Mediterranean Marine Science

Vol 2, No 1 (2001)

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S. STOYKOV, S. UZUNOVA

doi: 10.12681/mms.273

Mediterranean Marine Science
Vol. 2/1, 2001, 27-35

Dynamics of macrozoobenthos in the Southern Bulgarian Black Sea coastal and open-sea areas

ST. STOYKOV[1] and S. UZUNOVA[1]

[1] National Centre for Agrarian Sciences, Institute of Fishing Resources, Varna,
4, Primorski blvd., P.O. Box 72, Varna, 9000, Bulgaria
e-mail: ifr@abcis.bg

Manuscript received: 19 August 1999; accepted in revised form: 14 December 2000

Abstract

The paper presents results of analysis of 96 macrozoobenthic samples, collected on a seasonal basis in Bourgas Bay and in open-sea areas off Cape Emine (Bulgarian Black Sea) in 1996 and 1998. In total 96 taxa were established, distributed in four groups: Polychaeta, Mollusca, Crustacea and "Diversa". The average density of populations was 1756 ind.m^{-2} with a predominating abundance of Polychaeta species. The average biomass estimated was 183.02 g.m^{-2}, formed mainly by representatives of Mollusca. The latter species were measured together with the shells, which appraised their individual weights. Seven of the species found had a coefficient of constancy more than 50%. These were the most adapted species to the environmental conditions of the investigated areas. The quantitative and qualitative assessments in this study demonstrate an increasing tendency in the parameters obtained (density, biomass, species diversity) in comparison with previous investigations in the early 1990's, when intensive anthropogenic influence was widely perceived to disturb the balance of the Black Sea ecosystem.

The method used by Warwick (1986) to characterize the water quality of the studied areas allowed us to define them as rather clean or moderately polluted aquatories.

Keywords: Black Sea, Dynamics, Macrozoobenthos, Warwick's method.

Introduction

The organisms represented in the macrozoobenthic community of the Black Sea have always been of great scientific interest because of their sensitivity and response to environmental stress. Most of these animals live permanently attached to the bottom and anthropogenic pollution strongly influences them. In the 1980's the Black Sea was included in the list of the most ecologically threatened bodies of water on Earth. The coastal zone was widely perceived to be heavily polluted with an increasing tendency towards change and decline (GOLEMANSKI, 1998). The peak of pollution was reached at the end of the 1980's. Hypoxic situations were frequent at that time, leading to mass mortality of zoobenthic organisms and hyperbenthic fish (GOMOIU, 1992;

TODOROVA & KONSULOVA, 2000; MARINOV & STOYKOV, 1990).

Due to its specific geographic disposition and infrastructure, the Bourgas Bay and the neighbouring regions are characteristic in the following aspects: intensive industrial development of the populated areas in the vicinity of the bay, and especially of the city of Bourgas. The major Bulgarian port is situated here, as well as the petroleum refinery, and they discharge large amounts of pollutants into the sea (ALTMANN, 1990). The close proximity of the bay to the Bosphorus is important in relation to the input of Mediterranean waters with higher salinity, which controls the biodiversity of the studied area.

Since 1990 a relative decrease in anthropogenic pressure in the Black Sea has been reported, explained by the collapse of the former socialist economy. This has favoured the relative restoration of the pelagic and benthic communities of coastal waters (ATANASOVA *et al.,* 1995; MARINOV *et al*., 1995; STOYKOV & UZUNOVA, 1999).

The main purpose of this study is to investigate the changes in the biodiversity of the macrozoobenthos in the south Bulgarian Black Sea region, as well as its quantitative parameters - density and biomass. On the basis of the results obtained to apply Warwick's method (1986) and to characterise the waters in relation to their organic matter loading.

Materials and Methods

Samples were collected on a seasonal basis in 1996 and 1998 in the south Bulgarian Black Sea waters - in Bourgas Bay and at a transect off Cape Emine at depths from 6 to 128 m (Fig. 1). The sampling was carried out, using a "Van-Veen" grab with a mouth opening of 0.1 m^2. A total of 96 samples were processed and analysed - 64 from Bourgas Bay and 32 from transect Emine. The onboard primary processing of samples included their washing through sieves (d=0.6 mm) and preservation by 4% formalin. The laboratory processing included secondary washing, sorting by groups and identification of species, their number and weight. Density and biomass were estimated per 1 m^2 surface.

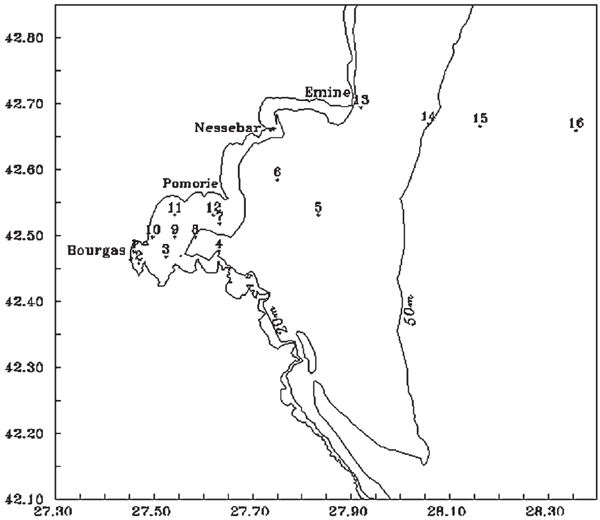

Fig. 1: Map of sampling stations.

The organisms from groups Turbellaria, Nemertina, Oligochaeta and Spongia and Nematoda were not identified to a species level and they were united in the group "Diversa".

The coefficient of constancy of a certain species was estimated by:

pF = m/n x 100,

where

m=number of stations, where the species was found;

n=number of all stations.

The level of organic pollution of the studied waters was qualitatively assessed using Warwick's method (1986), named ABC method (abundance, biomass, comparison).

Results and Discussion

A total of 96 taxa of macrozoobenthic organisms was found during the studied period. The predominating species and corresponding coefficients of constancy are presented in Table 1.

Table 1
Species composition and coefficient of constancy of macrobenthic species along the Southern Black Sea coast.

N:	Species	1996	1998
	Polychaeta		
1.	Melinna palmata Grube, 1869	96.75	100
2.	Neanthes succinea Frey&Lechart, 1847	70.73	32.5
3.	Heteromastus filiformis Claparede, 1864	53.21	39.5
4.	Capitomastus minimus Langerhans, 1880	30.4	38.5
5.	Harmothoe reticulata Claparede, 1870	18.5	7.5
6.	Spio filicornis O.F.Muller, 1776	26.85	30
7.	Notomastus profundus Eisig, 1887	-	7
8.	Nephtys cirrosa Ehlers,1868	18.41	17.75
9.	Nephtys hombergi Savugny, 1818	29.66	60.5
10.	Terebellides stroemi Sars, 1835	31.96	61
11.	Phyllodoce mucosa Oersted, 1843	9.46	23.5
12.	Pectinaria korenii Malmgren, 1865	12.7	5.5
13.	Aonides paucibranchiatus Southern, 1914	13	13
14.	Hediste diversicolor O.F.Muller, 1776	5.29	13.75
15.	Polydora ciliata Johnston, 1838	10.98	18.5
16.	Prionospio cirrifera Wiren, 1883	3.2	9.75
17.	Protodorullea kefersteini McIntosh, 1869	5.2	2.75
18.	Eulalia viridis Linnaeus, 1767	-	7
19.	Capitellides guiardi Mesnil, 1897	1.56	4.25
20.	Capitella capitata Fabricius, 1780	-	2
21.	Typosyllis prolifera Krohn, 1852	-	2
22.	Grubeosyllis clavata Claparede, 1868	1.66	-
23.	Cirrophorus branchiatus Ehlers, 1908	-	5.5
24.	Glycera tridactyla Scamarda, 1861	1.65	-
25.	Glycera alba O.F. Muller, 1788	3.13	-
26.	Eunice vittata Delle Chiaje, 1828	1.56	-
27.	Mysta picta Quatrefage, 1865	-	2.75

Table 1 (continued)

28.	Clymenura clypeata Saint-Joseph, 1894	8.3	-
29.	Nereis rava Ehlers, 1868	1.65	-
30.	Grubeasyllis limbata Claparede, 1868	-	2
31.	Hesionides arenaria Friedrich, 1937	-	2
32.	Harmothoe imbricata Linnaeus, 1767	1.5	-
33.	Phyllodoce tuberculata Bobretzky, 1868	-	5
	Mollusca		
34.	Chamelea gallina Linne, 1758	41	17.25
35.	Mytilus galloprovincialis Lamark, 1819	49.85	15.25
36.	Spisula subtruncata Da Costa, 1778	37.62	55.25
37.	Cardium edule L., 1916	65	25.75
38.	Sqapharca inaequivalvis Brugaiere, 1789	20.21	9.75
39.	Mya arenaria L., 1758	7.9	14.75
40.	Tellina exigua Poli, 1893	6.25	2.75
41.	Paphia rugata B.D.D., 1893	6.93	2.75
42.	Parvicardium exiguum Poli, 1790	14.95	8.25
43.	Nassarius reticulatus Linne, 1758	28.95	2.75
44.	Calyptraea chinensis Linne, 1758	7.9	7.5
45.	Parvicardium simile Milaschewitch, 1916	3.21	7.5
46.	Lepidochitona cinerea Linne, 1767	1.65	2
47.	Acanthocardia paucicostata Soverby, 1859	2.25	4.75
48.	Pitar rudis Poli, 1791	-	2
49.	Mytilaster lineatus Gmelin, 1790	2.25	-
50.	Lentidium mediterraneum Costa, 1829	2.25	-
51.	Polititapes aureus Gmelin, 1790	3.13	-
52.	Cyclope neritea Linnaeus, 1758	-	10.25
53.	Gouldia minima Montagu, 1803	4.8	-
54.	Modiolus phaseolinus Philippi, 1844	6.25	-
55.	Modiolus adriaticus Lamarck, 1819	1.6	-
56.	Moerella donacina L., 1758	3	-
	Crustacea		
57.	Ampelisca diadema A. Costa, 1853	55.98	57
58.	Corophium runcicorne Della Valle, 1893	12	14.75
59.	Microdeutopus versiculatus Bate, 1856	11	4.75
60.	Microdeutopus gryllotalpa A. Costa, 1853	4.69	5.87
61.	Corophium bonelli Milne-Edwards, 1830	7.88	4.77
62.	Melita palmata Montagu, 1813	8	2.75
63.	Corophium volutator Pallas, 1766	2.8	2.75
64.	Phtisica marina Slabber, 1778	6	11.75
65.	Decapoda larvae	7.8	2.75
66.	Balanus improvisus Darwin, 1854	42.68	25
67.	Diogenes pugilator Roux, 1828	15	11.8
68.	Perioculodes longimanus Bate & Westwood, 1868	3.75	2
69.	Brachynotus sexdentatus Risso, 1827	1.6	2
70.	Iphinoe elisae Bacescu, 1950	2.25	7

Table 1 (continued)

71.	Iphinoe tenella G.O.Sars, 1873	3	4.25
72.	Upogebia pusilla Petagna, 1792	1.56	2
73.	Monoculodes gibbosus Chevreux, 1900	-	2
74.	Jassa ocia Bate, 1862	-	2.8
75.	Leptocheirus pilosus Zaddach, 1844	-	2
76.	Caprella acanthifera Leach, 1814	6.9	-
77.	Microdeutopus damnoniensis Bate, 1856	3.9	-
78.	Apseudopsis ostroumovi Bac. &Carauchu, 1947	22.88	10.5
79.	Chaetogammarus olivii M.-Edwards, 1830	1.56	-
80.	Palaemon elegans Rathke, 1837	1.66	-
81.	Cumopsis goodsiri Van Beneden, 1868	1.8	-
82.	Atylus guttatus A. Costa, 1851	1.8	-
83.	Liocarcinus holsatus Fabricius, 1798	1.8	-
84.	Crangon crangon Linnaeus, 1758	3	-
85.	Corophium crassicorne Bruzelius, 1859	1.5	-
86.	Corophium acherusicum Costa, 1857	-	2.75
	Diversa		
87.	Actinia equina Linnaeus, 1766	11.7	2
88.	Oligochaeta sp.	8.8	18.75
89.	Phoronis euxinicola S. Long, 1907	53.6	45.2.5
90.	Nematoda sp.	2.25	4.75
91.	Nemertina sp.	10.26	4.25
92.	Micrura fasceolata Ehrenberg, 1831	3	-
93.	Amphiura stepanovi Djakonov, 1954	15.8	7
94.	Molgula euprocta Drasche, 1884	11.7	-
95.	Spongia sp.	2	-
96.	Turbellaria sp.	6.45	-

The species were grouped in - Polychaeta (33 species - 35.7% of total number), Mollusca (23 species - 22.6%), Crustacea (30 species - 32.2%) and "Diversa" (10 species - 9.5%).

The comparison between 1992 and 1996-98 results showed significant increase in species number from correspondingly 54 to 96 species, mainly due to Polychaeta species diversity - *Glycera alba, Polydora ciliata, Capitelides giardi,* etc. (Fig. 2). The new Mollusca species were *Lepidochiton cinaereus, Lentidium mediterraneum, Meretrix rudis,* and of *Crustacea - Corophium runcicorne, Microdeutopus gryllotalpa, Melita palmata, Phtisica marina,* etc.

In 1996-98 seven species were found with coefficient of constancy of more than 50%, which was related to their large ecological flexibility and high level of adaptation to environmental conditions. These species were listed as follows:

1. *Melinna palmata*
2. *Neanthes succinea*
3. *Ampelisca diadema*
4. *Terebellides stroemi*
5. *Heteromastus filiformis*
6. *Cardium edule*
7. *Phoronis euxinicola*

Some of the species mentioned above were found both in 1992 and 1996-98, such as the Polychaeta species *Melinna palmata* and crustacean *Ampelisca diadema* - they were well adapted to the frequent environ-

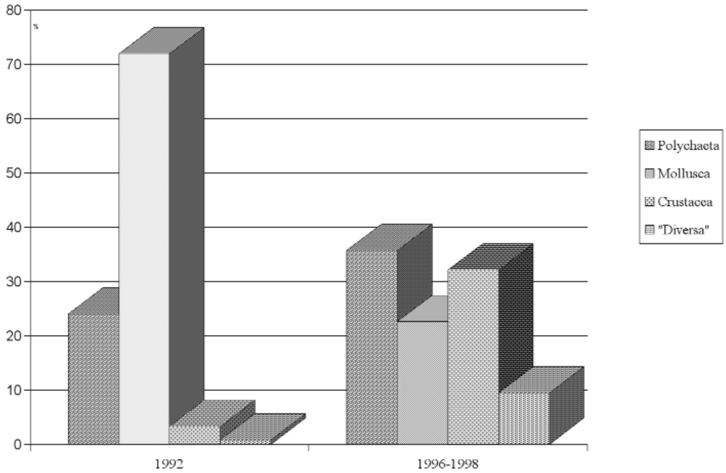

Fig. 2: Share of main macrozoobenthic groups in 1992 and 1996-98.

Table 2
Average density (ind.m^{-2}) of macrozoobenthos of the Southern Black Sea region.

	1996				1998			
Group	**winter**	**spring**	**summer**	**autumn**	**winter**	**spring**	**summer**	**autumn**
Polychaeta	768	1187	1045	927	1305	1067	1759	918
Mollusca	107	201	527	342	71	42	71	46
Crustacea	139	140	453	137	182	48	114	109
Diversa	49	41	538	105	24	78	58	3
Total	1036	1569	2563	1511	1582	1235	2002	1076

mental stress due to anthropogenic pressure in the studied areas. In 1992 the crustacean species *Corophium volutator*, the Mollusca species *Paphia rugata*, as vulnerable to hypoxic situations, showed low densities. In 1996-98 these species appeared again, due to relative improvement of environmental conditions and decrease in oxygen deficiency cases in shallow coastal waters. Nevertheless, in 1996-1998 species-indicators of high level of pollution, such as *Polydora ciliata* (PEARSON & ROSENBERG, 1978) were found in great density at some stations.

The average total density of macrozoobenthos for the period 1996-98 was 1576 ind.m^2. The densities of macrozoobenthos per season and per annum are presented in Table 2.

In 1996 the density was 1677 ind.m^{-2}, higher than in 1998 - 1477 ind.m^{-2}. In almost all seasons, the maximum density per group was found among Polychaeta species, due to their high resistance to oxygen deficiency (less than 0.05 ml.l^{-1}, ZAITSEV & MAMAEV, 1997).

The average total biomass of macrozoobenthos was 183.022 g.m^{-2} (Table 3). In all seasons (1996-98) the predominating group in the biomass was Mollusca. Some species were of especially high abundance, such as *Chamelea gallina* - up to 700.0 g.m^{-2}, *Sqapharca inaequivalvis* - 448.0 g.m^{-2}, *Mytilus galloprivincialis* - 311.45 g.m^{-2}.

The quantitative parameters of the macrozoobenthic community are the initial

Table 3
Average biomass (g.m^{-2}) of macrozoobenthos of the Southern Black Sea region.

Group	1996				1998			
	winter	**spring**	**summer**	**autumn**	**winter**	**spring**	**summer**	**autumn**
Polychaeta	9.770	19.595	13.903	13.16	16.779	13.084	37.973	24.144
Mollusca	40.99	136.960	304.729	508.730	99.603	100.839	58.714	8.498
Crustacea	4.365	2.815	7.869	8.865	4.917	2.170	0.446	0.574
Diversa	0.900	9.270	9.768	3.645	0.123	9.567	0.373	0.018
Total	56.025	168.640	336.269	534.400	121.422	116.660	97.526	33.234

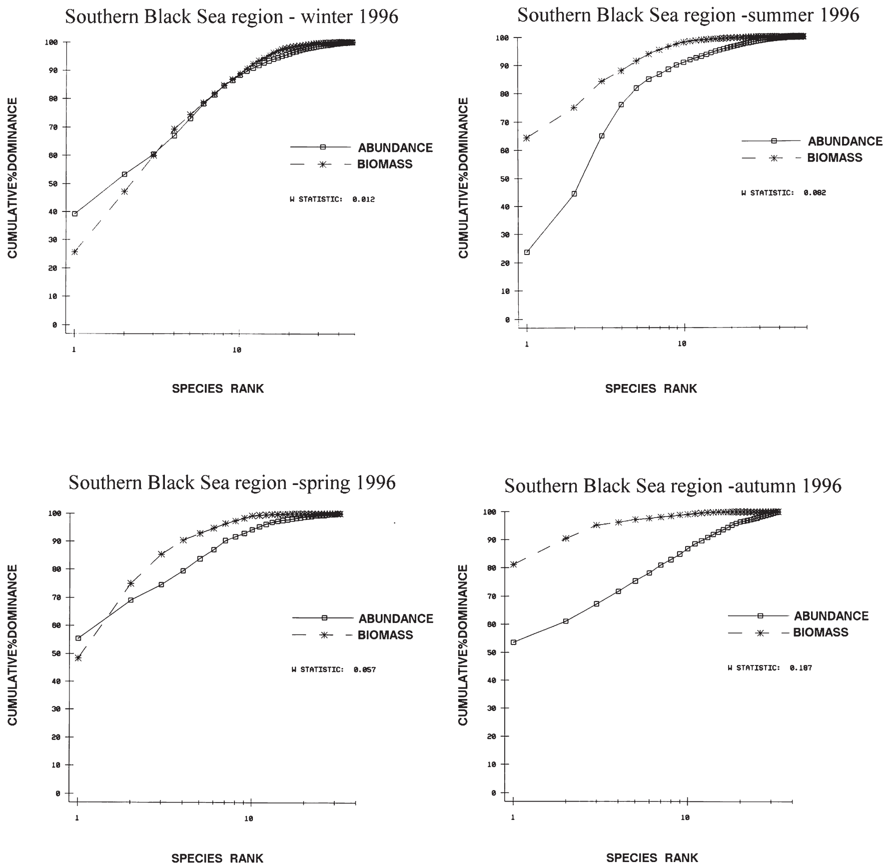

Fig. 3: ABC plots for macrozoobenthos from Southern Black Sea region in 1996.

data for Warwick's method (1986), which gives a qualitative assessment of the level of organic matter pollution for a certain marine area (Fig. 3, 4). According to this method, in winter and spring 1996 the studied waters were moderately polluted. For summer and autumn 1996 the disposition of the abundance and biomass curves on the graph indicated relatively clean waters. In 1998 in all seasons the abundance and bio-

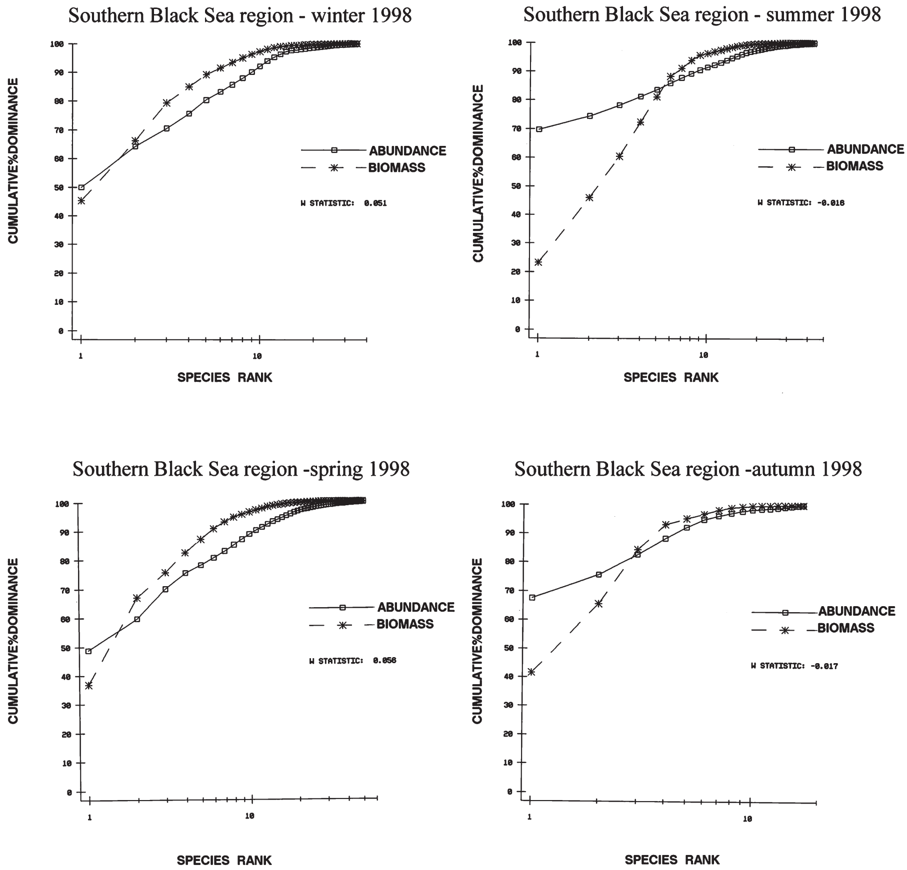

Fig. 4: ABC plots for macrozoobenthos from Southern Black Sea region in 1998.

mass curves crossed each other only once, which gave us evidence for considering the studied waters moderately polluted.

Conclusions

The macrozoobenthic communities are particularly sensitive to environmental pollution. In this sense, the increase in species number in the period 1992 - 1998 from 54 to 96 species indicates a relative decrease in the anthropogenic pressure in the studied areas - the southern Bulgarian Black Sea.

The development of some species in the late 1990's, which had disappeared in previous periods, evidences restoration of the benthic communities in the region. The qualitative parameters obtained (abundance and biomass) also support a conclusion regarding positive tendencies and using enabledus Warwick's method, to describe the southern Bulgarian Black Sea waters as moderately polluted.

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