II. ENVIRONMENT

The Black Sea is situated between latitudes 40°55'N - 46°37'N and longitudes 27°27'E - 41°47'E. Its maximum length is at 42°29'N latitude - 620 miles - and maximum width at 31027'E longitude - 332 miles. The greatest depth is 2 258 m. The general characteristics of the basin are the following (**Table 1**):

TABLE 1. General characteristics of Black Sea

Isobaths (m)	Area (km^2)	Volume (km^3)
0 - 25	16930	212
25 - 50	30937	1160
50 - 100	49057	3679
100 - 200	15399	2310
200 - 500	14284	4999
500 - 1000	22592	16944
1000 - 1500	38490	48113
1500 - 2000	69195	121091
over 2000	156604	331446
Total	413488	529954
According to Zaitsev (1993)	423000	534000

The shelf surface area of the Black Sea is 96 914 km^2 (23.44% of the total area). Out of it 43 960 km^2 (10.63%) are in the territory of Ukraine, 10 680 km^2 (2.58%) in Russia and Georgia, 10 700 km^2 (2.59%) in Bulgaria and 31 574 km^2 (7.64%) in Turkey and Romania.

On the basis of the morphological peculiarities of the shelf and the continental slope the Black Sea can be conditionally separated in 8 regions: 1. North-western; 2. South-western; 3. Turkish; 4. South-eastern; 5. Caucasian; 6. Kertch-Tamansky; 7. Crimean; 8. Central. Through the Kertch Strait it communicates with the Sea of Azov and through the Bosporus with the Mediterranean.

The Black Sea is a semi-closed basin with relatively great depths, small connection with the World Ocean, and high bioproductivity of the shelf zone - 242 tonnes of phytoplankton per km^2. Here discharge some big rivers like the Danube, Dneister, Dneiper, South Bug etc., which determines the lower salinity of Black Sea waters compared with those of the Marmara and Aegean Seas and Mediterranean.

The specific structure of the Black Sea was noted at the beginning of the oceanographic investigations of the basin: first of all, the existence of two layers, highly different with respect to the hydrological parameters and divided by a constant picnocline (halocline). The occurrence of hydrogen sulphide at depths of more than 125-224 m is another important peculiarity since surface waters saturated with oxygen represent only 12% of the total water volume. The deep (below 100 m) remain relatively isolated from the surface layer, where aerobic processes take place. For this reason, below the basic picnocline layer (an anoxic zone) is formed, preceded by an oxygen deficit zone, where the organic matter is oxidized to sulphates and by anaerobic bacterial reduction the sulphates are reduced to hydrogen sulphide.

The geostrophic circulation in the surface layer of the basin is presented by the **Main Black Sea Stream (MBS),** which generates extensive cyclone gyres in the central east and western regions and a multitude of smaller cyclones and anticyclones (**Figure 2**). At the external part of the **MBS**, due to its interaction with the continental slope, a ring of anticyclone gyres is formed, which generates a quasi homogenous **Convergence Zone (CZ)**.

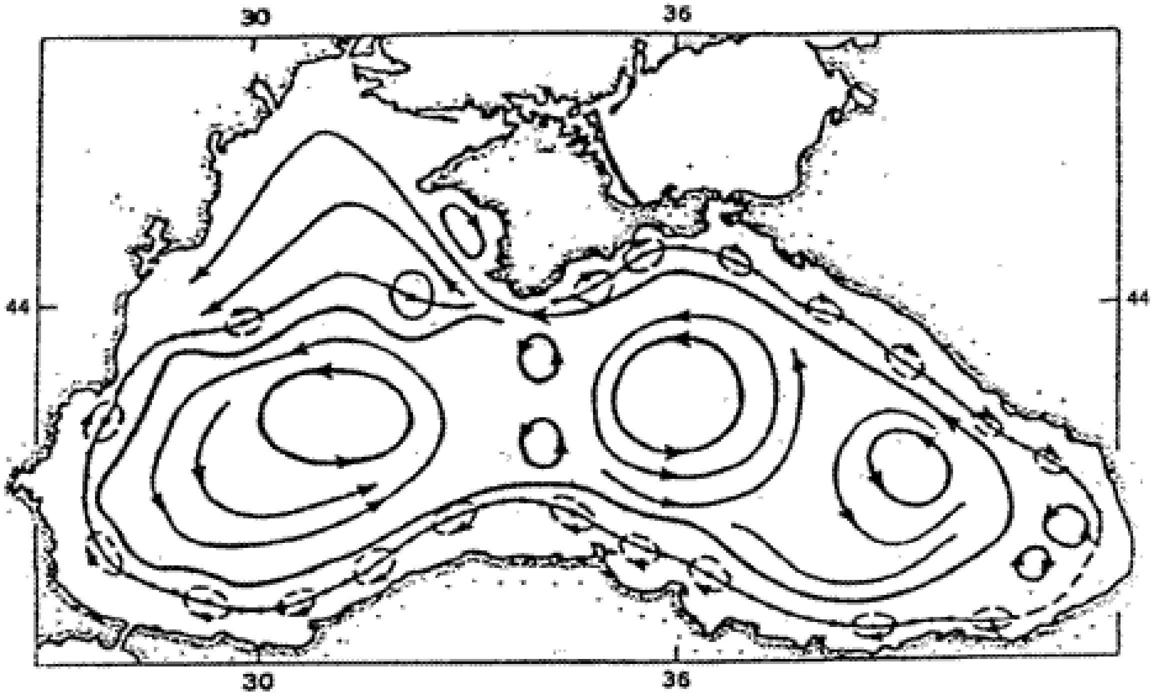

FIGURE 2. Surface circulation in the Black Sea (from Practical Ecology, 1990)

Despite the existence of the constant picnocline, recent studies show that the water column has an intensive vertical dynamic, especially in winter. The strong North and Northeast winds elevate the main cyclonic gyres domes (to 20-30 m from the surface in some areas), which breaks apart the picnocline and leads to increase of the convective mixing with 0.02 cm/s average speed (Ovchinnikov and Popov, 1987). In this **Divergence Zone (DZ)**, formed in such a way over an area of 40 000 km^2, about 3-4 000 km^3 as an average deep water's upwelling, exceeds 10 times the volume of the river inflow (Vinogradov *et al.*, 1992). The deep waters, shifted to the surface, mix with the cooled surface layer in a 1:5 ratio and initiate the so called "**Cold Intermediate Layer" (CIL)**, typical of the three layer summer hydrostructure. The **CIL** forming cold water, downwells from the picnocline domes, to the periphery of the cyclone gyres until it reaches the **MBS**, which spreads it throughout the basin.

The upwelling of water in the **DZ** of the central part of the basin is compensated by its downwelling in the **CZ** above the continental slope, which coincides with **CIL** downwelling to the periphery of the cyclone gyres (Ovchinnikov *et al***.**, 1991). The downwelling in **CZ** water is compensated by intensification of the **DZ** upwelling as well as by the actively upwelling of water on the continental slope in the coastal zone. Coastal upwelling is noted in some areas, due to the influence of the geomorphologic particularities of the coast and bottom and the local winds (e.g. **Cape Kaliakra**: Dimitrov *et al*., 1987; **Odessa Bay**: Vinogradova and Vassileva, 1992; **Peninsula of Crimea**: Blatov and Ivanov, 1992).

In winter, due to the impact of the low temperatures and the strong winds, the shelf zone is subject to intensive vertical mixing, which covers the total water column, from the surface to the bottom. In spring the surface layer warms up and a seasonal thermocline is noted in the 25-30 m layer. Thus, the typical the warm season, a three layer structure is observed in the open Sea, comprising an upper quasi-homogenous layer, with lower limit at the seasonal thermocline, a 6-8^{o}C cold intermediate layer between the seasonal thermocline and the constant picnocline, and an anaerobic zone below the picnocline. At this stratification, the vertical mixing is negligible: 1-1.6 x 10^{-7} cm/s (Boguslavsky *et al*., 1979).

In the north-western part of the Black Sea the summer vertical stratification is still better expressed owing to the influence of river inflow. The Danube waters form a vast frontal zone which spreads its influence over the whole western coast as far as the Bosporus (Rojdestvensky, 1954).

In summer the thermocline lies at depths of 25-30 m. Here inner waves are generated that form gyres in the proximity of the shelf zone, promoting vertical water exchange as well as the uptake of nutrients from deep waters euphotic layers (Kitkin, 1953; Bogdanova, 1959).

The temperature regime of the Black Sea is typical of temperate latitudes. The thermohaline structure of the offshore zone according to average data of Sorokin (1982) is shown in **Table 2**.

TABLE 2. Thermohaline structure of the Black Sea offshore zone

Depth (m)	Water temperature (^{Î}Ñ)	Salinity ($^{o}/_{oo}$)	Oxygen concentration (mg/l)	Hydrogen sulphide concentration (mg/l)
0	22.1 (7.1)*	18.24 (17.44)	5.6	0.0
10	22.1 (6.8)	18.34 (17.60)	6.7	0.0
20	15.7 (6.8)	18.40 (17.80)	7.4	0.0
30	9.3 (6.7)	18.93 (18.10)	5.8	0.0
50	7.7 (7.6)	19.80 (18.40)	5.4	0.0
100	8.1 (8.1)	20.63 (20.28)	0.8	0.0
150	8.4 (8.5)	21.01 (20.95)	0.2	0.15
200	8.6	21.34	0.05	0.75
500	8.9	22.05	0.0	5.15
1000	9.0	22.31	0.0	8.27
500	9.0	22.35	0.0	9.41
2000	9.1	22.36	0.0	9.21

* **-** in brackets, the values of the parameters during winter are shown

During winter the surface water layers in the north-western and north-eastern part of the sea cool to 0^{o}C. In summer they warm up to 24-27^{o}C in the inshore and to 21-23^{o}C in the offshore zone.

The water balance of the Black Sea is near equilibrium (**Table 3**). The prevailing portion of the river runoff is due to the Danube river - about 2 000 km^{3} per year.

The ionic composition of the Black Sea waters is similar to the oceanic (in %), except for the carbonic ion, the latter having in the Black Sea concentration substantially higher, especially in the deep layers (Skopintsev, 1975) (**Table 4)**.

The specific characteristics of the hydrochemical and hydrological structure of the Black Sea have set their imprint on the biota species composition as well as its abundance.

TABLE 3. Water balance of the Black Sea

Inflows - sources		Outflows - sources	
according to Solyankin (1963)		according to Solyankin (1963)	
river inflow	246	evaporation	332
atmospheric rainfall	129	outflow in	
inflow from		the Sea of Azov	32
the Sea of Azov	53	outflow in	
inflow from		the Sea of Marmara	340
the Sea of Marmara	176		
Total	704	Total	704
according to Rojdestvensky (1978)		according to Rojdestvensky (1978)	
river inflow	294	evaporation	301
atmospheric rainfall	254	outflow in	
inflow from		the Sea of Azov	29
the Sea of Azov	38	outflow in	
inflow from		Sea of Marmara	485
the Sea of Marmara	229		
Total	815	Total	815

TABLE 4. Ionic composition of Black Sea waters

Ions	Black Sea		Ocean
	0 - 300	300 - 2000	
Cl^-	55.230	55.250	55.200
Br^-	0.183	0.185	0.190
SO_4	7.540	7.410	7.690
CO_3	0.460	0.950	0.200
Na^+	31.360	31.230	30.590
K^+	1.020	1.070	1.100
Ca^{2+}	1.310	1.280	1.200
Mg^{2+}	3.240	3.740	3.720

The phytoplankton comprises 746 species, 525 of them being marine or brackish, 211 - freshwater or brackish , plus 10 species undefined in relation to salinity preference (Pitsik, 1979) - **Table 5**. In this list the new species that invaded the Black Sea during the last years are not included since their taxonomic position is not finally specified.

TABLE 5. Number of phytoplankton species in the Black Sea

Taxonomic groups	Sea and brackish waters Genera	Sea and brackish waters Species	Fresh and brackish waters Genera	Fresh and brackish waters Species	Grand total Genera	Grand total Species
Bacillario-phyta	55	245	24	93	64	342
Pyrrophyta	34	193	6	12	36	205
Chryso-phyta	25	47	2	3	27	51
Chloro-phyta	11	23	26	66	36	91
Cyano-phyta	5	8	10	24	12	34
Xanto-phyta	3	6	-	-	3	6
Eugleno-phyta	3	3	6	13	7	17
Total	136	525	74	211	185	746

The mean annual phytoplankton biomass varies considerably during the years (**Table 6**). The phytobenthos consists of macrophytes, sea grass and microphytes. This is the group mostly investigated off the Romanian coast where 388 species have been found (Bodeanu, 1979) (**Table 7)**.

TABLE 6. Phytoplankton biomass in the Black Sea

Years	North-western part	Eastern part	Years	North-western part	Eastern part
1960	-	36	1975	484	194
1961	1008	42	1976	672	1120
1962	696	29	1977	1533	1130
1963	-	45	1978	786	356
1964	722	100	1979	1921	405
1965	741	42	1980	2170	505
1966	511	120	1981	940	617
1967	512	134	1982	733	1369
1968	282	120	1983	933	256
1969	464	96	1984	918	418
1970	806	78	1985	201	180
1971	369	88	1986	381	136
1972	520	135	1987	557	346
1973	1621	114	1988	821	300
1974	1082	261	1989	988	-

TABLE 7. Number of macrophytobenthos species (Bodeanu, 1979)

Taxonomic groups	Marine	Marine and brackish	Brackish and fresh-water	Fresh water	Grand total
Bacillario-phyta	171	76	58	48	353
Pyrrophyta	13	1	-	-	14
Chlorophyta	2	-	4	2	8
Chrysophyta	6	-	-	-	6
Cyanophyta	5	-	1	-	6
Euglenophyta	1	-	-	-	1
Total	198	77	63	50	388

The annual microphytobenthos production is estimated to be around 15 million tonnes, the total biomass being 0.2 million tonnes. Ivanov and Beverton (1985) gave for the same parameters, values of 54.5 and 0.5 million tonnes, respectively.

According to Kalugina - Gutkin (1979) the number of macrophytobenthos species is the following (**Table 8**):

TABLE 8. Number of macrophytobenthos species in the Black Sea

Seaweed groups	Marine	Brackish and marine	Brackish	Fresh water and brackish	Grand total
green	31	42	7	5	85
brown	62	15	-	-	77
red	112	28	1	1	142
Total	205	85	8	6	304

The Phyllophoras and Cistozeiras are the dominant algae genera. In this view the vast meadow of red algae ("Zernov's phyllophora field") is unique in the world. It is situated in the north-western part of the Black Sea at depths of 30-65m, between 45-46^{o}N and 30-32^{o}E. In the early 1960s-1970s the total biomass was estimated at 7-12 million tonnes. As a result of eutrophication and pollution of the basin the phyllophora biomass steadily decreased (**Table 9)**.

The figures in brackets are according to data from "Commercial description of the Black Sea" (1988), the others are according to the annual reports of YugNIRO (Ukraine). In spite of some apparent differences in the point estimates (owing to different surface areas investigated) they reflect as a whole rather well the negative changes in the phyllophora biomass - the decline was around 21-36 fold in relation to the period 1960-1970. Ivanov and Beverton (1985) drew the same conclusion and noted that its total biomass has diminished from 6.6 to 2.5-3.0 million tonnes in 1974.

The total phytobenthos biomass has been estimated to be about 15 million tonnes and the production around 50 million tonnes, which represents about 3% of the overall production of organic matter in the Black Sea (Mashtakova, Rouhyanen, 1979; Hydrometeorology and Hydrochemistry, 1992). According to Ivanov and Beverton (1985) the macrophytobenthos biomass is 16.0 million tonnes and that of the production 17.6 million tonnes. Consequently, the total phytobenthos biomass is 16.5 million tonnes and the production 72.6 million tonnes.

TABLE 9. Surface area (km^2) and Phyllophora biomass (x 10^{-3} tonnes) during the period 1972 - 1993

Years	Area (km^2)	Biomass (x 10^{-3} tonnes)
1972	(1185.8)	(1868.4)
1973	no data	no data
1974	no data	no data
1975	(523.2)	1200.0 (983.8)
1976	no data	no data
1977	(355.9)	(976.9)
1978	?	1080.0
1979	(368.2)	1000.0 (143.6)
1980	(491.6)	790.0 (260.9)
1981	(440.8)	910.0 (223.0)
1982	no data	no data
1983	(110.4)	350.0 (258.2)
1984	(37.2)	790.0 (179.9)
1985	(38.2)	430.0 (122.2)
1986	?	580.0
1987	?	450.0
1988	?	340.0
1989	?	250.0
1990	no data	no data
1991	no data	no data
1992	?	300.0
1993	?	320.0

The zooplankton comprises basically 98 species. This figure may be increased to 120 species because of the Mediterranean immigrants, some of them having succeeded to adapt to the Black Sea environment. Besides, in spring and summer about 20 species (Mollusca, Polichaeta, Crustacea and other benthic and nektonic organisms) enrich the plankton community with their larval stages (Sorokin, 1982). **Table 10** shows the taxonomic composition of the primary zooplankton according to Grese and Fedorina (1979).

TABLE 10. Taxonomic composition of zooplankton in the Black Sea

Taxonomic groups	Family number	Genera number	Species number
Tintinoidea	4	9	25
Hydrozoaria	9	10	10
Scyphozoaria	2	2	2
Ctenophorae	1	1	1
Rotatoria	4	9	35
Cladocera	2	4	8
Copepoda	9	13	15
Chaetognatha	1	1	1
Appendicularia	1	1	1
Total	33	50	98

The zooplankton species have different origin and hence different ecology. The major part is concentrated in the upper 50 metre-layer (Nikitin, 1945; Hydrometeorology and Hydrochemistry, 1992) and the low border of distribution in the zones of circular streams lies at depths 175-200 m (Nikitin, 1949). In the central halistic parts, the lower border may rise up to 85-100 m. After Vinogradov *et al*. (1987) this border of zooplankton occurrence is determined by the dissolved oxygen concentration and not by the incidence of hydrogen sulphide.

According to Grese and Fedorina (1979) the zooplankton biomass of the different taxonomic groups is as follows (**Table 11**):

TABLE 11. Zooplankton biomass in the Black Sea

Taxonomic group	Biomass in wet weight th. tonnes	%	Dry weight in % to wet weight	Biomass in dry weight th. tonnes	%
Crustacea	2820	18.0	17.0	479.4	56.0
Noctilucae	5540	35.3	2.0	110.8	12.9
Ctenophorae	5335	34.1	2.3	122.7	14.3
Sagittae	424	2.7	4.7	19.9	2.3
Medusae	675	4.3	0.13	0.9	0.1
Other	878	5.6	14.0	122.9	14.4
Overall	15672	100.0	-	856.6	100.0

The indicated figures should be observed as mean values, as far as the zooplankton biomass differs in wide boundaries during the various years (**Table 12)**.

TABLE 12. Zooplankton biomass in layers 0 - 100m (mg/m^3)

Years	Eastern part of Black Sea	Western part of Black Sea	Average	Years	Eastern part of Black Sea	Western part of Black Sea	Average
1964	60.7	177.6	119.1	1979	64.8	69.8	67.3
1965	54.5	108.9	81.7	1980	113.2	225.1	169.2
1966	86.0	78.5	82.2	1981	118.1	67.3	92.7
1967	133.1	275.6	204.4	1982	43.9	58.2	51.0
1968	107.0	90.4	98.7	1983	69.5	43.9	56.7
1969	80.5	170.9	125.7	1984	85.3	42.5	63.9
1970	-	89.0	89.0	1985	73.9	77.8	75.8
1971	110.3	141.5	125.9	1986	58.3	87.8	73.0
1972	84.9	60.3	72.6	1987	77.3	36.5	56.9
1973	161.4	84.4	122.9	1988	84.5	46.9	65.7
1974	99.4	115.8	107.6	1989	113.3	50.3	81.8
1975	61.1	82.2	71.6	1990	76.8	70.8	73.8
1976	46.9	47.9	47.4	1991	29.6	75.9	52.8
1977	43.8	44.1	44.0	1992	75.8	48.0	61.9
1978	26.8	61.4	44.1				

The same is valid for the annual production, which varies from 90 to 120 million tonnes (Hydrometeorology and hydrochemistry, 1992), the last corresponding to 246.6-328.8 thousand tonnes daily production. The annual production of Sagitta is estimated to be about 31.7 million tonnes, and the daily products about 87 thousand tonnes.

According to Ivanov and Beverton (1985) the ecological factor used to determine the various trophic levels (Ke) is too low for the detritivore organisms and carnivores, 0.067 and 0.003 respectively. The above-mentioned authors explain the latter with the fact, that the mussels being a main consumer of detritus, are not eaten by other organisms. The extremely low level of utilization of the trophic base by predators is explained as due to negligible use of planktonic predators such as jelly-fish, Ctenophora, Sagitta, etc. , higher in the food chain.

The introduction (1982) and the mass development of the new species Ctenophora (*Mnemiopsis leidyi=Mnemia macradyi*) after summer 1988 caused significant changes in all trophic levels of the

Black sea ecosystem. Observations in experimental (aquariums) and natural conditions show that the mentioned species consumes the native species Ctenophora (Pleurobrachia), its own generation, fish-eggs and larvae of fishes but mostly copepoda (Vinogradov *et al.*, 1989; Vinogradov and Shushkina, 1992; Malishev and Archipov, 1992). In experiments it is proved that the food needs of this predator are extremely high (to the complete filling of the stomach). As a result, the biomass of Copepoda and Cladocera, according to different authors, decreased (in the layer 0-25m) from 6 to 8 times in comparison with the mean long-term summer zooplankton biomass (Malishev, Archipov, 1992); from 10 to 20 times (Lipskaia, Luchinskaia, 1990) and from 10 to 30 times (Vinogradov *et al.*, 1989). According to Bulgarian data (Atanasova, Velikova, Manasieva, in press) the summer and autumn zooplankton biomasses had decreased 5.7 and 3.8 times respectively in comparison with the period 1974-1987 and 11 and 6 fold during the period 1954-1973. The population explosion of *Mnemiopsis* and the following reducing of the remaining zooplankton is a normal process for the West Atlantic, from where this species is transferred. The mass development of it is due to its capability to inseminate itself, to its high fertility, accelerated rate of growth and high survival of the generation (to 10%) Reeve and Walter (1978); Miller (1974). In this connection the *Mnemiopsis* can successfully combat most of its competitors, but for the same reason it can with difficulty, keep its biomass at a high level (Kremer, 1976). That is why its biomass varies within wide boundaries depending on the food capacity of the water body. According to different authors in the period 1989-94 the Mnemiopsis' biomass varied from some thousand of million tonnes to some ten of million tonnes.

Having in mind the estimates of zooplankton production (of crustaceans as a main food) we shall indicate only those of Grishin, Kovalenko and Sorokolit - JugNIRO (personal communication - the full text of their report will be given in press after improving the estimates for 1993 and 1994) (**Table 13)**.

According to Vinogradov *et al*. (1989) Mnemiopsis biomass has reached 700 million tonnes.

TABLE 13. Biomass of jelly-fish and the new species Ctenophora (x 10^{-6} tonnes) during April-May and June -July (by data of Sorokin and Sorokolit YugNIRO)

Years	Biomass of jelly-fish IV-V	Biomass of jelly-fish VII-VIII	Biomass of Mnemiopsis VII-VIII
1976	7.1	69.5	
1981	10.7	91.5	
1982	32.3	48.4	
1983	5.4	41.5	
1984	7.7	45.4	
1986	4.6	12.3	
1987	4.6	12.3	
1988	5.4	4.6	
1989	6.1	5.4	33.7
1990	2.3	5.4	30.7
1991	0.8	6.2	40.5
1992	0.8	2.3	18.9
1993			10.0
1994			40.0

The zoobenthos of the Black sea is represented by 1518 species (without Protozoa), from which 156 are foundin river estuaries and freshwater, and 85 - in the Bosporus region (**Table 14**). The deepest layer of distribution is about 125-130 m, in the Bosporus region - 170-200 m. Only some Nematoda from the genus Desmoscolex, Trocoma and Cobbionema are found in depths from 200 to 600m, in the permanent anoxic zone (Zaitsev *et al*l, 1987). The mentioned aerobic organisms exist in the anaerobic zone due to its ability to use the accumulated carotinoides (in sediments) as a source of oxygen.

TABLE 14. Taxonomic groups of Zoobenthos in the Black Sea

Taxonomic groups	Overall species number	in brac-kish waters	at the Bospo-rus	Taxonomic groups	Overall species number	in brac-kish waters	at the Bospo-rus
Foraminifera	26	-	-	Scaphopoda	1	-	1
Spongia	28	-	-	Ostracoda	109	16	11
Hydrozoa	25	3	-	Harpacticoida	154	3	-
Anthozoa	5	-	-	Cirripedia	5	-	-
Turbelaria	103	-	-	Amphipoda	103	38	-
Nemertini	33	-	-	Isopoda	29	-	-
Nematoda	240	-	-	Tanaidacea	6	-	-
Rotatoria	40	21	-	Cumacea	23	9	-
Gastrotricha	23	-	-	Decapoda	32	1	-
Kynorhyncha	10	-	-	Aracina	27	3	-
Polychaeta	182	3	30	Pantopoda	8	-	-
Oligohaeta	39	23	-	Insecta	11	7	-
Sipunculidae	1	-	1	Tardiyrada	5	-	-
Bryozoa	18	-	-	Usteroidea	1	-	1
Camptozoa	2	-	-	Ophiuroidea	4	-	3
Phoronidae	1	-	-	Echinoidea	1	-	1
Loricata	3	-	-	Holothurioidea	8	-	3
Bivalvia	88	12	20	Ascidiae	8	-	-
Gastropoda	118	17	16	Total	1518	156	87

Most researchers accept that the period of eutrophication began in the early 1970s. This period was characterized by structural and functional changes in the Black Sea ecosystem, in consequence the local and global "blooms" of phytoplankton became more frequent, more continuous and covered a larger area (Prodanov, Dencheva, Ivanov, 1993). Besides the "blooms" are often followed by oxygen deficit and death of bottom and near-bottom organisms (Salsky, 1977; Zaitsev, 1977 - according to Zaitsev, 1993; Moncheva, 1991, 1992; Moncheva, Petrova-Karadjova and Palasov, 1993; Konsulova, Konsulov and Moncheva, 1990; Konsulova, 1991 - in press), especially in the narrow shore zone. In some cases even the pelagic species, such as anchovy and horse mackerel, are being influenced by the hypoxia (Zaitsev, 1993). According to the same author, the surface of the temporary acting anaerobic zones shows a tendency to increase (**Table 15)**.

TABLE 15. The surface area of anoxic zone (x 10^{-3} km^2) in the north-western part of the Black Sea

Years	Surface area	Years	Surface area	Years	Surface area
1973	3.5	1979	15.0	1985	5.0
1974	12.0	1980	30.0	1986	8.0
1975	10.0	1981	17.0	1987	9.0
1976	3.0	1982	12.0	1988	12.0
1977	11.0	1983	35.0	1989	20.0
1978	30.0	1984	10.0	1990	40.0

According to Zaitsev (1993) biological losses from a hypoxia over an 18 year period (1973-1990) are estimated over 60 million tonnes, including 5 million tonnes of fish (young and adult individuals).

During the period considered the anthropogenic pollution of the Black Sea has increased many times, the basin being historically burdened with a large anaerobic zone, as a result it has a small capacity for assimilating pollutants. That is why in Black Sea bottom fishes are rarely found to 100 m depth and pelagic and near-bottom fishes to 100-130 m (Prodanov, Dencheva and Ivanov, 1993).

The catchment area of the Black Sea is about 22 times greater than its surface. This is one of the main reasons for the quick contamination of the sea, in a consequence of intensification of industry and agriculture after 1960. By the end of the 1980s the river outflow to the sea annually has contained about 4-5 km^3 waste waters (about 5% of the total river inflow). Into the shelf zone enter annually an average of 400 thousand tonnes of biogenic substances, 410 thousand tonnes of petroleum products, 20 thousand tonnes of detergents, 700 tonnes of phenols. In accordance with the data of the State Hydrometeorology Service of the former USSR in 1970 (by Danube river) by the rivers in the Black Sea have penetrated 2.7 thousand tonnes nitrites and 16.5 thousand tonnes phosphates, and in 1979, correspondingly 13.5 and 27.0 thousand tonnes. Besides 180 thousand vessels with a total displacement of 12.5 million tonnes, coming through Bosporus, have polluted the sea additionally with about 12 thousand tonnes petrol (personal communication - academic Jakovlev - Director of JugNIRO). Similar estimates are given by Konovalov (1992). According to this author the Black Sea is polluted annually with about 100 thousand tonnes petroleum products, from which 40-50 thousand tonnes come through the Danube. The pollution of the sea with heavy metals and other chemical compounds (Marine Pollution '90, 1990) is considerable.

By the Danube into the Black Sea enter annually 60 tonnes mercury, 240 tonnes cadmium, 4000 tonnes lead, 900 tonnes chrome, etc. In relation to cuprous Black Sea is more polluted than the Mediterranean (2-3 times). The pollution of the sea with various chemical compounds (DDT, PVC, etc.) is very significant. Through the rivers Danube, Dnepr, Dnestr and South Bug into Black Sea come annually about 1200-5000 tonnes. According to UNEP most dangerous for the living organisms are the isotopes of radium, other nuclear fission products and mercury, followed by the pesticides, heavy metals, etc. (UNEP, 1986a, b, c; 1987). In comparison with the Mediterranean and Baltic seas, Black Sea is considerably more burdened by phosphates, nitrates, especially if having in mind the anaerobic zone. According to Konovalov (1992) these amounts are as follows: (**Table 16**).

As it is known, the most important influence on the marine ecosystems belongs to the phosphates, nitrates and calcium compounds that are the reason for growing old of water bodies (Vollenweider, 1976). Most influenced in this connection is the north-western part of the Black Sea, as far as by the above-mentioned rivers comes into the sea a great amount of nitrogen and phosphorus, which are transferred to the Bulgarian coasts by the currents characteristic of this region. In this connection the Bulgarian zone is more polluted by waters from the north-western part of the sea than from its own pollutants, for the exception of some coastal regions (near Varna and Burgas).

TABLE 16. Amounts of phosphates and nitrates (in tonnes per km^2) in the Black Sea, Mediterranean and Baltic Sea

Chemical compounds	Black Sea	Mediterranean	Baltic Sea
Phosphates	153842.5 0.286 (2.85*)	384606.0 0.102	82415.0 3.8 (0.19*)
Nitrates	437.5-875.0 8.1-16.2**	1093.0-2187.0 0.291-0.582	234.4-468.0 10.85-21.0

Note:* -the predicted value for the amount of phosphorus in the Baltic sea is in accordance with the international programme for control over phosphates, coming into sea (International Programme for phosphorus control on the Baltic).

** -the amounts of phosphorus and nitrogen are calculated for the volume of the aerobic zone of the Black sea.

The intensification of fishery after 1976, particularly the late forbiddance of bottom trawl-auls,which ruined the bottom biocenosis and spoiled the connections between bottom and pelagic waters, influenced negatively the state of the Black sea ecosystem. Schematically represented the most important changes which happened are the following:

- quantitative and qualitative decreasing of microphytobenthos, especially in the north-western part of the sea;
- increasing of continuity, intensity and regularity of "blooming" of phytoplankton;
- reducing of biodiversity, concentration and biomass of zoobenthos, as a result of regular and mass death, following, as usually occurs, the "blooming" of phytoplankton, as well as the mass development of new species, mainly the *Rapana thomasiana*, which is a predator of the black mussel *Mytilus galloprovincialis.* The concentrations of Rapana fell down many folds after its mass catch began, which was a favourable condition for increasing the biomass of the black mussel;
- the increasing of concentration and biomass of some stable species zoobenthos, mainly Polychaeta and Nematoda, is not able to compensate the dropping down of the total biomass, because besides the decreased biomass of the black mussel (in the 1960s it is about 10 million tonnes in the north-western part of the sea) the oyster *Ostrea edulis*, which abundance by the end of the 1950s was 50 million individuals almost completely disappear (Zakutski and Vinogradov, 1967);
- changes in the concentration and biomass of some zooplankton species. The domination of species as *N. miliaris*, *A. clausi*, *P. polyphemoides* is a fact, indicating eutrophication of the sea;
- sharp reducing of biomass of small zooplankton (Copepoda), which is a basic food, either for planktivorous fishes or for the larvae and the juveniles of the other fish species;
- sharp decreasing of the concentration and biomass of most of the fish populations, especially the summer spawned pelagic species: anchovy and horse mackerel.

As it is already known, many fish species in the Black Sea undertake seasonal migrations for nourishing, wintering and reproduction, and on this account the pollution of the sea or the over fishing by any Black Sea country (mainly Turkey and the former USSR) leads to the total reduction of concentration and biomass of the corresponding species.

This defines the necessity to generalize the data of all Black Sea countries, for the purpose of distinguishing the influence of anthropogenic factors (including the fishery) and the so-called natural factors - global climatic and cosmic processes. For example, according to Petrova-Karadjova and Apostolov (1988), the biodiversity and the quantitative development of various phytoplankton groups depend on the solar activity. These changes in the trophic basis also influence the survival of new generations, and consequently affect the state of the stock of the corresponding species in the following years.

The Black sea is inhabited by 168 species, from which 144 are typically marine ones, and 24 diadromous or partly anadromous. Along the Bulgarian coast, as a result of a detail studying the ichthyological bibliography, 126 species of marine and diadromous fishes are indicated (Prodanov, Dencheva and Ivanov, 1993). The classification of fishes is given according to the modification done by Rass (1987).

From the marine species the objects of intense fishery are sturgeons, shad, anchovy, sprat, horse mackerel, whiting, gobies, turbot, spiny dogfish, Mugilidae, bonito, bluefish, mackerel, etc. Up to the beginning of the 1970s, bonito, blue fish, mackerel, which as from 1968 was already not found in the Black sea, for the exception of the Bosporus region, represented a certain importance from an economic point of view.

As it was pointed out (**Figure 1**), after 1979 the fish catches in the Black Sea sharply increased, reaching 797.5 thousand tonnes in 1988, then dropped again to 216.5 thousand tonnes in 1991. In 1992 they had a slight tendency to increase. The accidental decrease of catches after 1988 is mainly due to summer spawning fish species (anchovy and horse mackerel), in connection with the massive development of new species Ctenophora, which biomass was very high in 1989. For other fish species the negative changes are not so obviously expressed, and for some of them, as for the shad (data in advance), even an increase of catches is observed. In this connection we shall consider more precisely the commercially valuable fish species, their stock dynamics and the causes, which determine it, as well.