REMARKS ON THE BENTHIC ORGANISMS DIVERSITY OF THE NW BLACK SEA

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Abstract. Based on benthos samples collected in the framework of the EROS 21 Programme (7–28 May 1997, the 2nd leg of R/V "Prof. Vodyanitskyi") the paper presents the qualitative and quantitative structure of benthic communities from the NW Black Sea. Starting from the fact that the state of the benthic populations reflects faithfully the ecosystem disturbances, the '97 data compared with the '95 ones highlight once again the state of ecological crisis of the Black Sea. In the 22 stations 118 organism types were recorded, 106 of them being determined to species. The biodiversity was more reduced in 1997 than in 1995, zoobenthos similitude being just 56%. One cannot assume a drastic reducing of benthos diversity, the reducing/variation of the species number being due rather to the random, irregular distribution on the bottoms; in the two years 175 types of bottom organisms were recorded. Benthic specific diversity varies along the depth gradient increasing from the coastal shallow bottoms to 30-70 m bottoms, where it reaches the highest values, then decreasing towards the shelf break. General average densities of benthic organisms were higher in 1997 than in 1995 (about 191000 vs. 29000 sps.m^{-2}); in front of the mouths of rivers Dniestr and Dniepr the most numerous populations of worms and crustaceans were recorded. General biomasses as well as those of polychaetes increase from shallow zones toward the 30-50 m bottoms and then decrease significantly; unusual high biomass on the deeper bottoms (>100 m) is the result of dense populations of polychaetes *Neanthes succinea*. Higher densities of some populations in 1997 as well as the presence of species considered extinct or extremely rare in the last years in the Black Sea (e. g. Sponges *Suberites* and *Adocia*, the Gastropod mollusc *Calyptrea chinensis* or the Tunicata *Asciedella aspersa* and *Cione intestinalis*, etc.) are considered as a positive factor for the benthic communities, a signal of slight recovery of the ecosystems; however the *Phyllophora* red algae are in a precarious ecological state.

Key words: zoobenthos diversity, quantitative distribution, NW Black Sea

1. INTRODUCTION

At the end of the 1980-1990 decade the Black Sea changes and ecological crises, especially in its north-western sector were well outlined (Gomoiu, 1981, 1992; Tolmazin, 1985; Vinogradov and Flint, 1987). At the benthos level, which may be considered a true barometer of the ecological pressure, the changes have affected both the communities qualitative and quantitative structure as well as the populations dynamics. In the '50–'70 benthic populations have been minutely studied and known (Bacescu *et al.*, 1971; Zenkevich, 1963); at that time the NW Black Sea was considered a zone of high biodiversity and bioproductivity. As in a chain reaction released by the unlimited input of nutrients, escaped from the normal control of biogeochemical cycles and beyond the carrying capacity of the reference system, the detunings of benthos, as a final link, have had at least 3 major consequences (Gomoiu, 1992):

1. the drastic decrease of the phyto (macro)- and zoobenthic associations specific diversity and abundance (having as consequences the decrease of the natural biofilter strength and of water selfpurifying capacity, the diminution of food zones/sources of some fishes);

2. the exuberant development of a few opportunistic species populations (some aboriginal, other recently penetrating into Black Sea, with high ecological flexibility, apt to respond rapidly to the sudden changes of some state variables;

3. the increase of quantitative fluctuations of populations size.

After 1980 the studies of benthos from the NW Black Sea reduced in scope, especially due to the economical crisis of the riparian countries, which were no longer able to financially sustain cruises like the past ones. Thanks to the EROS-21 programme new and important data concerning the state of benthal ecosystems have been obtained (Gomoiu, 1997). These data allow a better understanding and a more accurate prognosis of the basin derangements/recovery.

The researches in the framework of the EROS Programme had as logistical support on sea the R/V "Prof. Vodyanitskyi", which performed complex international expeditions in 1995 and 1997; the collection of the benthos samples were done each year in the second leg of the expeditions, the first time in August 4–28, 1995 and the second one in May 7–28, 1997.

The results of the August 1995 researches compared with previous data (Bacescu *et al.*, 1971) reflect the precarious state of the benthal populations in the NW Black Sea (Gomoiu, 1997; Panin *et al.*, 1996). The 1997 studies bring new contributions to the knowledge of benthal ecosystems from the interest area, especially supplementing the biodiversity list; in discussing the 1997 results some comparisons with those from 1995 will also be made.

2. WORKING METHODS

During the second expedition, Leg 2 (May 7-28, 1997) of the R/V "Professor Vodyanitskyi" in the NW Black Sea, 25 stations were performed, out of which 22 are situated on the biotic bottoms (Fig. 1–Stations IV-1–IV-24). In order to have a better orientation on the benthos researches in the framework of EROS 21 Black

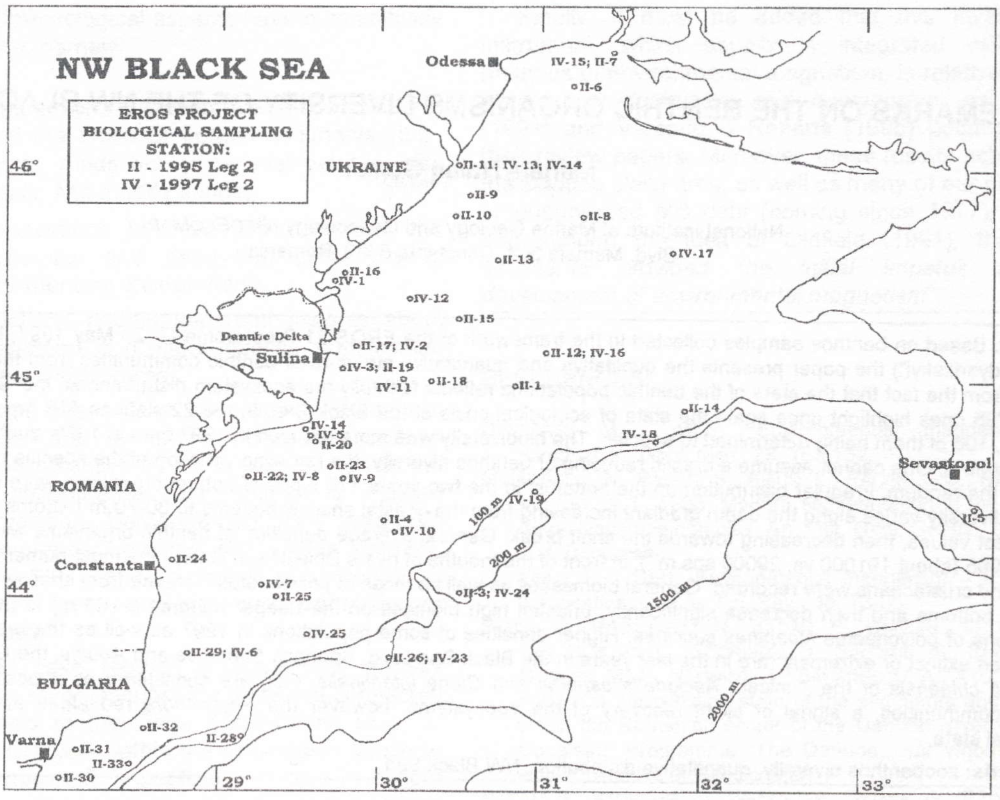

Fig. 1 Map of benthos station

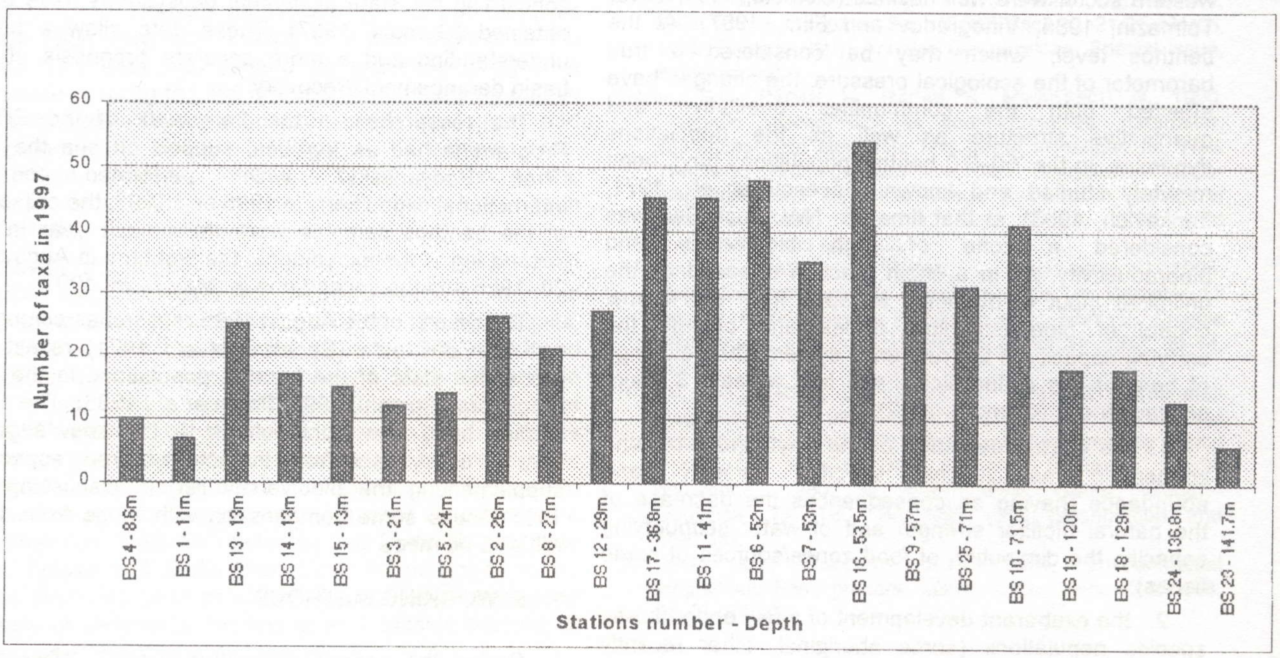

Fig. 2 Number of taxa found in the benthos stations
(ordered along the depth gradient)

Sea Programme, the position of stations performed in August 1995, have also been inscribed on the map (Figure 1–Stations II-1–II-33) in the research area the stations have an uneven distribution (Table1).

Sampling

The relatively small number of stations planned on the biotic bottoms from the NW Black Sea determined us to collect in each station as many samples as possible. Usually, the benthos samples have been taken from the sea bottom with the help of two devices: box-grab (S=1/6.25 m^2, h=60 cm) and multi-corer (with four sampling tubes–S=1/133 m^2, h=60 cm).

Several undisturbed sediment subsamples have been taken from the box-grab:

– with plastic boxes (S=1/250 m^2, h=2cm, colloquially named Micro (Table 1; m), especially for Foraminifera and Ostracoda studies;

– with a cylindrical plastic bottle with cut off bottom named "Bucov" (S=1/172 m^2, h=10-12 cm) (Table 1:B).

For a better information on the zoobenthos structure we also used the samples taken by dr. Jana Friedrich (Switzerland) from her benthic flux experiment chamber of the "Lander" (S=1/24.5 m^2, h=20 cm) (Table1: L) and by Jeroen Wijsman (The Netherlands) from its deck incubation tubes measuring the oxygen flux into the sediment thickness. The sediment from these tubes (colloquially named Incub – Table 1: I), taken from the large box-grab were sliced at 2 cm intervals and offered us to be analyzed on the fauna composition.

In the 22 benthos stations 78 samples were taken, many of them duplicates, so we obtained a total of 106 different subsamples. The samples were stained with Congo Red, preserved in 4% formaldehyde and stored in plastic bags.

Processing

In the laboratory the analyses of the zoobenthos samples have been carried out as follows:

– the content of each plastic bag was discharged (for short interval – 30-60 minutes) into a plastic basin containing tap water; this operation is done in order to soften the material and to prevent the possible damages of the water jet during the washing of the tiny meiobenthic organisms;

– washing of the sample through three sieves–1 mm, 0.250 mm and 0.100 mm mesh size – in order to remove the mud and to separate macro- and meio-zoobenthos; the washing was done slowly, stirring very gently by hand to prevent the damaging or loss of animals, and using a single fresh (tap) water jet from a low pressure hose; the sieve was gently shaken in water so that a flow occurred from below and thus the animals were obtained in good conditions;

– all the material retained by the three sieves has been examined by the binocular microscope; all animals were extracted, using fine tweezers and the species or group of species were identified and counted (in order to determine the density of populations); the larger organisms were measured and weighed (for size class, structure and biomass); for smaller organisms, the average wet weights inscribed in standard tables were used to calculate the biomass;

– all the numerical results concerning the occurrence of species and the number and weight of organisms in samples were processed computing (Excel 7.0 or Surfer 5.01 softwares) the following parameters:

1. Constancy or Frequency (F%) – or continuity of appearance indicating the frequency of the species in the studied area or associations;

2. Average density or biomass (D_{avg}, B_{avg}), calculated to one square meter for stations as a basic data, and then for depth or depositional zones; the biomass is expressed as total wet weight (referring to the whole organism, including shells or other hard parts of the body);

3. Dominance (D%) – or relative abundance, indicating the percentage of the number (D_D) or biomass (D_B) of the individuals belonging to a species or to a group of species from the total number or biomass of all species individuals in the samples from the studied area;

4. Index of ecological significance (W) – representing the relation between the constancy and abundance (density or biomass) reflects in a complex way the importance of each species in the community or association, permitting to rank the species into a hierarchy (R_{1D}, R_{2D} ...R_{1B}, R_{2B}...);

5. Shannon indices of diversity – H, H_{max} – index of maximum possible diversity in the sample and H_p – which is H/H_{max};

6. Index of similarity (Sørensen) – reflects the degree of resemblance between communities from different stations or zones;

Results and discussions

In 1997, as in 1995, the benthos stations performed in NW Black Sea have an uneven distribution in the research area, both as "covering" of different bathymetric zones and as "covering" the depositional systems (Figure 1). Thus a better "coverage" with stations is realized in the depth intervals of 8-20 m, 20-30 m, 50-60 m and 120-150 m and on the following depositional systems: Danube Delta Front and Prodelta (where one station could be representative for about 900 km^2) and Continental shelf edge (1 station/375 km^2); Dniestr and Dniepr mouth zones (1 station/4366 km^2) and especially the Continental shelf (1 station/7577 km^2) are very scarcely covered by stations (Table 1), the total lack or scarcity of stations should be mentioned for the following depth intervals: 30-50 m, 60-70 m, 80-120 m and 150-200 m; future investigations should take into consideration this bottom less studied in the last years.

On the biotic bottoms from NW Black Sea, 118 organism types were found in 1997, only 107 being determined to the species (Table 2). The most important organisms by their high frequency (euconstant forms) and numeric dominance are the Nematoda and Copepoda-Harpacticoida groups, which can not be sorted easily by species without a good specialist determination. Although our list of organisms contains only 90% taxa at the species level and 10% taxa at the supra-specific level (Table 2), in this paper discussing about diversity both species and groups will be equally considered.

Table 1 List of benthos stations performed in May 1997 on different depositional systems/zones from NW Black Sea.

Depositional zones	Surface		St. no. BS 97 -	Coordinates		Water depth m	Samples - Samplers)*: m B I M L	Living macrofauna observed on board direct in samplers:
	km²	%		Latitude N	Longitude E			
Danube Delta Front	1300	1.7	1	45°30.621	29°42.831	11.0	+ + + - -	Polychaeta worms
			2	45°12.169	29°50.787	26.0	+ + + + +	Polychaeta worms
			3	45°04.827	29°46.847	21.0	+ + - - -	Polychaeta worms
			4	44°46.160	29°33.605	8.6	+ + - - -	*Corbula, Mya, Ampelisca, Balanus*, worms
			5	44°45.062	29°34.687	24.0	+ + + - -	Polychaeta worms
Danube Prodelta	6000	8.0	8	44°35.036	29°11.318	27.0	+ + + + +	*Mya, Cardium, Balanus*
			9	44°34.357	29°46.067	57.0	+ + - + -	*Mytilus galloprovincialis*
			11	45°02.657	30°09.494	41.0	+ + - + -	*Mytilus galloprovincialis, Obelia*, worms
Dniestr Mouth	9300	12.4	13	46°02.934	30°29.360	13.0	+ + + + +	*Mya, Cardium, Balanus, Suberites*
			14	46°02.512	30°29.133	13.0	+ + - + -	Polychaeta, hard bottom
Dniepr Mouth	3800	5.1	15	46°32.984	31°25.099	13.0	+ + + + -	*Mya arenaria*, Polychaeta worms
Sediment Starving Continental Shelf	38600	51.6	12	45°25.537	30°11.687	29.0	+ + + + -	*Mytilus,. Obelia, Ampelisca*
			17	45°37.694	31°48.074	36.8	+ + + - -	*Mytilus, Amphiura, Phyllophora* – few small and thin branches
			16	45°09.730	31°02.960	53.5	+ + + + +	*Modiolus phaseolinus*, Sponges
			10	44°17.961	30°04.935	71.5	+ + - + -	*Modiolus phaseolinus*
			25	43°47.752	29°27.667	71.0	+ + - + -	*Modiolus phaseolinus*
Continental Shelf Danube Influenced	14300	19.1	6	43°44.919	28°47.935	52.0	+ + + + -	*Mytilus galloprovincialis*
			7	44°03.329	29°15.442	53.0	+ + + - -	*Mytilus galloprovincialis, Calyptrea*
Continental Shelf Edge	1500	2.0	18	44°43.800	31°41.959	129.0	+ + + + -	*Modiolus, Ciona intestinalis*
			19	44°29.456	30°59.512	120.0	+ + + + -	No living organisms in the box-grab; *Modiolus* in one tube of M
			23	43°41.883	30°03.517	141.7	+ + - - +	No living organisms
			24	44°00.451	30°29.179	136.8	+ + + + -	*Obelia, Sycon* on *Modiolus* shell
Total	**74800**	**99.9**					**78 samples**	

)* m – Micro; B – Bucov; I – Incub; M – Multicorer; L – Lander.

The number of taxa varies from one station to another (Fig. 2). Taking into consideration the whole qualitative structure of benthic communities, the similarity among the stations is rather low (Fig. 3); nuclei of higher resemblance are as follows:

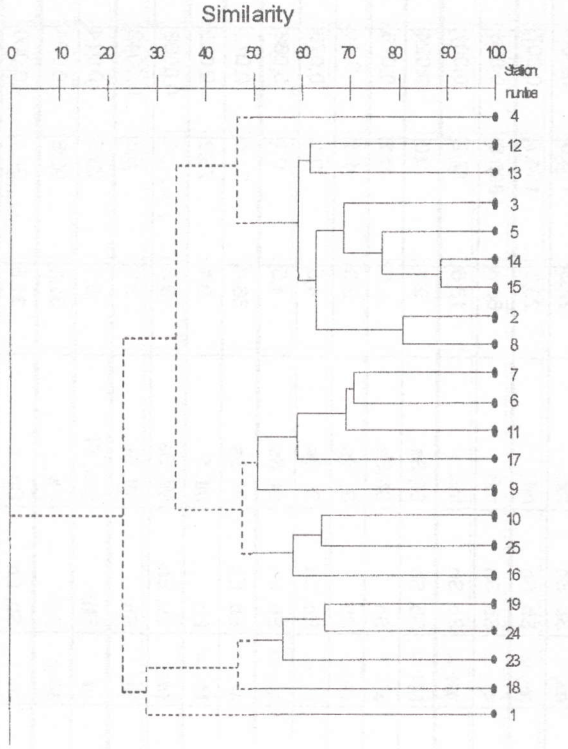

Fig. 3 Similarity (%) between the zoobenthos structure in different stations performed in May 1997 on NW Black Sea bottoms

– St. 14-15, situated in front of the rivers Dniestr and Dniepr;

– St. 2-8, under Danube influence;

– St. 6-7, located on the Continental shelf under the influence of the southward drift of Danube-borne sediments;

– St. 18-19 – 23-24, near the Continental shelf edge.

As a general rule, the factor controlling the similarity between benthic communities depends on the similarity between the depth of stations. Similarity linkage between St. 1-11 m and the group at deeper than 120 m stations is totally accidental, having an explanation by the common occurrence of the euribathic species *Obelia longissima*, Nematoda (? – undetermined to species) and *Capitella capitata*.

The analytical parameters, computed taking into account all stations (Table 2) demonstrate that on the NW Black Sea bottoms only few types of organisms seem to be relevant for the benthic ecosystems.

Constancy of species. Euconstant forms (found in 75.1-100% of stations) are only Nematoda worms, the Polychaeta *Capitella capitata* and Copepoda–Harpacticoida; constant species (50.1–75%) are the Foraminifera *Ammonia beccarii, Nonion depressulum* and *Cribroelphidium poeyanum*, the Polychaets worms *Neanthes succinea, Heteromastus filiformis* and *Clymene collaris* and Oligochaeta worms; accessory species (25.1–50%)–*Ammonia tepida, Fissurina lucida, Elphidium ponticum, Protelphidium subgranulosus* among Foraminifera, the Hydroida *Obelia longissima*, than a row of Polychaeta worms–*Melinna palmata, Protodrilus flavocapitatus, Aonides paucibranchiatus, Polydora ciliata, Nereis zonata* etc., *Mytilus galloprovincialis* and *Mya arenaria* among the Molluscs, *Cytheroma variabilis, Apseudes ostroumovi, Ampelisca diadema* etc. among Crustacea.

Abundance. Abundance of different populations of organisms varies between very large limits, e. g. from some specimens to hundreds of thousands specimens per sqm weighting from a few milligrams to hundreds of grams. Taking into account the total abundance of benthic organisms in NW Black Sea, the general dominance of each species/group was computed; at the same time the average densities and biomass were established (Table 2).

Dominance must be separately discussed for densities and for biomasses. Numerically eudominant (>10%) are only the euconstant forms–Nematoda and Copepoda-Harpacticoida, which represent more than 83% of the average density; there are no dominant forms (5.1–10%); the most important as sub-dominant species (2.1–5%) are the Polychaeta worm *Capitella capitata*, the Tanaidacea crustacean *Apseudes ostroumovi* and the Tunicata *Cyona intestinalis*; recedent taxa (1.1–2%) are the Foraminifera *Cribroelphidium poeyanum* and Olygochaeta worms; the most numerous forms are subrecedent (<1.1%) (Table 2).

Referring to biomasses, there is only one species eudominant–*Mytilus galloprovincialis*; dominant species are the Polychaeta worms *Neanthes succinea, Melinna palmata* and *Terebellides stroemi*, the Mollusca *Modiolus phaseolinus* and *Mya arenaria*; some other species are subdominant (*Cardium edule, Balanus improvisus, Cyona intestinalis* and *Ctenicella appendiculata*).

Ranking the index of ecological significance we can observe that the first 12 species the most important numerically in NW Black Sea are the meiobenthic ones (Nematoda, Harpacticoida, some Polychaeta, Foraminifera and Tanaidacea). The most important as biomass usually are the macro-benthic forms (Mollusca, large size Polychaeta, *Balanus improvisus*–Fig. 4).

In 1997, in comparison with 1995, the species ranked in the first 12 top are only half in the numerical classification and 66% in biomass classification, but while the densities are much higher in 1997, the biomasses are usually much lower, even the species do not keep their position in both years. Changes recorded in 1997 versus 1995 can also be observed from the major taxonomic structures of densities–high increase in the contribution of Worm and Crustaceans var. (Copepoda–Harpacticoida), decrease of Foraminifera, Mollusca and Ostracoda – for biomasses, severe decrease in the contribution of Mollusca and high increase of Polychaets and Crustaceans var. (Amphipoda, Isopoda, Cirripedia etc.) (Fig. 5).

Table 2. Taxonomical and ecological parameters characterizing benthic populations from NW Black Sea (including some species found in 1995)

Phylum / Class	Subclass/Order	Species	Ecology			F%	D_{avg} sps/m^{-2}	B_{avg} g/m^{-2}	D_D%	D_B%
Protozoa / Reticularea	Granuloreticulosia / O. Foraminiferida	*Fissurina lucida*	m	Eb, Eh	mf	40.9	325.1	0.015	0.170	0.0094
		Fissurina fragilis	m	Eb, Eh	mf	13.6	19.2	0.001	0.010	0.0006
		Esosyrinx jatzkoi	m	Sb, Sh	mf	18.2	45.9	0.002	0.024	0.0013
		Lagena vulgaris	m	Sb, Sh	mf	18.2	246.6	0.012	0.129	0.0073
		Laryngosygma williamsoni	m	Sb, Sh	mf	22.7	29.7	0.001	0.016	0.0009
		Ammonia beccari	m	Sb, Sh	mf	72.7	4025.5	0.187	2.105	0.1185
		Ammonia tepida	m	Sb, Sh	mf	50.0	1736.9	0.080	0.908	0.0505
		Cribroelphidium poeyanum	m	Sb, Sh	mf	54.5	1969.1	0.092	1.030	0.0582
		Elphidium haagensis	m	Sb, Sh	mf	9.1	43.3	0.002	0.023	0.0012
		Elphidium ponticum	m	Sb, Sh	mf	36.4	2006.0	0.092	1.049	0.0582
		Elphidium pulvereum	m	Sb, Sh	mf	13.6	304.0	0.015	0.159	0.0092
		*Elphidium incertum**	m	Sb, Sh	mf	3.3	3.9	0.0002	0.013	0.0001
		Protelphidium subgranosus	m	Sb, Sh	mf	27.3	113.8	0.005	0.060	0.0032
		*Protelphidium martcobi**	m	Sb, Sh	mf	23.3	154.7	0.007	0.526	0.003
Protozoa / Reticularea	Granuloreticulosia / O. Foraminiferida	*Nonion depressulum*	m	Sb, Sh	mf	63.6	1898.0	0.088	0.992	0.0554
		Nodosaria calomorpha	m	Sb, Sh	mf	13.6	17.2	0.001	0.009	0.0005
Porifera	O. Heterocoela	*Sycon ciliatum*	M	Sb, Sh	Sf, Ss	9.1	0.0	0.024	0.000	0.0153
	O. Haplosclerida	*Haliclona cinerea***	M	Sh	Sf, Ss	4.5	0.1	0.076	0.000	0.0479
Porifera	O. Haplosclerida	*Haliclona implexa**	M	Sh	Sf, Ss	3.3	1.1	0.44	0.004	0.192
	O. Hadromerida	*Suberites domuncula ***	M	Eb, Sh	Sf, Ss	4.5	0.1	0.076	0.000	0.0479
		*Suberites carnosus***	M	Eb, Sh	Sf, Ss	4.5	0.1	0.038	0.000	0.0240
Coelenterata	O. Hydroida	*Obelia longissima*	M	Eb, Eh	Pf, Ss	36.4	21.4	0.017	0.011	0.0109
Hydrozoa	O. Actinulida	Actinulida varia**	M	Eh	mf, S	9.1	78.2	0.008	0.041	0.0049
Anthozoa	O. Actinaria	*Actinothoe clavata**	M	Eb, Eh	Mf, Ss	3.3	1	0.0008	0.003	0.0001
	O. Ceriantharia	*Pachycerianthus solitarius**	M	Eh	Mf, Ss	3.3	5.3	0.0042	0.018	0.002
Plathelminthes	O. Neorhabdocoela	*Monocelis lineata***	m	Eh,	Cm, Sf	9.1	23.5	0.014	0.012	0.0089
Turbellaria	?	Varia	M-m	?	Vs	31.8	92.8	0.004	0.049	0.0023
Kinorhynchida	O. Cyclorhagida	*Pycnophies ponticus***	m	Sb, Eh	Cm, I	31.8	94.1	0.000	0.049	0.0002

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Phylum / Class	Subclass/Order	Species	Ecology			F%	D_{avg} sps/m^{-2}	B_{avg} g/m^{-2}	D_D%	D_B%
Nematoda	?	*Enoplolaimus conicus**	m	Eh	S	10	23.4	0.0001	0.08	0.0001
		*Enoplus euxinus**	m	Eh	S	26.7	26.9	0.0001	0.092	0.0001
		*Chromadorella pontica**	m	Eh	S	3.3	19.7	0.0001	0.067	0.0001
Nematoda	?	Varia	m	?	mf, S	100.0	128115.5	0.223	66.990	0.1410
Nemertini	O. Heteronemertini	*Micrura aurantiaca***	M-m		C, S	4.5	6.0	0.021	0.003	0.0134
		*Micrura fasciolata**	M-m		C, S	6.7	4	0.0108	0.014	0.005
		*Carinina heterosoma**	M-m		C, S	3.3	9	0.0317	0.031	0.014
	O. Hoplonemertini	*Tetrastemma melanocephalum***	M-m		C, S	4.5	2.0	0.001	0.001	0.0006
	?	Varia	M-m		C, S	31.8	33.9	0.053	0.018	0.0338
Polychaeta	O. Phyllodocida	*Phyllodoce lineata*	M-m		mf, I	36.4	59.2	0.207	0.031	0.1311
		*Phyllodoce mucossa**	M-m		mf, I	3.3	1.1	0.0009	0.004	0.002
		Phyllodoce maculata	M-m		mf, I	18.2	30.7	0.107	0.016	0.0678
		Harmothoe reticulata	M-m		mf. I	22.7	15.5	0.009	0.008	0.0059
		*Harmothoe imbricata***	M-m		mf, I	4.5	2.0	0.001	0.001	0.0008
		Polynoe scolopendrina	M		mf	18.2	12.2	0.007	0.006	0.0046
		*Syllis hialina***	M-m		C	27.3	98.7	0.079	0.052	0.0500
		*Syllis variegata**	M-m		C	3.3	1.1	0.0009	0.004	0.0001
		*Sthenelais boa**	M-m		C	6.7	1.7	0.0011	0.006	0.0001
		*Grubea clavata***	M-m		C	13.6	28.6	0.009	0.015	0.0054
		*Grubea limbata***	M-m		C	9.1	12.4	0.004	0.007	0.0024
Polychaeta	O. Phyllodocida	*Grubea tenuicirrata***	M-m		C	18.2	49.0	0.015	0.026	0.0093
		*Sphaerosyllis hystrix***	M-m		C	4.5	9.6	0.008	0.005	0.0049
		*Sphaerosyllis bulbosa***	M-m		C	18.2	73.5	0.023	0.038	0.0145
		Exogone gemmifera	m			13.6	98.6	0.079	0.052	0.0499
		*Eteone picta***	M-m			22.7	20.0	0.001	0.010	0.0005
		*Eulalia sanguinea***	M-m			4.5	6.0	0.004	0.003	0.0023
		*Lagisca extenuata**	M			3.3	3.3	0.002	0.011	0.001
		*Nereis rava**	M		CM, S	40	159.6	1.5945	0.543	0.694
		*Nereis costae**	M		CM, S	6.7	2.1	0.021	0.007	0.009
		*Nereis pelagica**	M		CM, S	3.3	1.8	0.018	0.006	0.008

Phylum / Class	Subclass/Order	Species	Ecology			F%	D_{avg} sps/m^{-2}	B_{avg} g/m^{-2}	D_D%	D_B%
Polychaeta	O. Phyllodocida	*Nereis zonata*	M		CM, Vs	45.5	343.8	1.972	0.180	1.2469
		Hediste diversicolor	M		CM, S	31.8	105.7	2.269	0.055	1.4349
		Neanthes succinea	M		CM, D, S	59.1	1444.3	14.442	0.755	9.1324
		Nereis longissima	M		CM, S	4.5	7.7	0.001	0.004	0.0004
Polychaeta		*Platynereis dumerilii**	M		CM, S	6.7	1	0.0022	0.003	0.001
		*Perinereis cultrifera**	M		CM, S	6.7	26.3	0.0158	0.089	0.016
		*Nereidomorpha sp.***	m			4.5	15.4	0.154	0.008	0.0973
Polychaeta	O. Phyllodocida	*Nephthys hombergi**	M		C, S	16.7	13.7	0.134	0.047	0.058
		Nephthys cirrosa	M	Sh	C, S	13.6	12.3	0.111	0.006	0.0703
		*Aricia estrulii**	m			3.3	3.3	0.0017	0.011	0.001
		*Aricia latreylii**	m			3.3	0.7	0.0004	0.002	0.0001
		*Theostoma capsulifera***	m			4.5	7.8	0.005	0.004	0.0030
	O. Spionida	*Scolelepis ciliata***	M-m		mf, S	13.6	13.8	0.004	0.007	0.0026
		*Aonides oxycephala***	M-m		Mf, S	4.5	15.6	0.109	0.008	0.0692
		*Aonides paucibranchiatus***	M-m		Mf, S	50.0	128.6	0.900	0.067	0.5692
		*Spio multioculata***	M-m	Sb, Eh	Sf, S	9.1	31.0	0.009	0.016	0.0059
		Spio filicornis	M-m	Sb, Eh	Sf, S	4.5	5.8	0.002	0.003	0.0011
		Polydora ciliata	M-m		Sf, mf, T	31.8	144.6	0.189	0.076	0.1193
		Prionospio cirrifera	M-m	Sb, Eh	Sf, S	4.5	2.6	0.018	0.001	0.0115
		*Magelona papilicornis**	M-m			3.3	1.2	0.0007	0.004	0.0001
		*Paraonis fulgens**	m		S	3.3	1.1	0	0.004	0.0001
Polychaeta	O. Spionida	*Paraonis gracilis***	m	?	S	4.5	4.0	0.028	0.002	0.0178
	O. Capitellida	*Heteromastus filiformis*	M-m		mf, S	59.1	488.7	0.420	0.256	0.2658
		*Notomastus lineatus***	M-m		Mf,I	4.5	4.0	0.003	0.002	0.0022
Polychaeta	O. Capitellida	*Capitella capitata*	M	Sh	Df	90.9	7298.2	1.072	3.816	0.6779
		*Clymene collaris***	m		mf, S	59.1	752.7	0.436	0.394	0.2760
Polychaeta	O. Terebellida	*Melinna palmata*	M	Eb, Eh	Df, T, S	50.0	380.7	13.925	0.199	8.8049
		*Pectinaria koreni**	M	Eb, Eh	Df, T, S	30	87.3	0.4415	0.297	0.192
		Terebellides stroemi	M		Df, T, S	31.8	158.9	14.304	0.083	9.0448
		*Polycirrus sp.***	m			4.5	3.0	0.021	0.002	0.0134

M.-T. Gomoiu - Remarks on the benthic organisms diversity of the NW Black Sea

Phylum / Class	Subclass/Order	Species	Ecology			F%	D_{avg} sps/m^{-2}	B_{avg} g/m^{-2}	D_D%	D_B%
	O. Sabellida	*Euchone rubrocincta*	M-m	Eh	S	4.5	30.2	0.018	0.016	0.0115
		*Oridia armandi***	M-m	Eh	S	9.1	49.8	0.022	0.026	0.0138
	?	Larvae*	m	Eh		50	409	0.0705	1.391	0.031
	?	Varia	m	Eh		9.1	16.4	0.010	0.009	0.0062
Archiannelida		*Protodrilus flavocapitatus*	m	Eb, Eh	mf, S	50.0	1034.6	0.930	0.541	0.5883
		Nerilla antennata	m	Sb,Sh	mf, S	9.1	45.4	0.027	0.024	0.0172
Oligochaeta		*Lumbricillus lineatus**	M-m	Eb	Df, D, S	53.3	347.6	0.0696	1.183	0.03
		Oligochaeta varia	M-m	?	Df, D, S	59.1	678.5	0.136	0.355	0.0858
Gastropoda	O. Mesogastropoda	*Cerithium vulgatum**	M	Eb, Eh	D	3.3	15.7	0.0016	0.053	0.001
		Calyptraea chinensis	M	Sb, Eh	D	4.5	0.1	0.005	0.000	0.0029
	O. Neogastropoda	*Nassa reticulata**	M	Eh	D	3.3	2.2	0.99	0.007	0.431
Gastropoda	?	Larvae*	m			26.7	80.2	0.0081	0.273	0.004
Bivalvia	O. Filibranchiata	*Scapharca cornea***	M	Sb, Eh	Sf, S	4.5	0.1	0.567	0.000	0.3587
		Mytilus galloprovincialis	M	Eb, Eh	Sf, S	36.4	47.2	49.194	0.025	31.1067
		*Modiolus adriaticus**	M	Eb, Eh	Sf	3.3	1.7	0.1133	0.006	0.049
		Modiolus phaseolinus	M	Eb, Eh	Sf	22.7	97.5	8.492	0.051	5.3696
	O.Eulamellibranchiata	*Cardium edule*	M	Eb, Eh	Sf, S	22.7	20.4	6.044	0.011	3.8220
		*Venus gallina**	M	Eb, Eh	Sf, S	3.3	4.4	0.044	0.015	0.019
Bivalvia		*Polititapes sp.***	M	Eb, Eh	Sf, S	4.5	1.0	1.511	0.001	0.9557
		*Spisula subtruncata**	M	Eb, Eh	Sf, S	3.3	1.1	0.814	0.004	0.354
		*Abra alba**	M	Eb, Eh	Sf, S	3.3	1.1	0.0132	0.004	0.006
		*Corbula mediterranea***	M	Sb, Eh	Sf, S	4.5	1.7	0.014	0.001	0.0091
		Mya arenaria	M	Sb, Eh	Sf, S	36.4	8.2	13.037	0.004	8.2435
	?	Larvae*	m			33.3	152	0.015	0.517	0.007
Phoronida		*Phoronis euxinicola**	M	Sb, Eh	Sf, S	6.7	2	0.0016	0.007	0.001
Crustacea	Ostracoda	*Carinocythereis rubra pontica*	m	Eb, Eh	D, S	27.3	64.1	0.004	0.033	0.0026
	O. Podocopida	*Carinocythereis carinata**	m	Eb, Eh	D, S	6.7	7.7	0.0005	0.026	0.0001
		*Callistocythere abjecta**	m	Eb, Eh	D, S	16.7	108.3	0.007	0.368	0.003
		Callistocythere crispata	m	Eb, Eh	D, S	4.5	34.1	0.002	0.018	0.0014
		Callistocythere diffusa	m	Eb, Eh	D, S	4.5	108.2	0.007	0.057	0.0044

Phylum / Class	Subclass/Order	Species	Ecology			F%	D_{avg} sps/m^{-2}	B_{avg} g/m^{-2}	D_D%	D_B%
Crustacea	Ostracoda									
	O. Podocopida	*Callistocythere flavidofusca**	m	Eb, Eh	D, S	3.3	7.7	0.0005	0.026	0.0001
		Cytheroma variabilis	m	Sb, Sh	D, S	40.9	841.8	0.053	0.440	0.0336
		*Cytheroma sp.**	m	Eb, Eh	D, S	3.3	19.3	0.0013	0.066	0.001
		*Cytheromorpha fuscata**	m	Eb, Eh	D, S	3.3	3.9	0.0003	0.013	0.0001
		*Levocytherura remanei**	m	Eb, Eh	D, S	3.3	27.1	0.0018	0.092	0.001
		Cyprideis littoralis	m	Eh, Sb	D, S	9.1	83.4	0.005	0.044	0.0034
		*Leptocythere devexa**	m	Eb, Eh	D, S	10	135.3	0.0088	0.46	0.004
		*Leptocythere lopatici**	m	Eb, Eh	D, S	6.7	7.7	0.0005	0.026	0.0001
		Leptocythere multipunctata	m	Eb, Eh	D, S	22.7	137.3	0.007	0.072	0.0045
		Leptocythere histriana	m	Sb, Sh	D, S	9.1	7.7	0.001	0.004	0.0003
Crustacea		*Semicytherura calamitica**	m	Eb, Eh	D, S	3.3	3.9	0.0003	0.013	0.0001
		*Loxoconcha aestuari**	m	Eb, Eh	D, S	3.3	3.9	0.0003	0.013	0.0001
		*Loxoconcha rhomboidea**	m	Eb, Eh	D, S	3.3	11.6	0.0008	0.039	0.0001
		Loxoconcha granulata	m	Eb, Eh	D, S	27.3	121.3	0.008	0.063	0.0049
		Paradoxostoma simile	m	Eb, Eh	D, S	9.1	13.5	0.001	0.007	0.0005
Crustacea	Ostracoda	*Sclerochilus gewemulleri*	m	Eb, Eh	D, S	4.5	5.7	0.000	0.003	0.0002
	O. Podocopida	*Xestoleberis cornelii*	m	Sb	D, S	31.8	88.6	0.006	0.046	0.0035
	Copepoda	*Harpacticus flexus*	m		mf, S	4.5	15.6	0.000	0.008	0.0002
		*Harpacticus gracilis**	m		mf, S	3.3	1.2	0.0001	0.004	0.0001
		*Tisbe furcata**	m		mf, S	3.3	1.7	0.0033	0.006	0.0001
	?	Varia	m		mf, S	95.5	32193.9	0.644	16.834	0.4072
	Cirripedia	*Balanus improvisus*	M	Sb, Eh	Sf, Ss	9.1	57.9	7.697	0.030	4.8670
	Tanaidacea	*Apseudes ostroumovi*	M	Sb, Sh	D, mf, S	40.9	1068.3	2.137	0.559	1.3511
	Cumacea	*Iphinoe elisae*	M	Eb, Eh	D, mf, S	40.9	124.9	0.052	0.065	0.0327
		*Iphinoe maeotica**	M	Eb, Eh	D, mf, S	6.7	1.9	0.0002	0.006	0.0001
		*Cumella limicola**	M	Eb, Eh	D, mf, S	3.3	1.1	0.0002	0.004	0.0001
		*Cumella pygmaea euxinica***	M	Eb, Eh	D, mf, S	18.2	38.6	0.006	0.020	0.0037
Crustacea		*Eudorella truncatula*	M-m	Eb, Eh	D, mf, S	13.6	24.6	0.006	0.013	0.0036
	Mysidacea	*Paramysis sp.***	M	Sh, Sb	mf, S	4.5	1.9	0.015	0.001	0.0097

Phylum / Class	Subclass/Order	Species	Ecology			F%	D_{avg} sps/m^{-2}	B_{avg} g/m^{-2}	D_D%	D_B%
	Isopoda	*Synisoma capito***	M	Eh, Eb	D, Vs	13.6	16.9	0.423	0.009	0.2678
	Amphipoda	*Apherusa bispinosa***	M	Sb	Vs	4.5	3.9	0.002	0.002	0.0012
		*Stenothoe monoculoides**	M			3.3	1	0.0006	0.003	0.0001
Crustacea	Amphipoda	*Orchomene humilis*	M	Sb	Vs	9.1	10.0	0.005	0.005	0.0031
		Ampelisca diadema	M	Eb, Eh	C/Df, T, Vs	36.4	207.5	0.987	0.108	0.6239
		*Microdeutopus gryllotalpa**	M	Sb, Eh	D, S	3.3	2.9	0.0059	0.01	0.003
		*Microdeutopus damnoniense***	M	Sb, Eh	D, S	31.8	109.7	0.177	0.057	0.1118
		*Stenogammarus sp.**	M	Sb, Eh	D, Vs	3.3	1	0.001	0.003	0.0001
		*Gammarus olivii***	M	Sb, Eh	D, Vs	9.1	61.8	0.056	0.032	0.0352
		*Corophium volutator**	M	Eb	D/Df, T, S	10	6.3	0.0025	0.021	0.001
		*Corophium nobile***	M	Eb	D/Df, T, S	18.2	58.2	0.042	0.030	0.0267
		*Erichthonius hunteri**	M	Eb	D/Df, T, S	3.3	0.8	0.0004	0.003	0.0001
		Caprella acanthifera	M	Eb, Eh	C, Vs	13.6	33.0	0.059	0.017	0.0375
		Phtisica marina	M	Eb, Eh	C, Vs	13.6	8.0	0.014	0.004	0.0087
	Decapoda	*Crangon crangon***	M	Sb	C, S	4.5	2.1	0.422	0.001	0.2668
Chelicerata	Acarina	*Halacarelus basteri affinis***	M	Eb, Eh	C, Vs	18.2	130.7	0.009	0.068	0.0058
		*Copidognathus magnipalpus***	M	Eb, Eh	C, Vs	4.5	9.1	0.001	0.005	0.0004
		*Copidognathus pectiniger***	M	Eb, Eh	C, Vs	9.1	10.0	0.000	0.005	0.0001
		*Copidognathus sp.**	M	Eb, Eh	C, Vs	3.3	3.1	0.0002	0.011	0.0001
		Varia**	M	Eb, Eh	C, Vs	22.7	305.2	0.021	0.160	0.0135
Chelicerata	Pantopoda	*Callipallene phantoma***	M-m	Sh, Eb	?	9.1	7.7	0.003	0.004	0.0017
Echinodermata	Holothurida / O. Apoda	*Leptosynapta inhaerens***	M	Sb, Eh	D, I	22.7	22.4	0.004	0.012	0.0028
		*Oestergrenia sp.***	M	Sb, Eh	D, I	4.5	3.0	0.001	0.002	0.0008
	Ophiurida / O. Ophiurae	*Amphiura stepanovi*	M	Sb, Eh	Mf, Sf	22.7	41.1	0.786	0.021	0.4967
Ascidiacea	O.Phlebobranchia	*Ascidiella adspersa***	M	Sb, Eh	Sf, S	4.5	0.2	0.014	0.000	0.0090
		*Cyona intestinalis***	M	Sb, Eh	Sf, Ss	9.1	2.2	4.850	0.001	3.0668
	O. Stolidobranchia	*Ctenicella appendiculata***	M	Sb, Eh	Sf, S	4.5	3.0	6.650	0.002	4.2050
		Molgula euprocta	M	Sb, Eh	Sf, Ss	4.5	2.9	0.866	0.002	0.5475

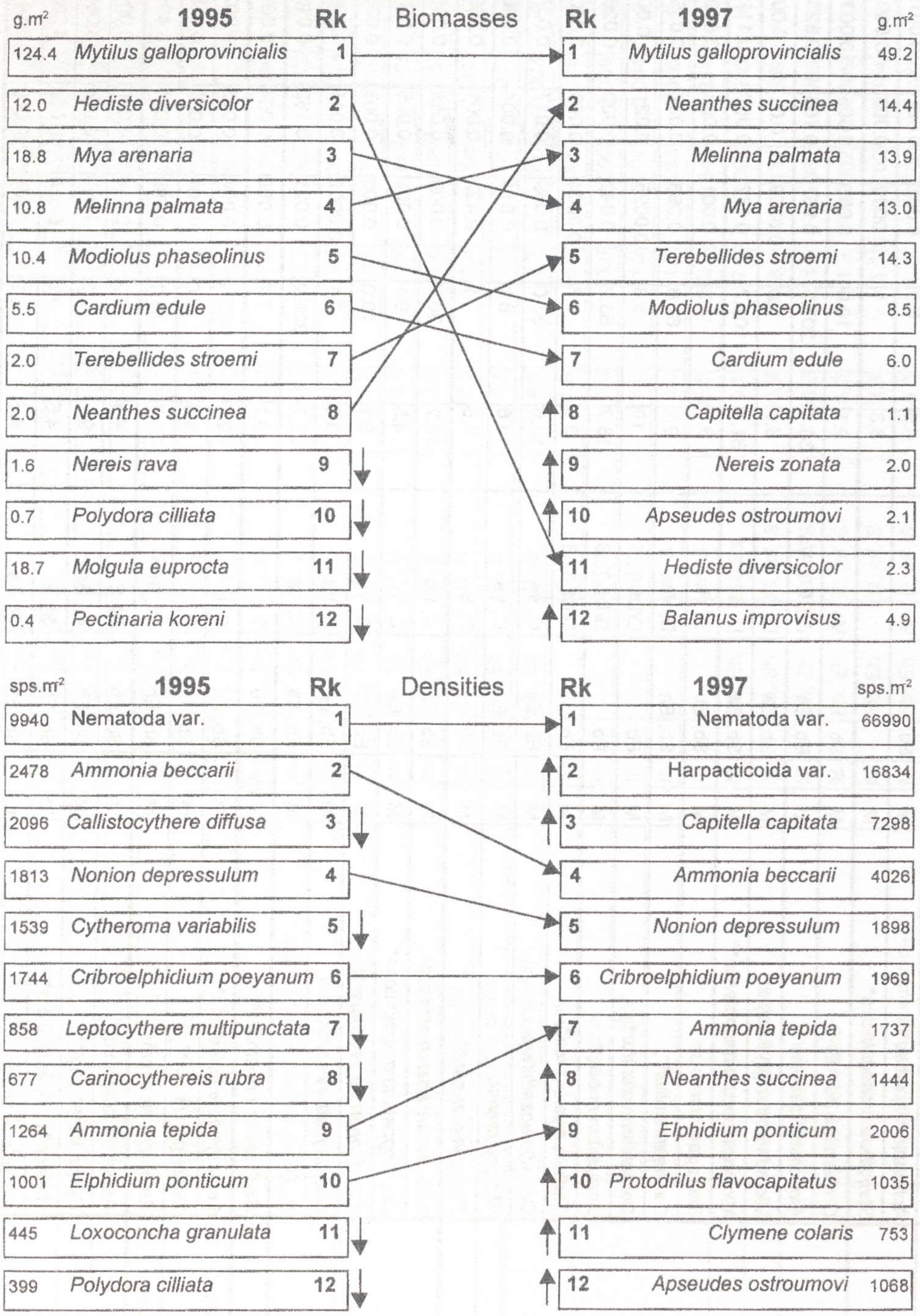


Fig. 4 Changes in the rank of benthic species in NW Black Sea from 1995 to 1997

Symbols of the Table 2:

C = carnivore	Sh = stenohaline organism	BC = basically carnivore	D_{avg} = average density
T = tubicole	Df = deposit feeder	Vs = various substrata	B_{avg} = average biomass
D = detritivore	Eb = eurybathic organism	CM = macrophagus carnivore	D_D% = dominance in densities
Ss = sessil	Eh = euryhaline organism	Cm = microphagus carnivore	D_B% = dominance in biomasses
I = iliophilous	Sb = stenobathic organism	? = No informations	* = species present in 1995, not found in 1997
S = sedimentophilous	Sf = suspension feeder	F% = constancy	** = species found in 1997 and absent in 1995

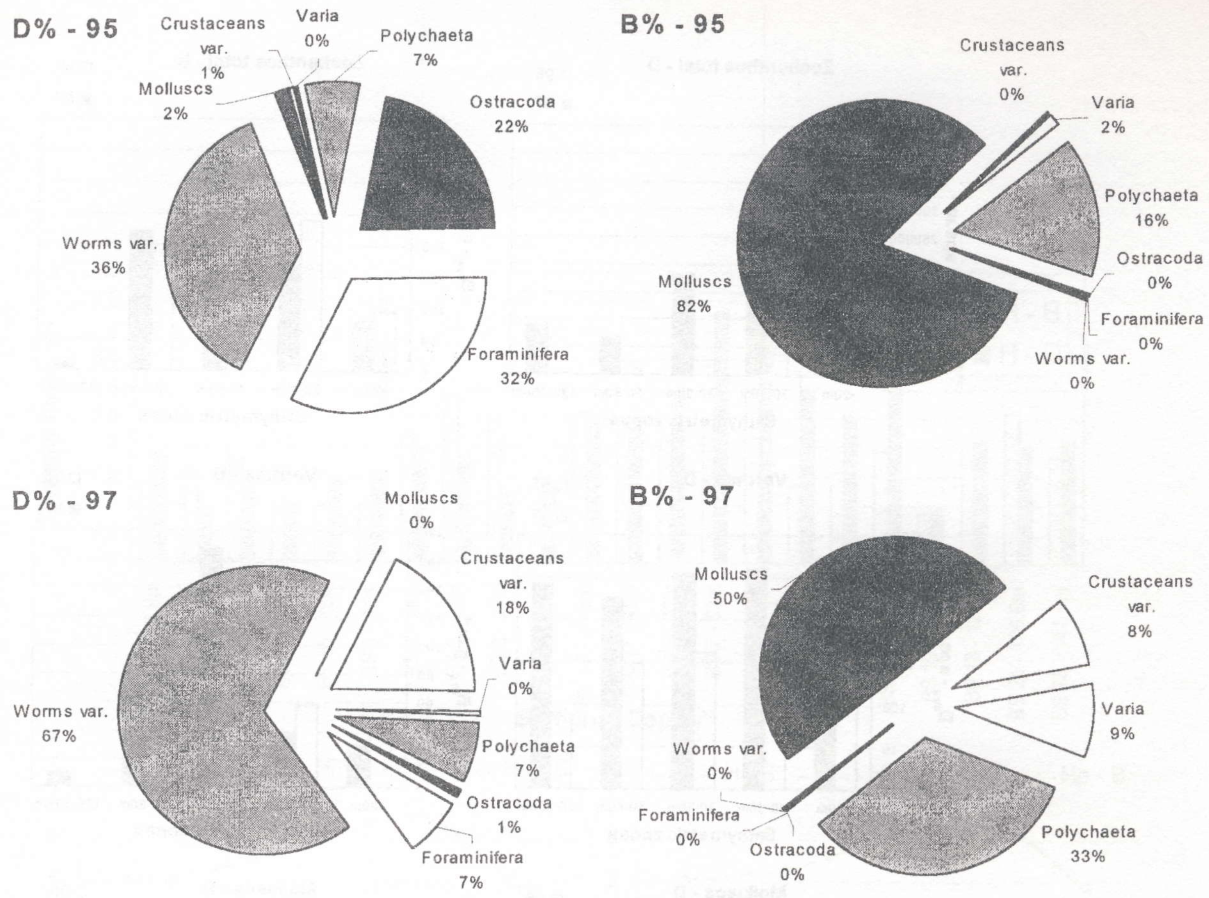


Fig. 5 Major taxonomic structure of densities (D%) and biomasses (B%) of benthic populations

Distribution of populations. From the general characterization of the benthic populations from the NW Black Sea bottoms, some remarks referring to their distribution in the research area are necessary.

Distribution on bathymetric zones. Coastal zones bottoms, less than 20 m depth, comprising 33 types of organisms, are dominated numerically by Nematoda (R_{1D} in the zone–about 300000 sps.m^{-2}), Harpacticoida (R_{2D}–86000 sps.m^{-2}) and the Polychaeta *Capitella capitata* (R_{3D}–10000 sps.m^{-2}) and ponderously by the Polychaeta *Neanthes succinea* (R_{1B}–20.7 g.m^{-2}), Mollusca *Mya arenaria* (R_{2B}–17.4 g.m^{-2}) and Cirripedia *Balanus improvisus* (R_{3B}–25.4 g.m^{-2}). The number of species varies from 7 (St. 1–in front of the Danube Delta) to 20 (St. 13–in front of the Dniestr mouth). The average density of zoobenthos in this shallow water zone is 411550 sps.m^{-2} (Fig. 6) being the highest average value for the NW Black Sea bathymetric zones. The individual values in the 5 stations representing the zone vary between 54028 sps.m^{-2} (St. 15–Dniepr mouth) and 695.728 sps.m^{-2} (St. 14–Dniestr mouth). The biomasses vary between 20.9 g.m^{-2} (St. 1) and 173.4 g.m^{-2} (St. 4, where the soft-shell clam *Mya arenaria* dominates by 80%), giving an average of 62.5 g.m^{-2}.

The most specific organisms in this shallow zone are *Capitella capitata, Neanthes succinea* and *Nereis zonata* among the Polychaeta worms, *Mya arenaria, Corbula mediteranea* and *Scapharca inequivalvis* among the Bivalvia.

The bottoms at 20-30 m were dwelled in May 1997 by 40 types of organisms; among them the most important as dominance are Nematoda (R_{1D}–141367 sps.m^{-2}), Harpacticoida (R_{2D}–29510 sps.m^{-2}), *Capitella capitata* (R_{3D}–12 898 sps.m^{-2}) and *Mya arenaria* (R_{1B}–36.2 g.m^{-2}), *Neanthes succinea* (R_{2B}–22.9 g.m^{-2}), *Mytilus galloprovincialis* (R_{3B} – 110.4 g.m^{-2}) etc. the number of species and their abundance in the 5 investigated stations vary as follows: 12 (St. 3) – 27 (St. 12) species, 54028 (St. 3) – 395694 (St. 8) sps.m^{-2} and 67.7 (St. 2) – 575.1 (St. 12) g.m^{-2}. The average abundance of the benthic organisms in the zone 20-3- m is 208695 sps.m^{-2} and 201.4 g.m^{-2} (Figure 6) the most characteristic components being *Mya arenaria, Cardium edule lamarcki* and *Mytilus galloprovincialis* among the Bivalvia, *Capitella capitata, Neanthes succinea, Nereis zonata, Hediste diversicolor* among the Polychaeta etc.

Bathimetric zone 30-50 m is difficult to be characterized after the data obtained only in two stations – St. 11, situated in Danube Prodelta depositional system and St. 17, located in the NE of Sediment starving continental shelf. In each of the two stations 45 taxa were found but the similarity between these stations is only 56%; there are in total 65 species, the most specific being *Capitella capitata* (13389 sps.m^{-2}), *Neanthes succinea* (3662 sps.m^{-2}), *Melinna palmata* (961 sps.m^{-2}), *Polydora ciliata* (541 sps.m^{-2}), *Terebellides stroemi* (731 sps.m^{-2}), *Syllis hyalina* (385 sps.m^{-2}) and *Hediste diversicolor* (22 sps.m^{-2}) among the Polychaeta and *Mytilus galloprovincialis* (54 sps.m^{-2} –

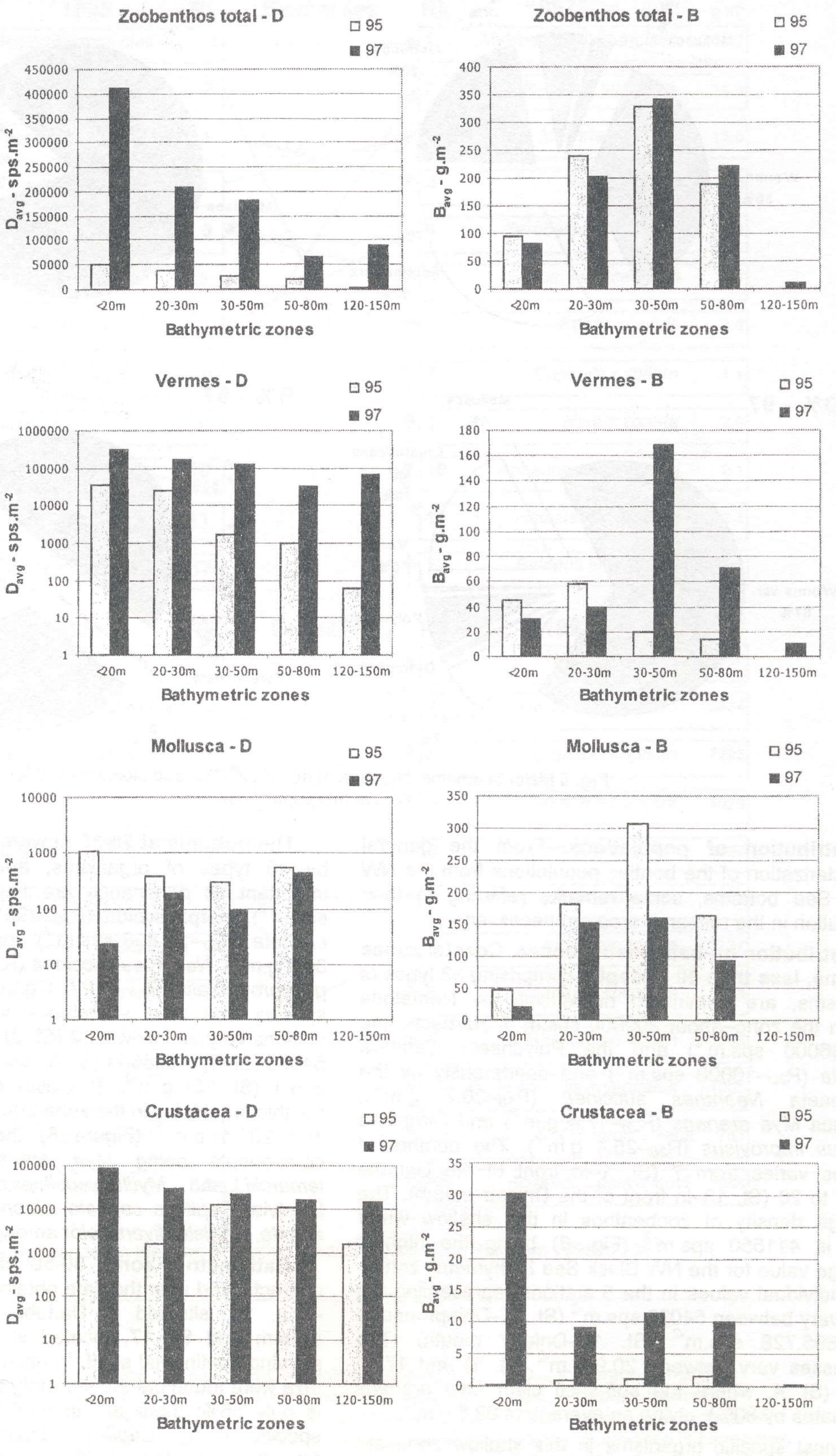
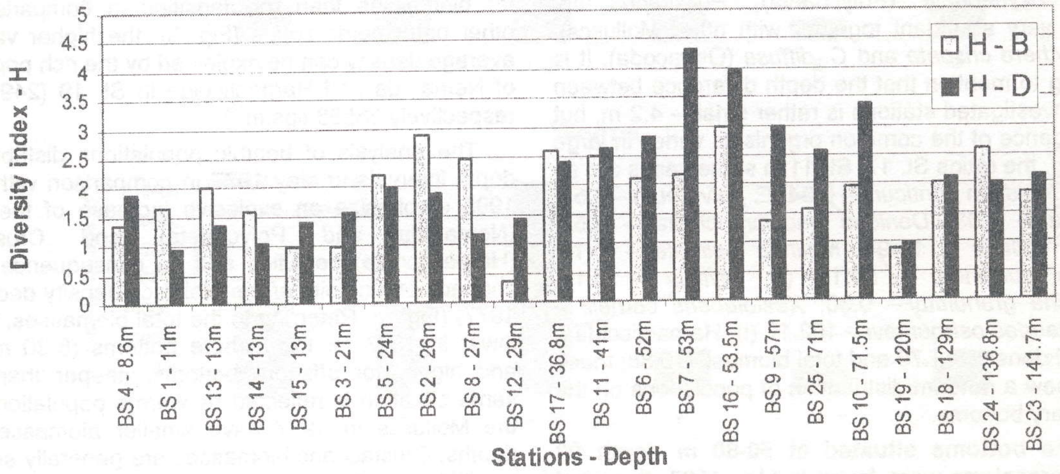


Fig. 6 Variations of average densities (D) and biomasses (B)



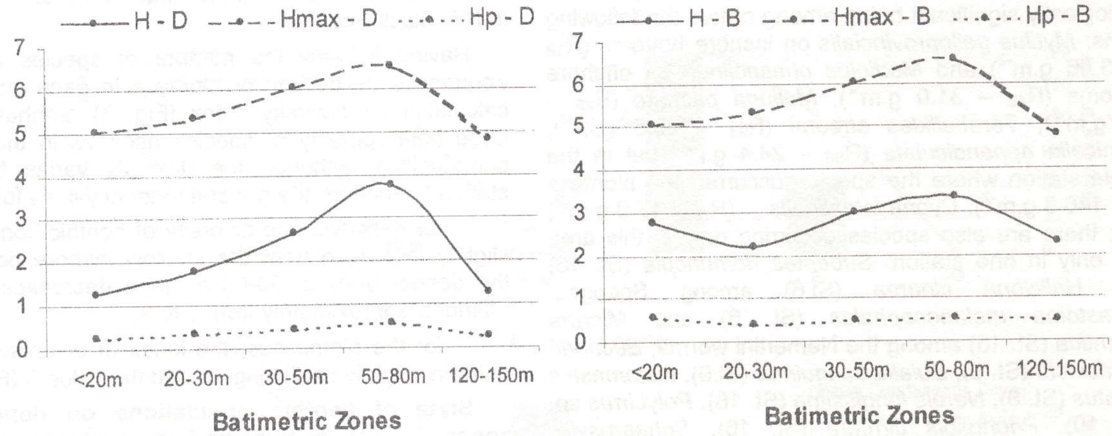


Fig. 7 Variations of Density (D) and biomass (B) diversity indices on depth gradient

105.7 g.m^{-2}), *Cardium edule lamarcki* (28 sps.m^{-2} – 37.7 g.m^{-2}) and *Polytitapes* sp. (11 sps.m^{-2} – 16.6 g.m^{-2}), among the Mollusca etc.; average values of the density and biomass are 181987 sps.m^{-2} and 343.2 g.m^{-2} (the highest mean biomass for the bathymetric zones, given by *Mytilus* and Polychaeta worms) (Fig. 6). It seems that at intermediate depths of 30-50 m the old nucleus of *Mytilus galloprovincialis* biocoenosis attracts some species, which have their singular occurrence only here: *Aonides oxycephala* (Polychaeta), *Polytitapes* sp. (formerly very abundant together with other Molluscs), *Callistocythere crispata* and *C. diffusa* (Ostracoda). It is interesting to mention that the depth difference between the two investigated stations is rather small – 4.2 m, but the abundance of the common organisms varies in large limits, e. g. the ratios St. 17: St. 11 in some cases are as follows: *Elphidium ponticum* – 0.34; *E. pulvereum* – 8.55; Nematoda – 2.03; *Donides paucibranchiata* – 4.52; *Clymene collaris* – 10-94; *Melinna palmata* – 0.10; *Neanthes succinea* – 85.16 (!); *Mytilus* – 0.17; *Loxoconcha granulata* – 0.30; *Xestoleberis cornelii* – 2.23; *Apseudes ostroumovi* – 102.17 (!); Harpacticoida – 0.46; total density – 1.79 and total biomass – 0.88; these figures show a random distribution of populations on the sedimentary bottoms.

On **the bottoms situated at 50-80 m depth** 93 types of organisms were found in May 1997, the most ecologically significant being among others the following forms: *Mytilus galloprovincialis* on inshore bottoms (R_{1B} – 53.06 g.m^{-2}) and *Modiolus phaseolinus* on offshore bottoms (R_{4B} – 31.0 g.m^{-2}), *Melinna palmata* (R_{2B} – 34.7g.m^{-2}), *Terebellides stroemi* (R_{3B} – 28.6 g.m^{-2}), *Ctenicella appendiculata* (R_{5B} – 24.4 g.m^{-2} but in the single station where the species occurred the biomass was 146.3 g.m^{-2}), *Cyona intestinalis* (R_{7B} – 17.0 g.m^{-2}) etc.; there are also species occurring only in this area and only in one station: *Suberites domuncula* (St. 16) and *Haliclona cinerea* (St.6) among Sponges, *Tetrastoma melanocephalus* (St. 6) and *Micrura aurantica* (St. 16) among the Nemertini worms, *Euchone rubracincta* (St. 9), *Eulalia sanguinea* (St.9), *Notomastus lineatus* (St. 6), *Nereis longissima* (St. 16), *Polycirrus* sp. (St. 10), *Prionospis cirrifera* (St. 16), *Sphaerosyllis hystrix* (St. 16) and *Theostoma capsulifera* (St. 9) among the Polychaeta worms, than Gastropoda *Calyptrea chinensis* (St. 16), Ostracoda *Sclerochilus gewemülleri* (St. 16), Amphipoda *Apherura bispinosis* (St. 25), Tunicata *Molgula euprocta* and *Ctenicella appendiculata* (St. 7 and 10) and Halacarida *Copidognatus magnipulpus* (St. 10). The most numerous singular species are in the Station 16 where 54 taxa were recorded.

On the 50-80 m depth bottoms the average abundance of zoobenthos is 64888 sps.m^{-2} with 221.9 g.m^{-2} (Fig. 6); the limits of variation are 20416 (St. 7) – 110702 (St. 9) sps.m^{-2} for densities and 59.8 (St. 7) – 508.8 (St. 6) g.m^{-2} for biomasses.

In **the deeper zones 120-150 m**, covered by white-gray mud with *Modiolus phaseolinus* shells, 28 taxa were present in May 1997: 7 species of Foraminifera, 11 species of Polychaeta and one representative of Coelenterata, Spongia, Kinorhynchida (*Pycnophies ponticus*), Mollusca Bivalvia (*Modiolus phaseolinus*), Ostracoda, Tanaidacea, Tunicata and the groups of Nematoda, Harpacticoida and Halacarida. The zone is known as being poor (Bacescu *et al.*, 1971), but actually it is poorer than our expectations. The number of taxa varies from 18 to 6, the tendency being a slight decrease with the increase of the depth (Fig. 2). The most important forms through their biomasses are *Neanthes succinea* (R_{1B} – 6.4 g.m^{-2}), *Protodrilus flavocapitatus* (R_{2B} – 1.9 g.m^{-2}), *Cyona intestinalis* (R_{3B} – 1.1 g.m^{-2}), *Aonides paucibranchiatus* (R_{4B} – 0.4 g.m^{-2}) etc.; the abundance of benthic organisms is generally low, lower for biomasses than for densities in comparison with other bathymetric zones (Fig. 6); the higher values for average density can be explained by the rich populations of Nematoda and Harpacticoida in St. 19 (249176 and respectively 56588 sps.m^{-2}).

The analysis of benthic populations distribution on depth intervals in May 1977 in comparison with August 1995 emphasize an explosive increase of the Worms (Nematoda and Polychaeta) and Crustaceans (Harpacticoida) densities and as consequence of total zoobenthos (in spite of the Molluscs density decrease in 1977) (Fig. 6). Referring to the total biomasses, they are lower in 1977 for the inshore bottoms (8-30 m depth) and higher for offshore bottoms, deeper than 30 m; same situation is reflected by worms populations, while the Molluscs in 1977 have smaller biomasses at all depths. Crustaceans biomasses are generally small, but in 1977 the values are higher than in 1995, everywhere in NW Black Sea.

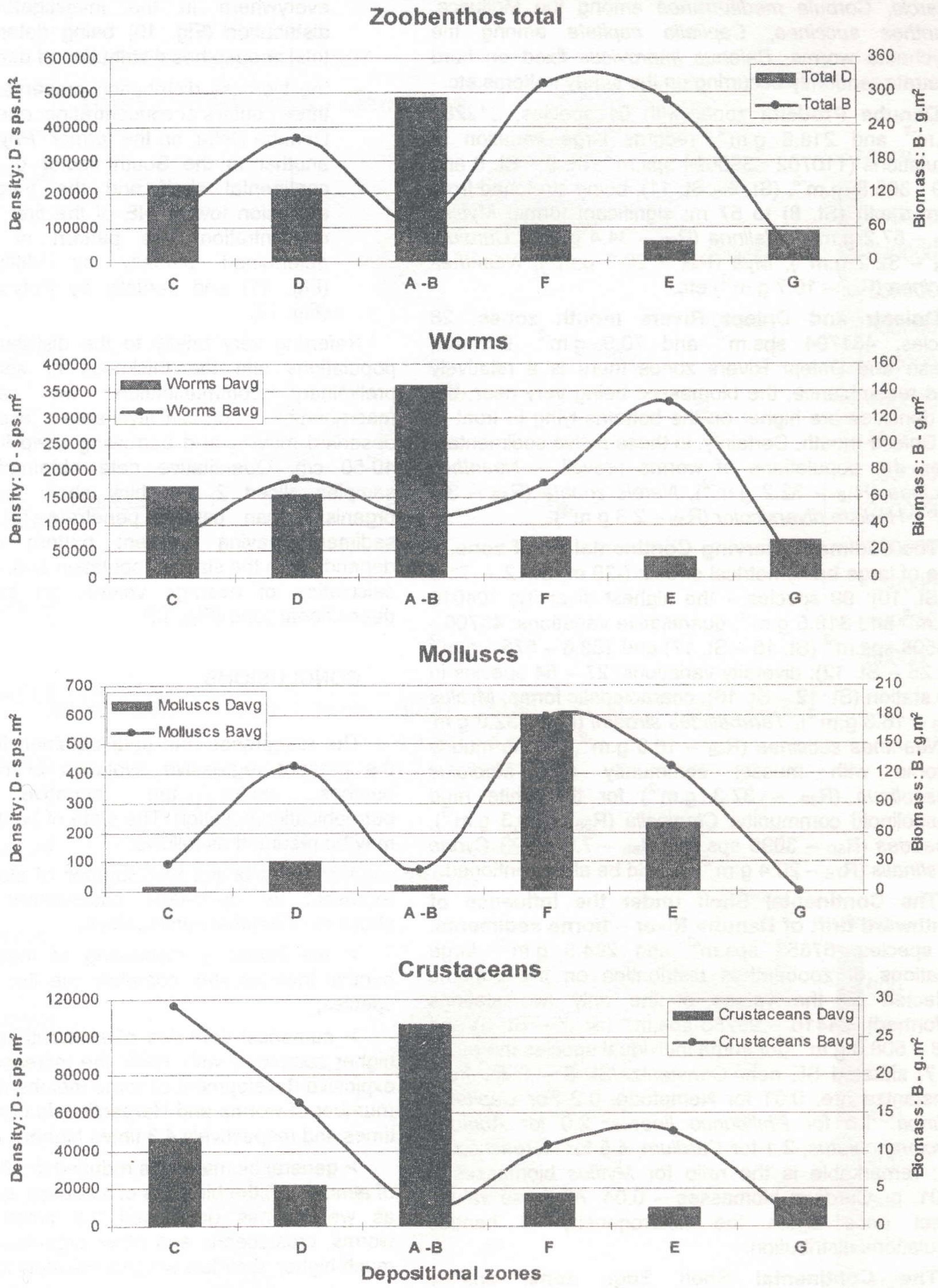
Having in view the number of species and their abundance as density or biomass in each station, the calculation of diversity index (Fig. 7) emphasizes the large heterogeneity of species richness in the benthic communities; although the diversity varies from one station to another, the general tendency is as follows:

– for densities, the diversity of benthic communities slightly increasee from the shallow inshore bottoms to the deeper ones at 50-80 m, than decreases towards offshore, approximately from 1 to 3;

– for the biomasses, the index of diversity is more uniform, slightly oscillating around the value 3 (Fig. 6).

State of benthic populations on depositional zones. The data from the performed stations, processed according to depositional systems (Fig. 8) show that the most numerically abundant populations of zoobenthos are dwelling the sediments of the bottoms distributed in front of Rivers Dniestr and Dniepr; these populations are dominated by Nematoda worms and Harpacticoida crustaceans, groups almost invariably on the top places in the ranking of taxa according to the index of ecological importance as density; the Molluscs have their maximum development of populations, both as number and biomass, on the Sediment starving continental shelf. Also, from the beginning it is necessary to mention that the highest biomasses are distributed on the continental shelf zones, both influenced or not by the Danube River sediment discharge. The main peculiarities of depositional systems in the NW Black Sea in connection with the benthic populations (average values) were in May 1997 as follows:

Danube Delta Front: 35 species, 227301 sps.m^{-2} and 62.5 g.m^{-2}, is characterized by meiobenthic population having high densities, up to 539842 sps.m^{-2}, but low biomasses (20.9-85.3 g.m^{-2}, St. 1 – St. 5); the most important taxa are *Mya arenaria, Cardium edule*



C	D	A	B	F	E	G
Delta Front	Danube Prodelta	Dniepr mouth	Dniestr mouth	Sediment starving	Influenced shelf	Near shelf break

Fig. 8 Average densities (D) and biomasses (B) of benthic populations from NW Black Sea depositional zones in 1997

lamarcki, Corbula mediterranea among the Mollusca, *Neanthes succinea, Capitella capitata* among the Polychaeta worms, *Balanus improvisus* fixed on hard substrata randomly occurring on the sandy bottoms etc.

Danube Prodelta zone, with 61 species, 212287 sps.m^{-2} and 218.8 g.m^{-2}, records large variation of populations (110702 - 395694 sps.m^{-2}, St. 9 – St. 8 and 90.9 - 365.8 g.m^{-2}, (St. 9 - St. 11), being stretched from 27 m depth (St. 8) to 57 m; significant forms: *Mytilus* (R_{1B} – 57.2 g.m^{-2}), *Melinna* (R_{2B} – 34.4 g.m^{-2}), *Cardium* (R_{3B} – 32.2 g.m^{-2}), *Mya* (R_{4B} – 26.7 g.m^{-2}), *Neanthes succinea* (R_{5B} – 10.7 g.m^{-2}) etc.

Dniestr and Dniepr Rivers mouth zones: 28 species, 481794 sps.m^{-2} and 70.9 g.m^{-2}. Between Dniestr and Dniepr Rivers zones there is a relatively good resemblance, the biomasses being very near, but the densities are higher on the bottoms lying in front of the Dniestr mouth. Certainly, in these active sedimentary areas the populations of worms prevail – *Neanthes succinea* (R_{1B} – 32.2 g.m^{-2}), *Nereis zonata* (R_{3B} – 3.1 g.m^{-2}), *Hediste diversicolor* (R_{4B} – 2.3 g.m^{-2}).

The sediment Starving Continental Shelf zone, a zone of large bathymetrical stretch (-29 m, St.12 – -71.5 m, St. 10): 99 species – the highest diversity; 104016 sps.m^{-2} and 313.5 g.m^{-2}; quantitative variations: 45706 - 235508 sps.m^{-2} (St. 16 – St. 17) and 158.6 – 575.1 g.m^{-2} (St. 25 – St. 12); diversity variations: 27 – 54 species in one station (St. 12 – St. 16); characteristic forms: *Mytilus* (R_{1B} – 16.3 g.m^{-2}), *Terebellides stroemi* (R_{2B} – 32.6 g.m^{-2}), *Neanthes succinea* (R_{4B} – 16.3 g.m^{-2}, for the muddy bottoms with mussel community and *Modiolus phaseolinus* (R_{3B} – 37.3 g.m^{-2}) for the white mud phaseolinoid community; *Ctenicella* (R_{5B} – 29,3 g.m^{-2}), *Apseudes* (R_{5D} – 3095 sps.m^{-2}, R_{6B} – 7.6 g.m^{-2}) *Cyona intestinalis* (R_{7B} – 20.4 g.m^{-2}) should be also mentioned.

The Continental Shelf under the influence of Southward drift of Danube River – borne sediments: 53 species, 57853 sps.m^{-2} and 284.3 g.m^{-2}; large variations of zoobenthos distribution on the bottoms (reflected by the values of the only two stations performed): 24416 – 95285 sps.m^{-2} (St. 7 – St. 6) and 59.8 – 508.8 g.m^{-2} (for some individual species the ratios St. 7, situated SE near Constantza/St. 6 – S far from Constantza are: 0.01 for Nematoda, 0.2 For *Capitella, Melinna*, 1.5 for *Phillodoce lineata*, 2.0 for *Aonides paucibranchiatus*, 2.1 for *Cardium*, 4.5 for Harpacticoida etc.; remarkable is the ratio for *Mytilus* biomasses – 0.001, or *Cardium* biomasses – 0.04. All these values reflect once again the heterogeneity of benthic populations distribution.

The Continental Shelf Edge zone, entirely corresponds with the bathymetric zone of 120-150 m described above.

Despite of the computation limits the maps of quantitative distribution of benthic populations in the NW Black Sea (Figs. 9-12) support in a very synthetical way the following conclusions:

- the zoobenthos as a pool of different populations is numerically concentrated in the coastal waters directly influenced by the rivers Dniestr, Dniepr and Danube (Fig. 9);
- dominant populations are those of Nematoda and Harpacticoida, meiobenthic forms present everywhere in the investigated area, their distribution (Fig. 10) being determinant for the total zoobenthos distribution of densities;
- the biomass distribution presents, more or less, three centers of concentration: one situated NE of Danube Delta, on the former "*Phyllophora* beds", another in the South sector of the Romanian continental shelf and the third one as an extension toward NE of the first field of benthic concentration; this pattern of distribution is determined partially by Molluscs biomass (Fig. 11) and partially by Polychaeta biomass (Fig. 12).

Referring very briefly to the distribution of benthic populations into the thickness of sediments, as a preliminary communication, we can say that macrobenthic forms–Polychaeta especially, were observed moving and burrowing deep in mud down to 40-50 cm. Quantitative data obtained from "Incub" samples sliced 2 cm thick show that the benthic organisms can usually penetrate to 10-12 cm in sediment, having different pattern of distribution, depending on the size of population and, as a result from calculation of average values, on bathymetric and depositional zone (Fig. 13).

CONCLUSIONS

The researches and data obtained in 1997 confirm the present regressive evolution of NW Black Sea benthos under the negative effects of eutrophication/pollution. The state of benthic populations may be resumed as follows:

➢ in spite of the low number of stations, the data represent an up-to-date assessment of qualitative structure of benthal communities;

➢ the inventory monitoring of macro- and meio-benthic invertebrates complete the list of taxa to 175 species;

➢ numerical densities of zoobenthos are 5.5 times higher compared with 1995; the increase is due to the explosive development of some meiobenthal populations (number of worms and Harpacticoida crustaceans is 9.4 times and respectively 4.3 times higher);

➢ general biomass has reduced in 1997 with a factor of almost 1.5; the biomass of Molluscs, usually dominant as weight, has decreased 2.5 times; although the worms, crustaceans and other organisms densities are much higher, their low weights maintain low biomasses;

➢ the actual "metabolism" of the benthic ecosystems seems to be controlled by worm populations which process actively the sediment enriched with organic matter;

➢ diversity and abundance decrease of Molluscs populations can reflect a decrease of the benthal biofilter strength, a worsening of the ecological situation in 1997 on the NW Black Sea bottoms;

➢ occurrence in some offshore stations of certain species considered to be extinct or very rare nowadays in the Black Sea, as are *Suberites* and *Adocia* among the Sponges, *Calyptrea chinensis* among the Molluscs, *Ascidiella aspersa* and *Cione intestinalis* among the

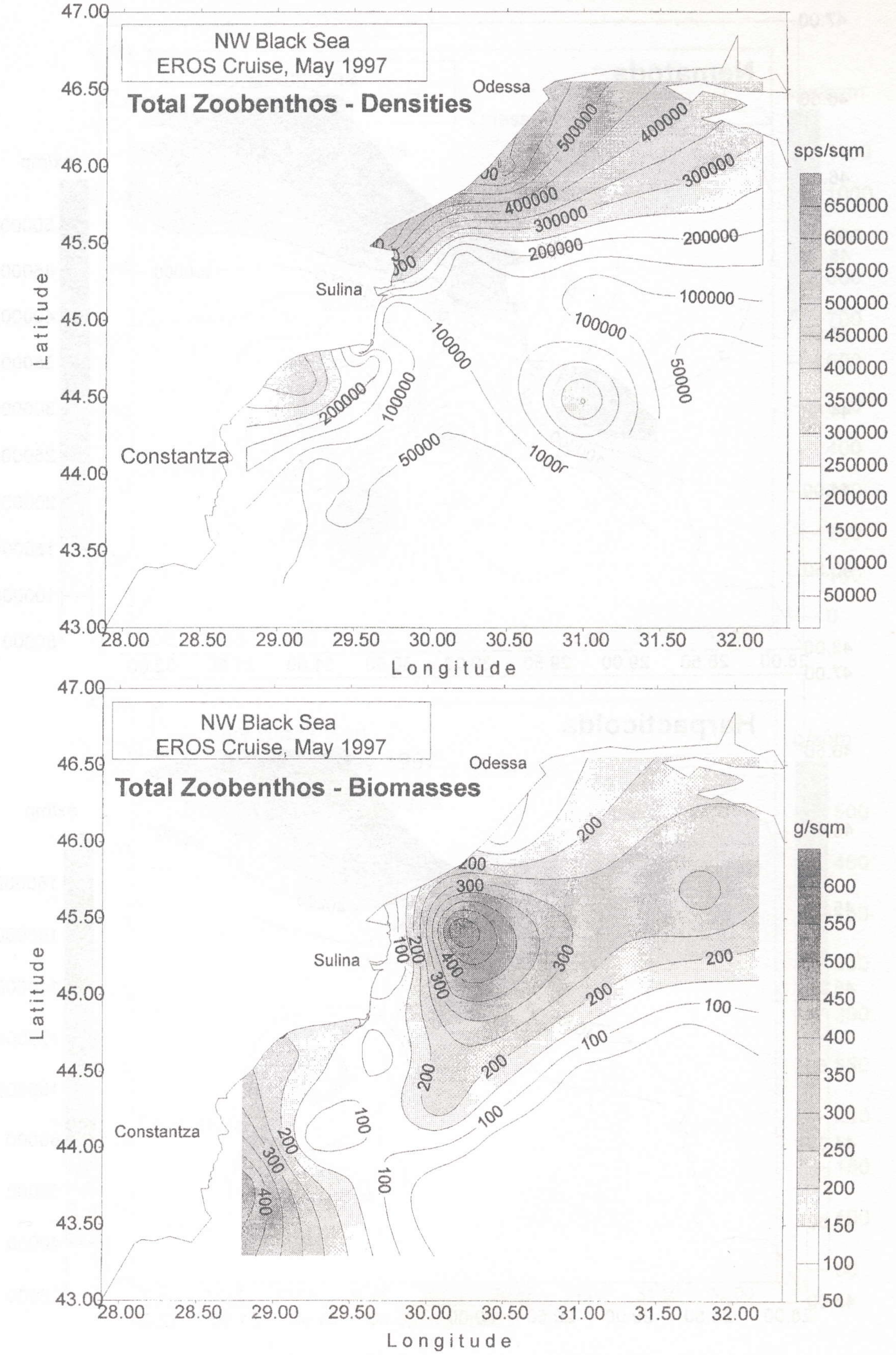


Fig. 9 Quantitative distribution of zoobenthos in May 1997

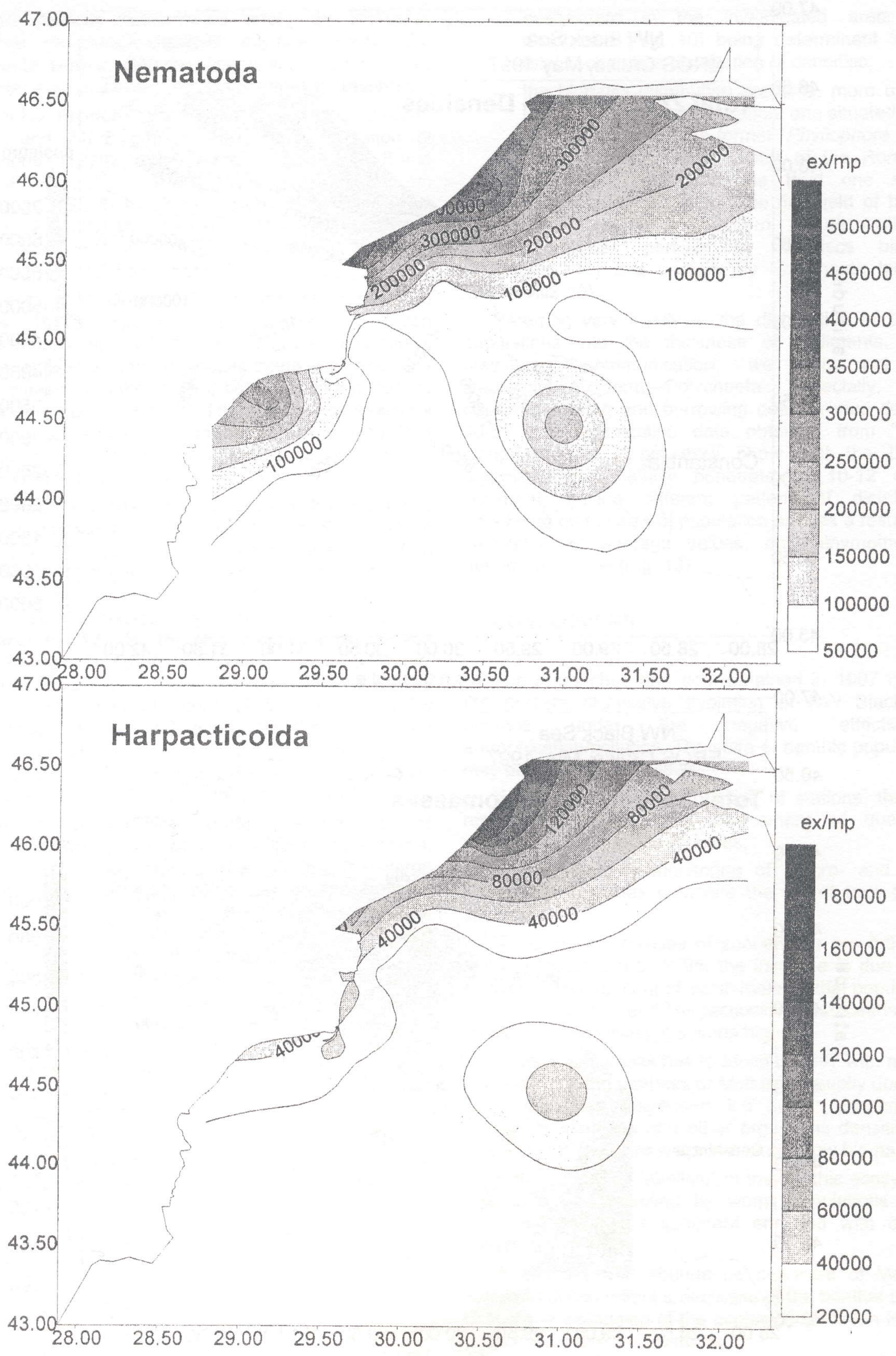


Fig. 10 Quantitative distribution of some meiobenthic population in May 1997

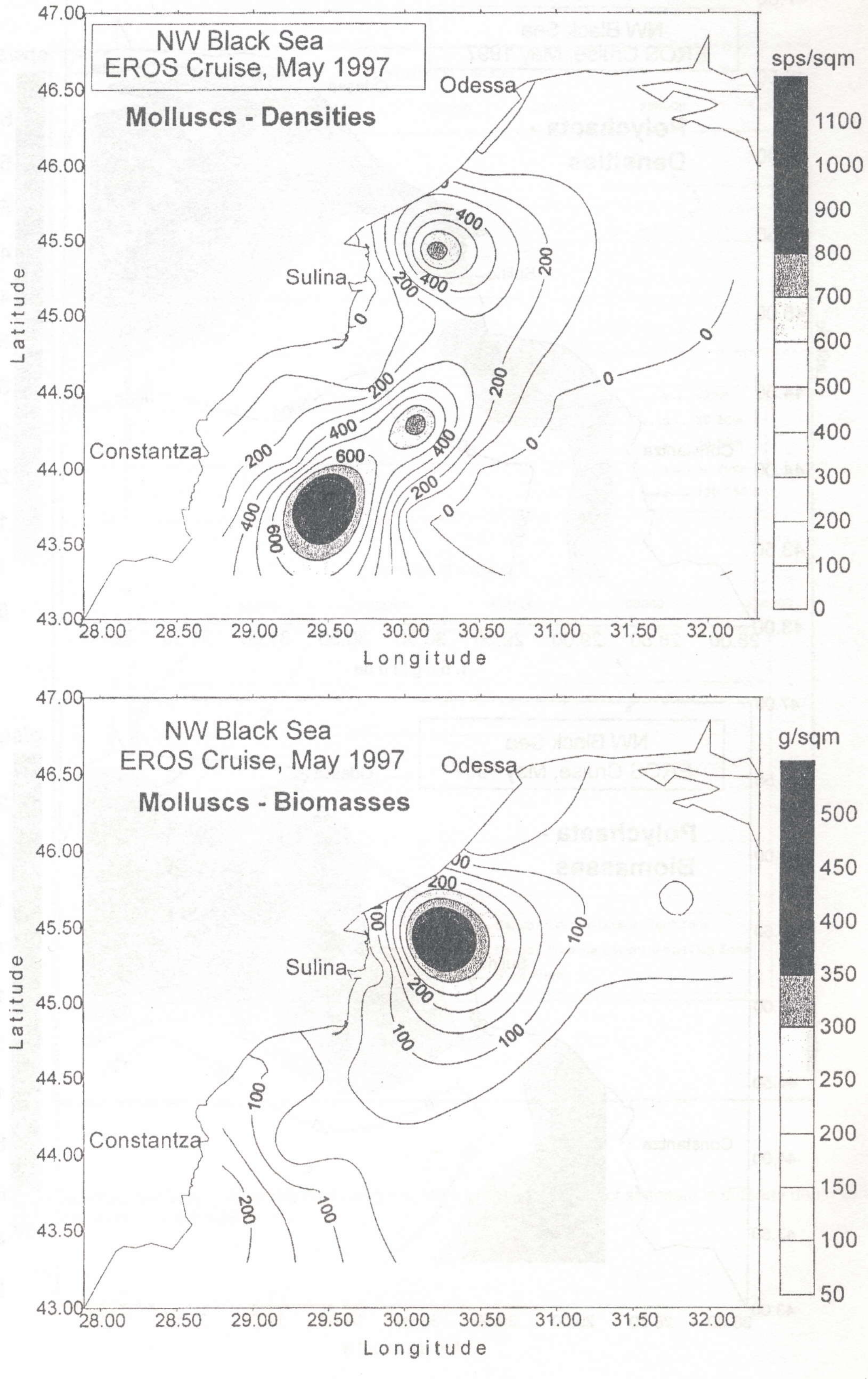


Fig. 11 Quantitative distribution of Molluscs populations in May 1997

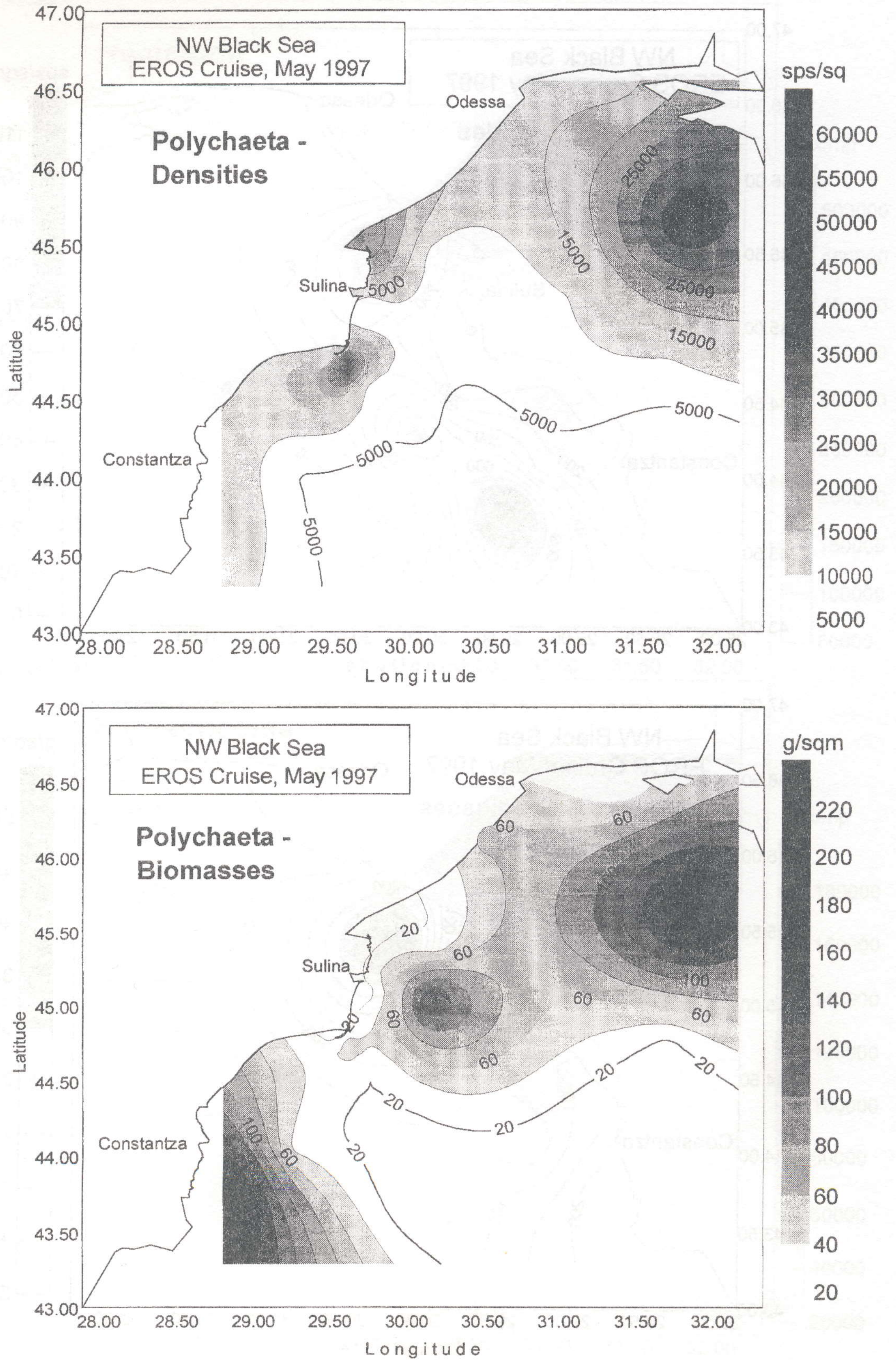


Fig. 12 Quantitative distribution of Polychaeta population in May 1997

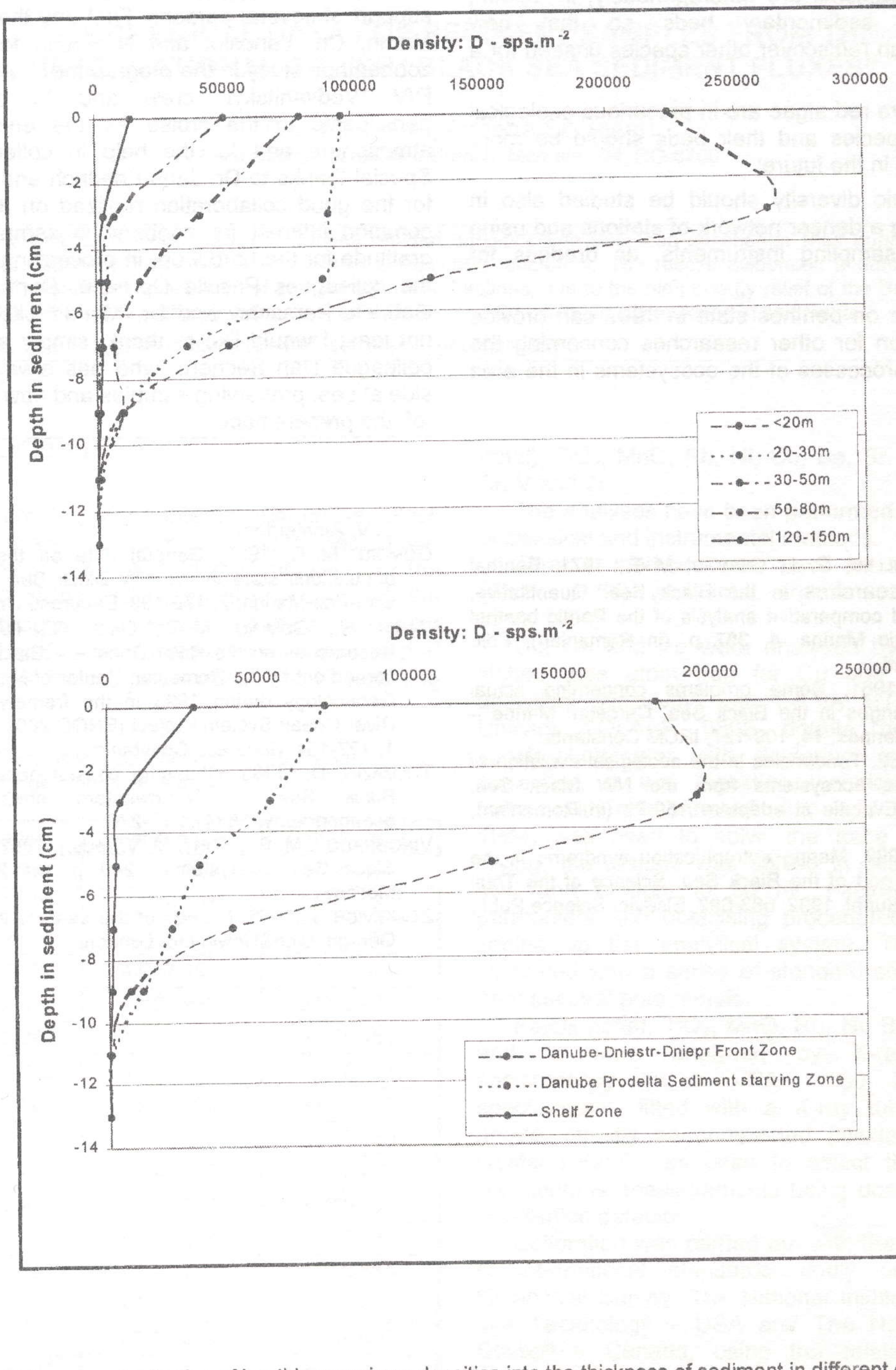


Fig. 13 Average distribution of benthic organisms densities into the thickness of sediment in different depth zones and depositional systems.

Tunicates, is a positive fact giving hope for the future state of the benthic circumlittoral ecosystems;

➢benthic organisms are heterogenously, in "spots", distributed on sedimentary beds so that new investigations can rediscover other species unseen for a long time;

➢ *Phyllophora* red algae are in precarious ecological situation: this species and their beds should be more minutely studied in the future;

➢ the benthic diversity should be studied also in future controlling a denser network of stations and using supplementary sampling instruments, as dredges for instance;

➢ the results on benthos state in 1997 can provide useful information for other researches concerning the structures and processes of the ecosystems in the area of interest.

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REFERENCES

BĂCESCU, M., MÜLLER, G. I., GOMOIU, M.-T., 1971, Benthal ecological researches in the Black Sea. Quantitative, qualitative and comparative analysis of the Pontic benthal fauna. Ecologie Marina, **4**, 357 p. (in Romanian). Edit. Acad. Bucuresti.

GOMOIU, M.-T., 1981, Some problems concerning actual ecological changes in the Black Sea. Cercetari Marine – Recherches Marines, **14**, 109-127, IRCM Constanta.

GOMOIU, M.-T.,1982, Tendencies in the ecological evolution of coastal marine ecosystems from the NW Black Sea. Simpozionul "Evolutie si adaptare", 59-73 (in Romanian), Cluj-Napoca.

GOMOIU, M.-T., 1992, Marine eutrophication syndrome in the north-western part of the Black Sea. Science of the Total Environment, Suppl. 1992, 683-692, Elsevier Science Publ., B. V. Amsterdam.

GOMOIU, M.-T., 1997, General data on the marine benthic populations state in the NW Black Sea, in August 1995. Geo-Eco-Marina, **2**, 179-199, Bucuresti-Constantza.

PANIN, N., GOMOIU, M.-T., OAIE, G., RĂDAN, S., 1996, Researches on the River Danube – Black Sea ecosystem carried out by the Romanian Center of Marine Geology and Geoecology during 1995 in the framework of European River Ocean System Project (EROS 200). Geo-Eco-Marina, 1, 127-154, Bucuresti-Constantza.

TOLMAZIN, D., 1985, Changing coastal oceanography of the Black Sea, I, Northwestern shelf. Progress in oceanography, **15** (4), 217-276.

VINOGRADOV, M. E. , FLINT, M. V. (eds.), 1987, Present state of Black Sea ecosystems., 240 p. (in Russian), Nauka, Moscow.

ZENKEVICH, L.,1963, Biology of the seas of the USSR, 955 p, George Allen&Unwin Ltd, London.