastal waters off Gelendtzik in 1996. These eggs were also present in the stomodaeum contents of *M. leidyi* and *Aurelia aurita* in this area.

In the southern area more eggs and larvae occurred in the inshore and slope waters than in offshore waters [20, 23]. The species diversity was much higher in the southern Black Sea. In 1991 its value of biodiversity was 1.8 which had increased to 2.2 in 1996. Among the other the occurrence of eggs and larvae of valuable species such as *Sarda sarda* (Atlantic bonito), *Pomatomus saltatrix* (bluefish), *Solea lascaris* (sand sole), and *Psetta maxima maetica* (turbot) were noted. Additionally, two larvae of *Scomber scomber* (mackerel) were observed in summer samples taken in the southern region in 1992 for the first time. It was known previously that this species reproduce only in the Sea of Marmara. In 1996, in addition, the eggs of *Arnoglossus kessleri* (scaldfish) and *Mugil soiuy*, and the larvae of *Spicara smaris* (picarel), *Serranus scriba* (painted comber) were found in this region.

Thus, comparison of 1990's data of the abundance and species diversity of summer ichthyoplankton in the north-eastern and the southern Black Sea shows a significant difference between these two regions. The density of both eggs and larvae was much higher in the southern area as was species diversity even at the beginning of the 1990's.

Despite an increase in the northern area during last years, the biodiversity in the southern Black Sea was still higher than the north (Fig. 8).

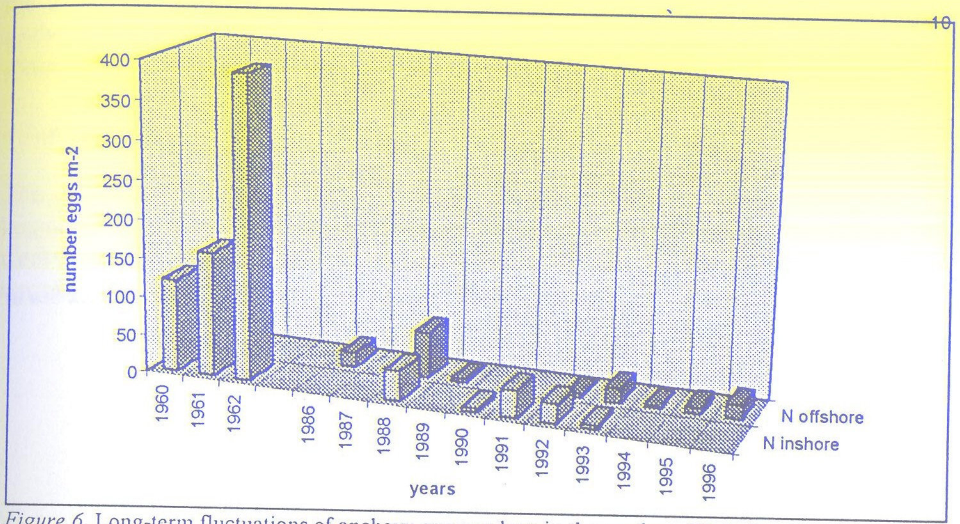

Figure 6. Long-term fluctuations of anchovy egg numbers in the northern Black Sea.(data before 1992 extracted from published data of Niermann et al. [23]).

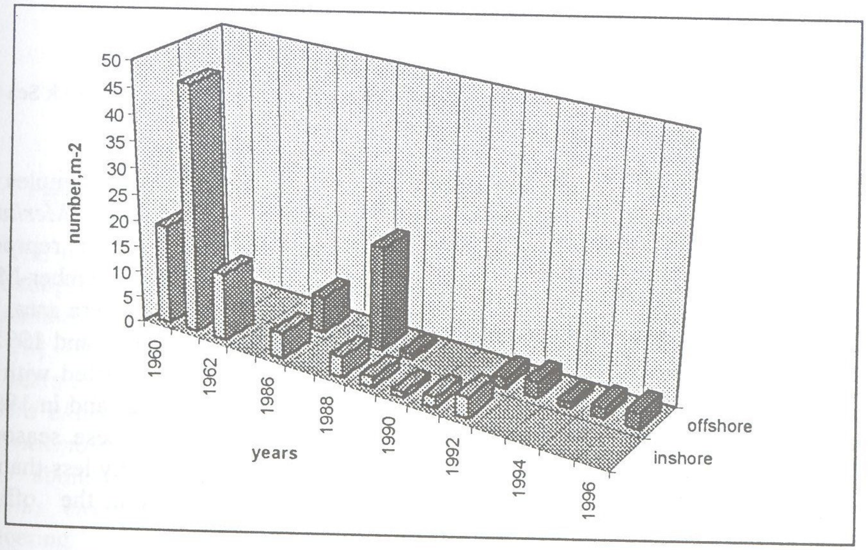

Figure 7. Long-term fluctuations of anchovy larval numbers in the northern Black Sea. (data before 1992 extracted from published data of Niermann et al. [23])

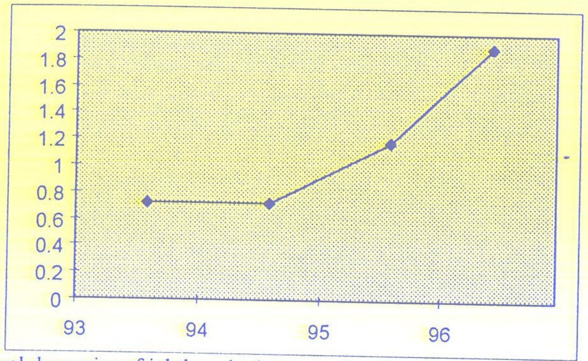

Figure 8. Inter-annual dynamics of ichthyoplankton species diversity in the north-eastern Black Sea in summer.

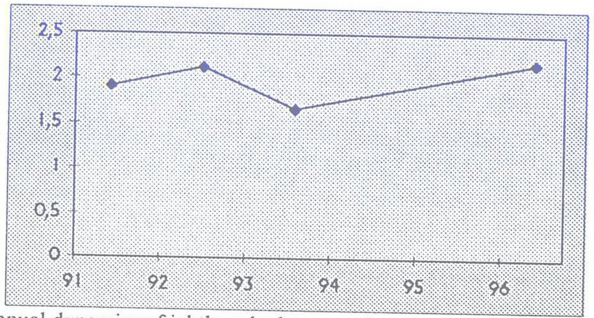

Figure 9. Inter-annual dynamics of ichthyoplankton species diversity in the southern Black Sea in summer.

The winter spawning species were represented in the ichthyoplankton samples only oy the eggs and larvae of *Sprattus sprattus phalericus* (sprat) and *Merlangus nerlangus euxinus* (whiting) in the north-eastern Black Sea. These species reproduce hroughout the year, but the most intensive spawning occurs during November-March 27]. Many sprat eggs were recorded in November 1993 in the north-eastern area, their verage number in the investigated area being 207 ind. m^{-2}. Between 1994 and 1995 the umber of sprat eggs in samples was lower. This finding may be connected with the ime of surveys. In 1994 the survey was performed in August-September and in 1995 in Aarch as well as August-September. The spawning of sprat during these seasons is sually poor. The numbers of eggs and larvae of whiting were significantly less than that f sprat. All the eggs and larvae of both species were located only in the offshore vaters.

Three species dominated the winter ichthyoplankton of the southern Black Sea: *prattus sprattus phalericus, Merlangus merlangus* and *Platichthys flesus luscus* lounder). Sprat was the most abundant species being even more abundant in the

southern region than in the north. Next was whiting on account of egg and larval density and third, the eggs of flounder which were rather low in numbers. Nevertheless, eggs of the latter were present in the winter-spring samples during every survey although its spawning was not recorded previously. Thus, abundance and species diversity of winter spawning species were also higher in the southern Black Sea.

3.3. ZOOPLANKTON

The abundance and species composition of zooplankton began to change at the beginning of 1980s. The population of neustonic species family *Pontellidae* and *Centropages ponticus* began to decline. This effect was explained by the increasing toxicants accumulation in the surface microlayer [2].

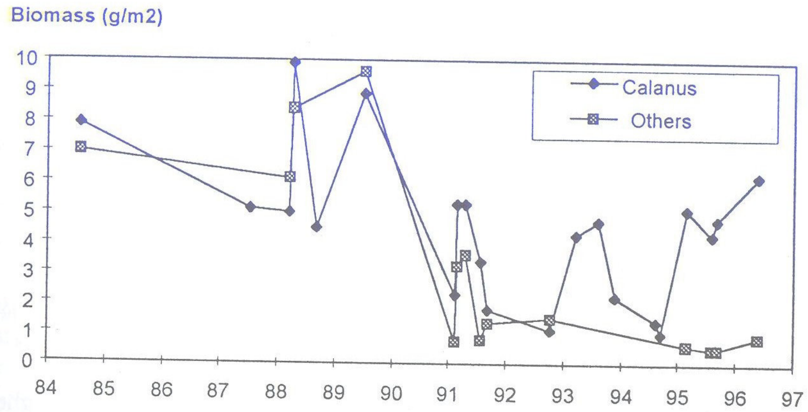

Figure 10. Long-term fluctuations in the biomass of *Calanus euxinus* and other copepods.

The mass development of *M. leidyi* resulted in a decrease in the density of the mesozooplankton and its species diversity (Fig.10, 11), especially of such species as *Pontellidae, Oithona nana, Sagitta setosa* which virtually disappeared during 1990-1992 [11, 28]. These species were recorded among the food contents of *M. leidyi* during the first years of its mass development. But later the main food sources for *M. leidyi* became *Acartia clausi* and *Calanus euxinus* in the open sea and *Cladocera* (mainly *Pleopis polyphaemoides*) in inshore waters [29, 30, 31, 32]. During 1992-1993 when the *M. leidyi* abundance declined, the zooplankton abundance began to rise. The species *Calanus euxinus, Pseudocalanus elongatus* and *Sagitta setosa* were seen to be recovering.

The density of *M. leidyi* began to increase again in 1994. And in autumn 1994 when the *M. leidyi* biomass was at its highest, the zooplankton biomass dropped. In 1995 the *Mnemiopsis* abundance gradually began to decrease, while in spring and

August - September 1995 the biomass of zooplankton and particularly *Calanus euxinus* rose significantly. The biomass of other copepods still remained rather low, but their number and species diversity increased (Fig. 11). These processes continued in June 1996. Although the number of *Pseudocalanus elongatus* and *Acartia clausi* increased more than the other copepods, the number of *Oithona similis* and *Paracalanus parvus* increased too. The population of *Sagitta setosa* also significantly recovered during 1995-1996. For the first time since their complete disappearance from the Black Sea, some individuals of *Pontella mediterranea* and *Centropages ponticus* were found in the north-eastern area in 1995-1996, and some individuals *Anomolocera patersoni* were sampled in 1996 in the southern area. In the inshore waters of both regions the gastropod veligers appeared during last years.

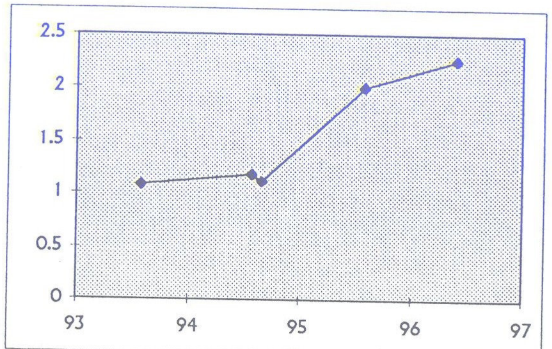

Figure 11. Inter-annual summer dynamics in mesozooplankton species diversity index in the open waters of the north-eastern Black Sea.

The biomass, number and species diversity of mesozooplankton were higher in the outhern area than in the northern during all years of investigations. In 1996 the biomass f fodder zooplankton was 6.1 g m^{-2} in the north-eastern Black Sea and 9.5 g m^{-2} in the outhern region. The biodiversity index increased from 1.4 in 1993 to 2.8 in 1996 for the outhern Black Sea.

Nevertheless the total number and biomass of all species remained much lower than efore the *M. leidyi* invasion (Fig. 9).

. Discussion

he changes in species diversity of the main pelagic groups of the Black Sea zooplankton nd ichthyoplankton began in the northern area in the 1970's , many years before the *M. idyi* invasion.

It is well-known that until the mid 1970's the northern Black Sea was the most nportant area for the spawning of all commercial fish species. Among them were aluable species such as the predators bonito *Sarda sarda* and blue fish *Pomatomus*

saltatrix, and the demersal species turbot *Psetta maxima maetica*, scaldfish *Arnoglosus kesleri*, flounder *Platichthys flesus luscus*, sand sole *Solea lascaris nasuta*. It was also the main spawning area for the Black Sea anchovy *E. encrasicolus ponticus* and the hibernation grounds of the Azov anchovy *E. encrasicolus maeticus* [33]. Part of the population of the striped mullet *Mullus barbatus ponticus* migrated from the southern to the northern Black Sea for spawning [4, 34].

However, during the 1970's the unregulated diversion of fresh water for irrigation and power generation resulted in a decrease in river flow and changes in the hydrological regime. These events were considerable in the northern Black Sea where the influence of major rivers such as the Danube, the Dnieper, the Dniester, the Don and the Cuban determined the hydrochemical regime. The surface currents in the northern Black Sea are generated by the inflow of these rivers and the Strait of Kerch [35]. The river inflow and the Sea of Azov waters affect also the velocity of the rim current in its western region (Rumenian current) and in its central part which is directed towards the Bosphorus. This influence is particularly strong great during the spring flood. These currents determine the extent of migrations of the predator species - *Scomber scomber, Sarda sarda* and *Pomatomus saltatrix* and *Trachurus trachurus* in spring to the northern Black Sea [4]. A decrease of velocities of the currents limited the extent of migrations of these species to the north and a decrease in the number of migrated fish [1].

Simultaneously, the input of nutrients and toxic substances from the large catchment basin caused changes in the hydrochemical regime and anthropogenic eutrophication followed. Eutrophication affects the diversity of species in different ways. All of these events caused the beginning of changes in species diversity both in zooplankton and fish composition in the northern Black Sea [1, 2, 36]. A major decline in the large commercial fish species such as *Sarda sarda, Pomatomus saltarix, Scomber scomber, Trachurus trachurus* followed owing to the reduced migration from the Aegean Sea and the Sea of Marmara to the north. Stocks of many commercial demersal species such as *Psetta maxima, Arnoglosus kesleri, Platichthys flesus luscus*, and *Solea lascaris nasuta* reduced significantly caused by changes in the bottom conditions and increased turbidity due to eutrophication [18, 37]. Eutrophication had an indirect effect on the zooplankton species diversity through its impact on the phytoplankton. The abundance of *Noctiluca miliaris* and herbivorous zooplankton species increased, but other large crustacean species decreased.

Overfishing of all countries during 1970-1980 led a decrease in the number of valuable species [4, 5, 6, 38].

In contrast to the northern area, Turkish rivers discharging into the Black Sea (which are in smaller size compared to the rivers of the northwestern Black Sea) are not employed in energy generation and therefore human impact on the hydrological regime was not significant. The nutrient load and industrial/domestic waste content of these rivers was less than those in the northern area [39].

By the beginning of the 1980's the increase in the jellyfish *Aurelia aurita* population had occurred [40, 41] which was considerable for the entire Black Sea.

As a result of all these events the species diversity of communities representing the secondary (mesozooplankton) and higher trophic (fish) levels significantly decreased at the end of the 1970's and continued throughout the 1980's. This decrease was much more considerable in the northern area. Pelagic fish communities throughout the whole Black Sea became dominated by the planktivorous species (*Engraulis encrasicolus, Trachurus mediterraneus ponticus, Sprattus sprattus phalericus)*, while other pelagic species decreased in the southern region and became scarce in the northern area [1, 2, 38]. Among them the Black Sea anchovy during the 1980's became the most abundant fish species in the catches of all riparian countries. The fishing pressure greatly increased on anchovy. For an optimum exploitation, the catch of anchovy should make up not more than 50 % of the total stock but instead it comprised 60-80% since 1984 [33]. Small sized individuals dominated the catches of all countries during 1987-1991 [21, 38, 42]. Despite this the quantity of anchovy was still high prior to 1989. The total catch of anchovy reached a maximum in 1988 amounting to about 80% of resources [21]. Following this peak catch, fishing resources in 1989 were only about one-seventh of those in 1988 (unpublished data of YugNIRO).

Therefore the species diversity was changing even before the mass development of *M. leidyi*. After the heavy overfishing of anchovy in 1988, which was the main food competitor of *M. leidyi*, the explosive development of this ctenophore followed in 1989. Consequently, the most pronounced changes began in the Black Sea ecosystem began [7].

A huge decline in the ichthyo- and mesozooplankton numerical abundance followed. The changes were also in species diversity, particularly in the north-eastern Black Sea which was already severely damaged. The comparison of inter-annual fluctuations of *M. leidyi*, zooplankton, summer spawning fishes, mainly anchovy eggs and larvae and species diversity of zoo- and ichthyoplankton clearly demonstrates the negative correlation between *M. leidyi* abundance and the population densities of all of these species (Figs. 1-7). This was not evident for the winter spawning fish species namely sprat and whiting. And overall the number of sprat eggs and larvae did not decline so greatly as the eggs and larvae of summer spawning species. This could be explained by the fact that both these species inhabit the intermediate layer during warm seasons and their main spawning occurs in winter when the population of *M. leidyi* is very much reduced.

Since 1992 when the number of *Mnemiopsis leidyi* decreased, the number and species diversity of summer ichthyoplankton and zooplankton gradually began to increase. During the following years the ichthyo- and zooplankton abundance correlated with the *Mnemiopsis* abundance and with the new decline of *Mnemiopsis* during 1995-1996 the abundance of ichthyo- and zooplankton and particularly their species diversity rose, even more considerably than in 1992-1993 (Figs. 3, 4). A higher abundance and species diversity in zooplankton and ichthyoplankton were recorded in the southern Black Sea.

In contrast to the statement of Ivanov and Beverton [4] the highest number of anchovy eggs and larvae was found in the southern region during 1991-1996. The appearance of eggs and larvae of such predatory species *Sarda sarda, Pomatomus saltatrix* and even *Scomber scomber* and demersal species namely *Platichthys flesus lascus, Psetta maxima maetica,* and *Solea lascaris nasuta* were recorded off the Anatolian coast, although in former years their spawning grounds were only found in the northern Black Sea [5, 34]. The change in spawning location for part of the population of certain species may be explained by better environmental conditions and food availability in the southern area in contrast to the northern one. This statement can be supported by the study of Tkach et al. [43] which compared the gut contents of larvae in the northern and southern areas, and which showed that food concentration was generally higher in the larval gut contents of the southern area during the period 1992-1996.

Thus, the assessment of the distribution of ichthyoplankton in the entire Black Sea during the 1990's from our own and published data [23, 24, 26, 44, 45] showed the southern area to be the most abundant in terms of ichthyo- and zooplankton and richest in their species diversity.

The eggs and larvae of valuable species such as *Sarda sarda, Pomatomus saltatrix, Platichthys flesus lascus, Psetta maxima maetica,* and *Solea lascaris nasuta* occurred in a low numbers also in the north-western Black Sea [24, 44, 45], but were almost completely absent in the north-eastern area.

Comparison of ichthyoplankton data with species diversity of catches demonstrated the same situation. The species diversity of Turkish catches was found to be the highest. Turkish catches *of Sarda sarda, Pomatomus saltatrix, Scomber scomber , S. japonicus, Trachurus trachurus, Psetta maxima maetica, Solea lascaris nasuta, Mullus barbatus, M. surmuletus,* and *E. encrasicolus ponticus* increased during 1993-1994, and in addition, sprat was also caught with the Turkish catch of sprat being the highest (Data of Turkish State Statistics). Species such as *Pomatomus saltatrix, Psetta maxima maetica* and *Solea lascaris nasuta* were recorded in Bulgarian and Romanian catches in a low numbers in 1995 (National Romanian reports). Among these species only *Psetta maxima maetica* was recorded in very low numbers in Ukrainian and Russian catches in 1995.

Thus according to combined data (data of Ichthyological Commission), *Scomber scomber, S. japonicus* and *Trachurus trachurus* occur near the Bosphorus and off the Anatolia, *Sarda sarda* have now migrated to be found only off the Bosphorus and Anatolia and in very few numbers in the north-western Black Sea, whereas *Pomatomus saltatrix* is a more abundant species and it can migrate further way to the north-west. It is also most probable that the part of the population of all these species which have migrated across the central part of the Black Sea to the Caucasus area (in the north-eastern region), now migrate to the Anatolian area (the southern part).

In 1995 the most abundant species in Russian and Ukrainian catches were the Azov anchovy, sprat and whiting. The Russian catch is now the poorest both in weight and species diversity. Nevertheless such species as the striped mullet appeared again in Russian catches in 1995. One of the most important commercial fish species in Russia now is the mullet *Mugil soiuy*.

Thus the species diversity and abundance of eggs and larvae of small pelagic fish and zooplankton which dropped after the *M. leidyi* explosion rose again during recent years even though the new decline in *Mnemiopsis* was not very profound. Most of the valuable species which disappeared from the northern area are now found in the southern area in ichthyoplankton samples and in Turkish catches.

These results indicate that the pelagic community of the Black Sea is now adapting to new environmental conditions on the one hand and to the invader *M. leidyi* on the other hand.

In addition, the higher increase of species diversity in the northern region seems to be connected also with an improvement of environmental conditions due to a decrease in industrial and agricultural wastes associated with the closure of some industrial and agricultural enterprises in Russia and Ukraine.

Species diversity is closely connected with the community resistance. It is generally held that mature systems characterised by an excess of structural elements and the overlapping of functional links are more resistant [46]. It should be noted that the analysis of relations between diversity and resistance is complicated by the fact that the resistance itself is ambiguous: first, the ability of the ecosystem to resist the influence of external factors (stable resistance) and second, the ability of ecosystem to restore itself after the influence terminates (resilient resistance). In the case of the Black Sea we can observe the combination of both resistances, the community trying to resist the influence of the gelatinous carnivores and beginning to restore itself after their decrease and the restoration of environmental conditions. However, certainly both gelatinous carnivore species still dominate in the Black Sea pelagic community and collapse of economy is a emporal event and therefore we can assess these observed results only in terms of a ositive sign with respect to an improvement in the ecosystem state. It does not avoid he demand in practical measures for further restoration of the environment which is still legraded in the hope for recovery of fish resources .

5. Acknowledgements. This study was conducted with funds of Scientific Affairs Division of NATO within the framework of the Science for Stability program, NATO-TU Black Sea project; Russian Foundation for Fundamental Investigations (RFFI 96-04-51051) and funds of project "Biodiversity". We thank to Mrs Alison M. Kideys for improving the English of the text.

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