ICES STATUTORY MEETING 1993

C.M. 1993/L:69
Sess.S

MNEMIOPSIS LEIDYI IN THE AZOV SEA: BIOLOGY, POPULATION DYNAMICS, IMPACT TO THE ECOSYSTEM AND FISHERIES

dr.S.P.Volovik, dr.Z.A.Myrzoyan, ir.G.S.Volovik.

Research Institute of the Azov Sea Fishery Problems,

21/2 Beregovaya St., Rostov/Don, 344007, Russia

ABSTRACT

In 1988 a new-comer ctenophore Mnemiopsis Leidyi appeared in the Azov Sea. Within several next years it became the dominating form of predatory zooplankton, average its biomass during the period of abundance (august-september) had changed from 32 up to 106 g/cubic m. Ctenophore lives in the Azov Sea only during warm part of year: a small quantity of Mnemiopsis flows with water from the Black Sea through the Kerch Channel in spring, until August-September it occupies the whole aquatory of the sea (where salinity not less than 3%) and then its quantity abrubtly reduces - in the beginning of winter a very few animals are being observed. It is appears that in early spring only adult large size Mnemiopsis have found out, in the summer and autumn dominate juveniles and small size ctenophore.

Mnemiopsis intrusion has caused damage to existing trophical interrelations in the ecosystem of the sea, devastated the food stok (in july-august biomass of food zooplankton including meroplankton declined from the level of 330 before invading down to 0.004 mg/cubic m. in 1991-1992) and reproduction of indigenous harvest species of fish (anchovy, kilka, etc.). Catches of mentioned species reduced from 120-220 thousands tonnes down to 10-30 thousands tonnes in 1989-1992.

On the data within the long period observation on the characteristics of the Azov Sea ecosystem a ctenophore population dynamics mathematical model has been elaborated. The model describes real dynamics of population and size structure.

The Azov Sea is the extreme link in the Mideterranean waterbody. From time immemorial it was famous with its fish stocks and even not far ago the Azov Sea was the most productive sea the World Ocean over (Moiseev,1969). It is a very small sea. Its surface area is 37800 square km, greatest depth is 14 m, average depth is 8.5 m and its volume amounts 320 cubic km. Temperature varies from -0.7 deg C in January-February up to 26 deg C (off-shore regions) and 30 deg C (coastal regions) in July-August annually. Currents in the shallow Azov Sea are mostly formed by the winds.

The Azov Sea is a brackish water sea. Salinity of the Azov Sea changes from almost full absence of salts (mineralization 1 g/l in the estuary of the Don River and the Easten part of the Taganrog Bay) up to 15 -17 g/l in the Kerch Straits and adjacent areas of the Azov, where influence of water which flows from the Black Sea through the Kerch Straits is observed. Oscillation of average salinity of this waterbody is in interval of 5 g/l within last 70 years. During the period of natural rivers flow (before 1952) its absolute value changed from 9.1 to 12.2 g/l. The period after is charecterized by very intensive usage of continental runoff for the needs of agriculture, industry as well as municipal and other anthropogenic activity, average salinity varied from 10 to 14 g/l. Within last decade its value was only 11-12 g/l. Nevertheless, this oscillation of salinity, despite of its small value, is of vital importance for the biology of the sea, because it determines habitats, taxonomic composition and productivity of the Azov Sea biota (Volovik at all,1993).

Biota of the Azov Sea is characterized by rather wide structure and formed by the representatives of genetically different groups - freshwater, seawater, brackishwater and relict complexes. The special peculiarity of taxonomic structure is not a great quantity of phytoplankton, zooplankton, zoobenthos and fish species which form a great deal production. In spite of regulating of rivers flow, productivity of biota has been staying on a rather high level even in nearest past. Less than in former days, but high enough. Within the period before 1952 average biomass of phytoplankton in off-shore regions was 3.0, zooplankton - 0.34 g/cubic m, zoobenthos - 321 g/square m, in 1988-1992 biomass varied in intervals: 0.5 - 2.3, 0.2 - 0.4 g/cubic m and 194 - 248 g/square m accordingly. Favourable hydrological, hydrochemical and feeding conditions as well as large surface area of spawning-grounds of the Azov Sea basin caused forming of wealthy stocks of harvest fish species. Within the period of bloom of the Azov Sea fishery (the 30-s) it was caught about 300 thousands tonnes of fish, more than a half was anadromous species (sturgeon,herring) and semi-anadromous species (pike-perch, bream, sea-roach) of fish. After rivers flow regulating, dealt with destroying of reproduction mechanism of mentioned species, sea fish species became dominating in fish catches (goby, anchovy, Azov kilka). The whole catches of fish were not more than 150-250 thousands tonnes. During last five years a newcomer ctenophore Mnemiopsis Leidyi has been appearing in the Azov Sea, its causes the decrease of cathches down to 10-30 thousands tonnes. Anchovy and kilka, which presented earlier 90-95 % of catches, practically have lost their fishery importance.

In 1988 a new organism - ctenophore Mnemiopsis Leidyi - was found out in the South part of the Azov Sea. It came from the Black Sea, where it had been brought in the beginning of 80-s with ballast water of ships from the Atlantic Coast of America. This ctenophore is meant as one kind of biological pollution of the Azov Sea and within a very short time period - during next 1989 - Mnemiopsis caused large -scale and manyfold changes of pelagic part of biota of the Azov Sea. Sustainable study of mentioned newcomer, more exactly, the study of its spread mechanism over the territory of the sea, population dynamics and impact estimation to other levels of trophic chain - is being carried out since 1989 on the data recieved from research expeditions (6-9 times per year) in off-shore regions and constantly provided coast testing (from special coast stations). Ctenophore catches were carried out by plankton net (inlet diameter is 0.5 m) on 33 stations situated evenly over the aquatory of the sea.

PENETRATION AND ANNUAL CTENOPHORE DEVELOPMENT CYCLE. Possessed information allows to affirm that Mnemiopsis inhabits in the Azov Sea only within warm year period. In 1989-1991 it was found out in April-May, 1993- in the end of June, and it was observed only in the South region of the sea adjacent to the Kerch Straits. In July-August it did spread over almost the whole aquatory of the sea and in the end of August-September was found in the Taganrog Bay. In the end of September its habitat was maximum (90-95% of the sea), everywhere, where salinity was not less than 3 g/l (Fig.1). During all the period of obseration in December-March there was no a single ctenophore found out in all of the regions free from ice, inspite of its abundance in previous months. In several cases: 1990, 1992 and 1993 - Mnemiopsis was not observed even in the end of sring (May 1992) and beginning of summer (June 1993). A few reasons are known about ctenophore mortality in the Azov Sea during cold year period and considered features of its biology allows to qualify Mnemiopsis Leidyi as temporary invader what is not peculiar for Mnemiopsis native habitat (Miller,1974,Deason,1982). Ctenophore penetration to the Azov Sea takes place with intensive spring water flow through the Kerch Straits from the Black Sea. Usually it happens due to long-period Southern winds which cause a bore from the Black Sea or after strong Nothern or Easten winds when compensational Black Sea water flow takes place. Both situations mentioned above are determined by meteorological conditions and change from year to year. Nevertheless, for years of observation a fact is common that firstly ctenophore is met on a small aquatory in the Southern part of the sea. Taking into account that time of penetration is quite different for every year, it is very interesting and important to consider a mechanism of its spread over the Azov Sea. The dynamics of ctenophore spread depends on concrete meteorological conditions and movement of the sea water, because constant currents are not usual for the Azov Sea and dynamics of region water exchange is defined by wind activity. That is why, some years ctenophore developed very intensively in June-beginning of July mostly in the Easten part (1989,1990) or in the central part (1991,1992) of the sea and only afterwards it spread to other regions in September.

Ctenophore usually spread over the territory of the Azov Sea very fast. This property allows it to impact hardly to summer-autumn plankton community which is a food for Mnemiopsis. Because of small depth of the sea, ctenophore inhabits all layers of water. There is no any found peculiarities of vertical movement of Mnemiopsis Leidyi in the Azov Sea.

POPULATION SIZE STRUCTURE very differs within a year period. When population development starts (in spring-summer beginnig), mostly adult animals are met. Their size is 20-55 mm. Juveniles and larvae are usually absent. Quantity of juveniles (less than 5 mm) is about 10%. In the end of summer and in autumn the base of ctenophore population is small and middle size (5-15 mm) animals, big ctenophore is very rarely met this time (Fig.2). The maximum size is not more than 70-80 mm.

CTENOPHORE BIOMASS is rather different from year to year, as well as within one year and depends on region of the sea. Biomass also depends on penetration time from the Black sea, spread over the territory of the Azov Sea and quantity of available food. In common, it is possible to mention two biomass dynamics scenarios: early (April 1989) and late (May-June 1990 - 1993) penetration to the Azov Sea thruogh the Kerch Straits. In the beginning of its living in the Azov Sea a very few animals was observed in the region adjacent to the Kerch Straits.

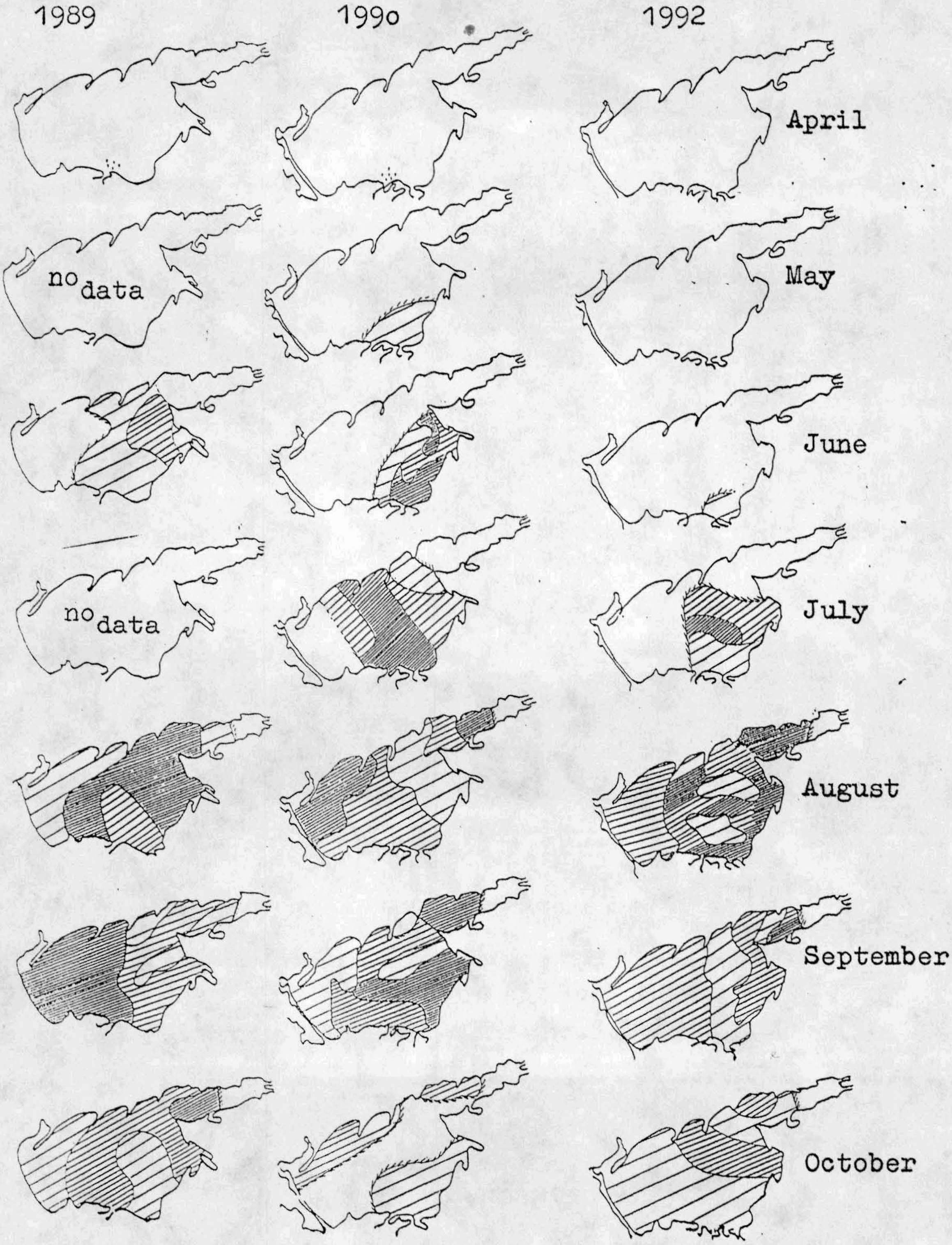

Fig.1. Distribution and biomass of Mnemiopsis leidyi in the Azov sea

single animals   0,1-15   15-50   >50   g/cub.m w.w.

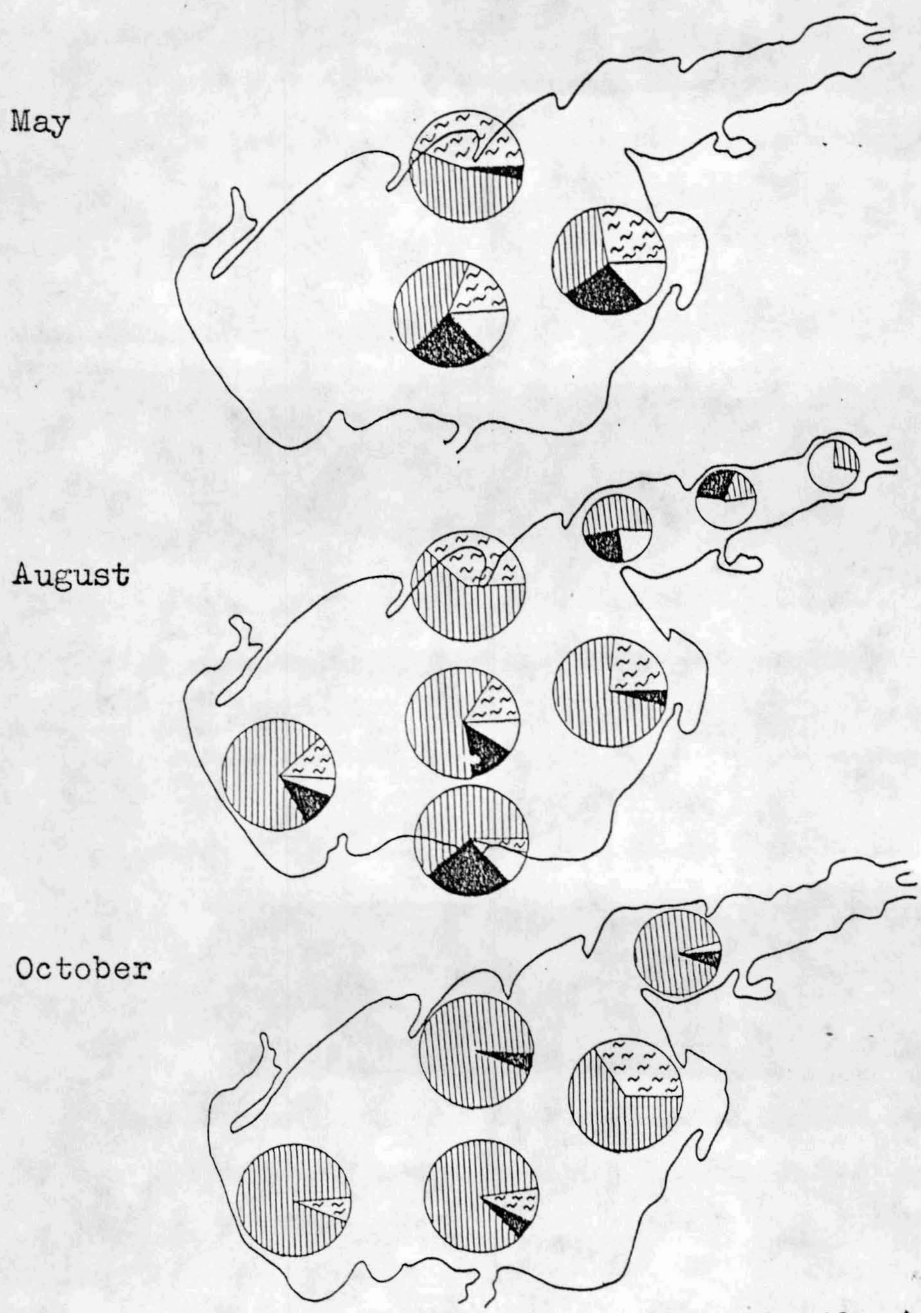

Fig.2.Mnemiopsis population size composition in the Azov sea

Table 1

Mnemiopsis leidyi biomass in the Azov sea

(g/ cub.m w.w.)

years	months				
	VI	VII	VIII	IX	X
			the Azov sea		
I989	0,I -77,5 II,3	*)	7,0-I9I,I 60,7	7,4-283,0 I06,0	8,0 - 67,3 25,2
I990	6,0 -I4I,0 43,0	6,0-I3I,0 44,0	0,4 -433,0 68,0	2,0 -580,0 39,0	I,0 - 44,0 7,0
I99I	0,2 - I4,8 3,I	3,0 -I99,0 68,0	3,0 -3I8,0 I02,0	7,0 -285,0 69,2	4,0 - 37,0 I5,0
I992	0	I,0 -24I,0 57,0	I,0 -307,0 5I,0	I,0-I29,0 32,4	I,0 - 74,0 I5,3
			the Taganrog bay		
I989	0	*)	I6,5 -58,0 38,2	95,5-728,0 226,0	4,0 - 95,6 49,0
I990	0	0	5,0 -I47,0 45,0	45,0 -298,0 I23,0	23,0-397,0 54,0
I99I	0	0	I4,0-505,0 I77,0	40,0-583,0 I54,0	8,0 - 37,0 I5,0
I992	0	0	I,0 -424,0 I23,0	2,0 -270,0 66,4	9,0 - 6I,0 32,4

Footnote: interval/ average; *) - no data

When Mnemiopsis appears in April (I scenario), the first part of summer and mid-summer is characterized by very fast increasing of its biomass (0.07-0.35 in May - 11-43 g wet weight/cubic m in June, maximum value is 78- 141 g wet weight/cubic m. When ctenophore appears in the end of May-June (II scenario), its abundance has been observed only in July. By this time ctenophore inhibits only on 40% of the aquatory (I scenario - 80%). Quantity of Mnemiopsis increases abruptly in the beginning of summer from 3 g wet weight/cubic m biomass to 56-68 g wet weight/cubic m, maximum value 199-241 g wet weight/cubic m (Tabl.1), average value for the sea is 62 g wet weight /cubic m. In October biomass reduces in the sea as well as in the Taganrog Bay (16 and 38 g wet weight/cubic m)(Tabl.1). If ctenophore biomass in any one region is compared, it will be seen that within one month period Mnemiopsis quantity will reach its maximum and then will reduce very rapidly (Fig.1). This process with taking into consideration the absence of natural ctenophore predators is defined by food dynamics.

So, maximum of Mnemiopsis biomass has been observed in August or September. The average biomass produced during vegetation period in the Azov Sea is estimated as 22.6 million tonnes of wet weight. Greatest ctenophore stock (32 million tonnes) was marked in 1989. A trend of reducing of year stock is being found out. Average quantity of Mnemiopsis population for all the regions varies 0.5-7.4 thousands per square meter in July and up to 33 thousands in August.

All mentioned above data means that intensity of ctenophore development in the Azov Sea exeeds very much its own habitat - coastal regions of America (3-100/cubic m-Mounford,1980,Deason and Smayda,1982, Kremer,1976, Miller,1974) and equals development level of the Black Sea (Vinogradov,1989,Shushkina,Musaeva,1990,Shushkina at al,1991).

Process of ctenophore feeding was not specially studied, but literary data says that its ration does not differ much on composition and quantity for the Black Sea from native habitat (Viogradov,1989,Tsikhon-Lukanina at all,1991, Shushkina at all,1990, Kremer,1976, Larsen 1988,Reeve at all, 1989).

The Azov Sea has its specifical hydrochemical composition. That is why, the data on ctenophore chemical composition recieved during sampling in the Azov Sea is of vital importance. Dry weight is about 2% of wet weight, protein is 0.17% of wet weight, there are 17 amino acids in it. Among microelements dominate Cr-7.9, Co-0.016, Hg-0.22, Cu-40.5, Pb-1.6, Ni-2.8, Ba-7.6, Be-0.03, Sr-300, Al-56, Fe-45.5 microgramm/g dry weight.

To estimate ctenophore feeding out impact to plankton community of the Azov Sea would be possible with the help of data before and after its invasion (Tabl.2). A fact is worth underlining that intensity of zooplankton development in spring has increased due to absence of ctenophore and decreased in summer-autumn (in more than 200 times) due to its abundance. Decline of taxonomic quantity and size structure of zooplankton has stated during the period of ctenophore "bloom".Comparing season oscillations of population size structure, it has become possible to ascertain that the biggest damage to Azov zooplankton is caused by Mnemiopsis juveniles and larvae.

Wealthy food resources of the Azov Sea were used mostly by anchovy and kilka which formed production up to 1.8 million tonnes, biomass of their population together reached 1.7 million tonnes (Volovik, 1986). After its penetration to the Azov Sea Mnemiopsis became the main rival on feeding out of food resources and, possibly, the direct predator on anchovy larvae and juveniles. Within the whole period of observation only on several stations where ctenophore was pointed out some quantity of anchovy spawn and larvae was found. As a rule, there was no anchovy spawn or larvae in the regions which Mnemiopsis inhibited. The feeding out of fish (anchovy and kilka)

Table 2

Zooplankton biomass before and after Mnemiopsis introduction to the Azov sea (mg/ cub. m w.w.)

years	months					
	IУ	У	УI	УП	УШ	X
		the Azov sea				
I979-I987	96	298	445	298	240	I07
I989	6 - 5I7 / I62	-	2 - 303 / 77	I - 87 / I7	0,02 - 82 / 9	0,I -593 / 7I
I990	0,2 -862 / 283	93 -4792 / 970	4-654 / I59	0,I -394 / 42	0,02 - I2 / 2	0,04-59 / II
I99I	6 - 620 / I88	-	89 -4088 / II84	8 - 862 / 96	0,0I - I9 / I	0,04 -II / I
I992	I - 350 / 69	I - 5I80 / I079	I2I-2390 / 844	4 - 408 / 89	0,04 - 3 / I	I - 26 / I0
		the Taganrog bay				
I979-I987	97	269	592	750	637	874
I989	20 - 3I0 / I08	5I8-37I3 / I829	I0 - 626 / 238	0,4 -I86 / 46	3 -I944 / 474	I4 -998 / 280
I990	56 - 7I2 / 277	63- 669 / 403	I3 - 57I / I32	3 - 465 / I84	0,0I -3442 / 620	2 - 567 / 260
I99I	6 - 724 / I96	I0-3284 / 730	II-3284 / 730	I6-4320 / I006	0,4 - I07 / 40	0,5-395 / I09
I92	7 - 243 / 48	II -I606 / 880	I9-I045 / 302	29 -300 / I36	2 - 66 / 27	3 - 273 / 56

Footnote: interval/ average

Ctenophore biomass

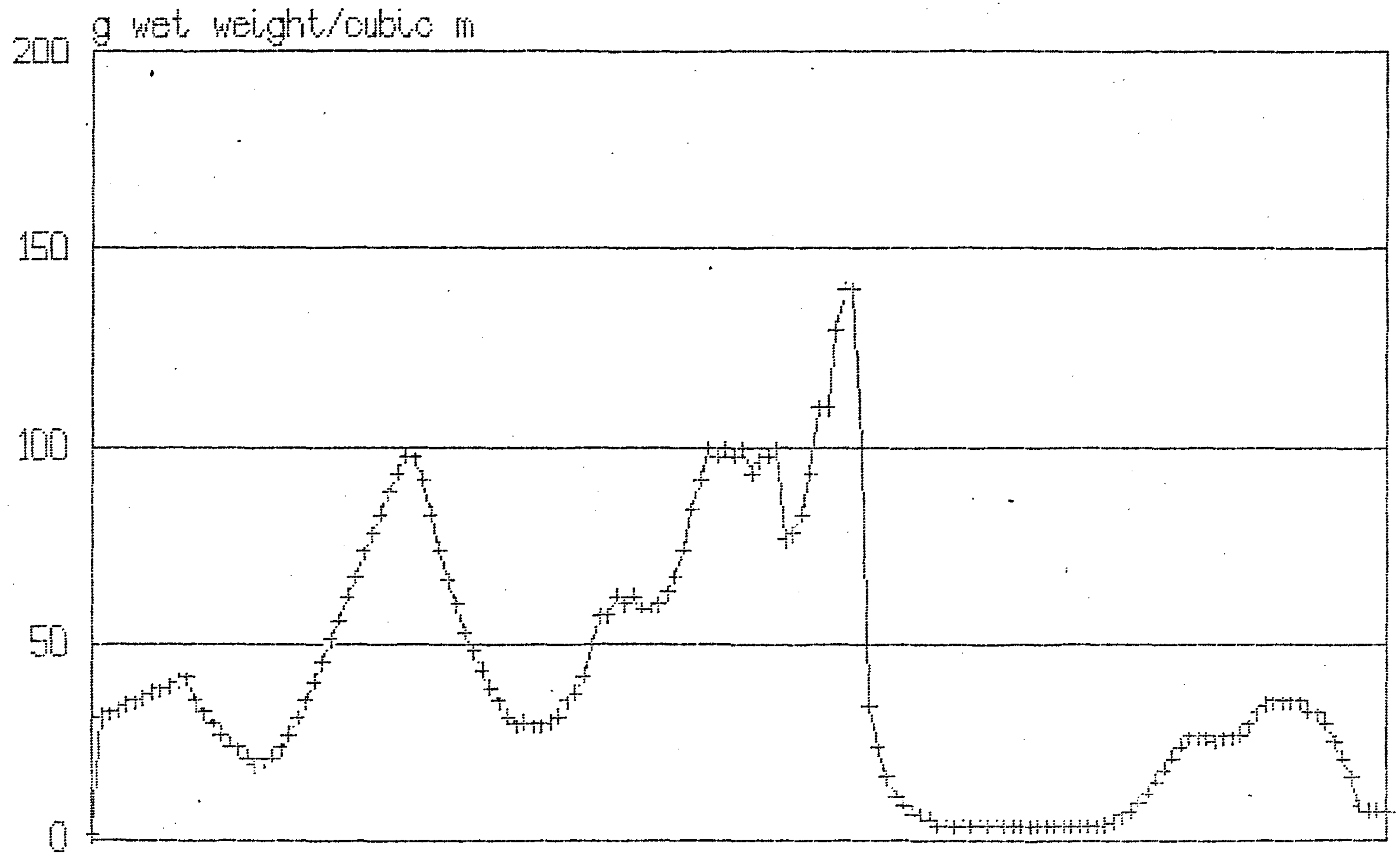

FIG.3 days

Graphic was built for I scenario
Penetration day - 1.06

food caused a lack of necessary accumulated energy what did it impossible for fish to migrate, to winter and to develop sexual products. That is why, strong changes were registrated as well as destriying of population reproduction, decline of their production (kilka - 4-5 times, anchovy - more than 10 times), population biomass and harvest stocks. All mentioned has caused demage to large-scale fishery. Losses from Mnemiopsis introduction are appraised at 30-40 million US$ annually for the Azov Sea. The similar figure for the Black Sea is 240 million US$(Caddy,1991).

A Mnemiopsis population dynamics model was elaborated for development intensity prediction and ctenophore influence to the Azov Sea ecosystem and populations of harvest fishes estimation. The model describes ctenophore spread along the waterbody, feeding, food assimilation, respiration and extraction, reproduction and mortality, biomass and population dynamics and other processes (Fig.3). Firstly the model was built on the methodology used by american scientists (Kremer,1975,1977, Kremer,Reeve,1989, Reeve at all,1989), but results were wrong for conditions of the Azov Sea, because there is no usual ctenophore food enough. It was necessary to elaborate feeding model for the Azov Sea conditions. It was done on existed literary data (Vinogradov at all,1989; Shushkina at all,1990,Tsikhon-Lukanina at all,1991, Zaika,1990). An idea that Mnemiopsis feeds on mezoplankton organisms (including meroplankton) proved by mentioned scientists from the Black Sea Oceanological Institute named after Shirshov was used. Verification of the model with all the factors has shown that ctenophore population oscillations within the period of its living in the Azov Sea have two or three maxximum (Fig.3). For every of them a special population size structure is typical. Natural sampling in the Azov Sea proved only size - weight characteristics of Mnemiopsis population. In essential habitat Mnemiopsis population has one maximum in season population dynamics (Kremer,1979).

Carried out research convinces in necessity of further study of Mnemiopsis biology in the Azov Sea basin. This is the only way to solve the problem of ecosystem protection from harmful impact of this invader.

RFERENCES

Caddy J.F. 1992 Rehabilitetion of Natural Resources. (Environmental management and protection of the Black Sea. Technical Expert Meeting, 20-21.05.92, Constanza, Romania. Working group II. Background Document). FAO, GFCM,p. 22.

Deason E.E. 1982 Mnemiopsis Leidyi (Ctenophora) in Narragansett Bay, 1975-1979. Abundance, size composition and estimation of grazing. Estuar. Coast. Shelf. Sci. 15(2):121-134.

Deason E.E. and T.J.Smayda 1982 Ctenophore-Zooplankton-Phytoplankton Interaction in Narragansett Bay, Rhode Island, USA. J.Plankton Res. 4(2): 219-236.

Kremer P. 1975 The Ecology of the Ctenophore Mnemiopsis Leidyi in Narragansett Bay. Rh.D.Thesis.Univ. Rhode Island, USA, p.33.

Kremer P. 1976 Population Dynamics and Ecological Energetics of a Pulsed Zooplankton Predator the Ctenophore Mnemiopsis Leidyi. Wiley, Martin (ed.). Estuarine Processes. Vol.1. Uses, Stresses and Adaptation to the Estuary. Academic Press: New York:197-215.

Kremer P. 1977 Respiration and Excretion by the Ctenophore Mnemiopsis Leidyi. Mar.Biol. 44,1:43-50.

Kremer P. and Reeve M.R. 1989 Growth Dynamics of a Ctenophore (Mnemiopsis) in Relation to Variable Food Supply. II. Carbon Budget and Growth Model. J.Plankton Res. 11:553-574.

Larson R.J. 1988 Feeding and Functional Morphology of the Lobate Ctenophore Mnemiopsis Mccradyi. Estuarine Coastal Shelf. Sci. 27,5:495-502.

Miller R.J. 1974 Distribution and Biomass of an Estuarine

Ctenophore Population, Mnemiopsis Leidyi (A.Agassiz). Chesapeake Sci. 15:1-8.

Moiseev P.A. 1969 Biological Resources of World Ocean. Moscow. 338pp.

Mounford K.1980 Occurance and Predation by Mnemiopsis Leidyi in Barnegat Bay, New Jersey. Estuar. Coast. Mar.Sci. 10:393-402.

Reeve M.R., Syms M.A., Kremer P. 1989 Growth Dynamics of a Ctenophore (Mnemiopsis) in Relation to Variable Food Supply. I. Carbon biomass, feeding, eggs production, growth and assimilation efficiency. J.Plankt.Res. 11,3:535-552.

Shushkina E.A., Musaeva E.I. 1990 Structure of Epipelagic Zooplankton Community and its Changes Related to the Envasion of Mnemiopsis Leidyi in the Black Sea. Oceanology, 30,2:306-310.

Shushkina E.A., Nikolaeva G.G., Lukasheva T.A. 1990 Changes in the Structure of the Black Sea Plankton Community at Mass Reproduction of Sea Gooseberries Mnemiopsis Leidyi (Agassiz). Oceanology, 51,1:54-60.

Tsikhon-Lukanina E.A., Rezmichenko O.G., Lukashova T.A. 1991 Quantitative Aspects of Feeding in the Black Sea Ctenophore Mnemiopsis Leidyi. Oceanology, 31,2:272-276.

Vinogradov M.E., Shushkina E.A., Musaeva E.I., Sorokin P.Yu. 1989 Ctenophore Mnemiopsis Leidyi (A.Agassiz) (Ctenophora;Lobate) - new settlers in the Black Sea. Oceanology,XXIX,2:293-299.

Volovik S.P. 1986 Main Direction of Changes of the Azov Sea Ecosystem Relate to Development of Economy in its Basin. Voprosy Ikhtiologii, 26,1: 33-47.

Volovik S.P., Dubinina V.G. and Semenov A.D. 1993 Hydrobiology and Dynamics of Fishing in the Sea of Azov. FAO Studies and Reviews, N64:5-59.

S. Volovik