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THE MACROZOOBENTHOS OF AN AEGEAN EMBAYMENT

By

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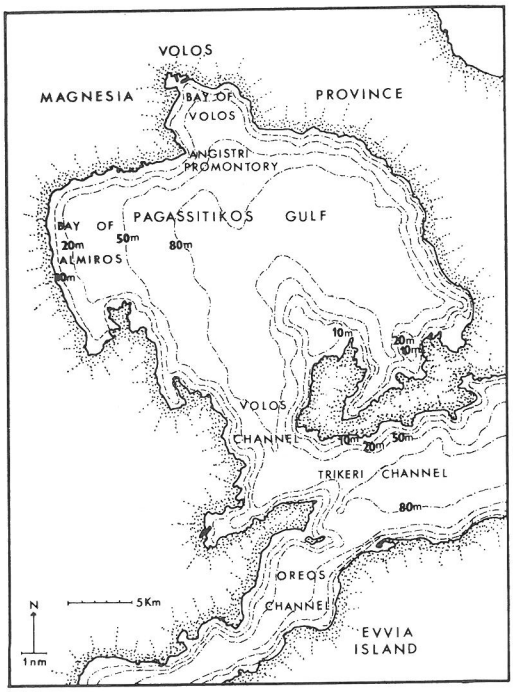
ABSTRACT

The macrozoobenthos of the relatively uninterfered and semi-inclosed Greek gulf of Pagassitikos was collected during six cruises, at a total of 39 locations, from August 1975 to December 1976. The observed species were listed in phylogenetic order, along with their abundances. Most of them belonged to the groups of *Polychaeta (56%), Crustacea (16%), Mollusca (14%)* and *Echinoderma (6%).* The most abundant species were by far *Onchnesoma steenstrupii, Tharyx dorsobranchialis, Paraonis gracilis gracilis, Callianassa stebbingi* and *Thiasyra flexuosa.* The number of species, g, and that of individuals, i, in a 0.1 m^2 area were a function of Satsmadjis's index of coarseness $s' = s + t/(0.2s + 5)$, where s and t represent the percentages of sand and silt in the substrate. For the groups of stations A, B and C, with s' means of 49, 15 and 10, g was 34, 14 and 10 and i 90, 29 and 17. Depth, h, had also its own effect, but a negative one, on g and i, presumably because it tends to lower the dissolved oxygen level. The nutrients concentrations in the bottom waters had a positive influence on benthos. They varied substantially from cruise to cruise independent of season.

INTRODUCTION

In August 1975, a comprehensive oceanographic investigation was carried out for the first time in the Gulf of Pagassitikos. This part of the Aegean Archipelago had not yet suffered appreciably from the impact of man. Furthermore, two rather narrow channels afford it some isolation from the open sea. In consequence, a baseline survey of benthos for ecological purposes offered enhanced interest, especially in the absence of any previous study of macrofauna.



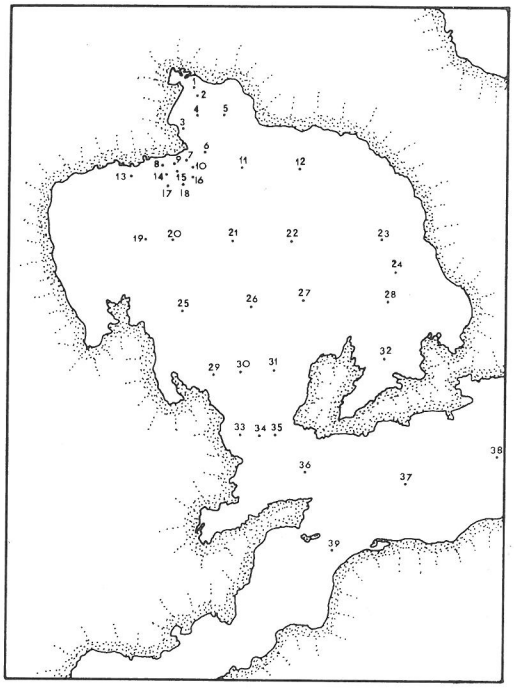
Description of the area

The Pagassitikos Gulf (Fig. 1) is a well defined marine expanse along the eastern shore of Greece, midway between Athens and Thessaloniki. It is about 20 km long and 30 km wide. It communicates with the western section of the Aegean Archipelago through the 6 km wide Volos Channel and the 11 km wide Trikeri Channel, delimited to the south by the northern tip of the elongated Evvia Island. It extends in the north into the Bay of Volos, which receives the domestic wastes and the industrial effluents of the capital of the Magnesia province, whose population reaches 100,000 inhabitants. The unsullied Bay of Almiros constitutes the major part of its western end. It has a rather even bottom, the depth of which ranges in the main from 50 to 100 metres. Little fresh water reaches it, owing to the streams in the vicinity being small or intermittent.

METHODOLOGY

Sediment sampling

The sediment samples were collected during six cruises, in August, Novem-



ber 1975, February, May, August and December 1976. A van-Veen grab was used, with an area of 0,18 m^2 on the first trip and 0.10 m^2 thereafter. The total number of sampling stations was 56, but those visited once only (15 in August 1975 and 2 in August 1976) were for that reason ignored in the present study. In consequence, the retained locations, shown in Fig. 2, amount to only 39. Of these, 20 (stations 2, 4, 5, 6, 7, 8, 11, 12, 16, 17, 20, 21, 22, 25, 26, 27, 33, 35, 36, 37) were investigated six times, 8 (stations 9, 10, 13, 14, 15, 18, 38, 39) five times, 7 (stations 1, 3, 19, 23, 28, 30, 34) four times, 1 (station 32) three times and 3 (stations 24, 29, 31) twice.

Macrozoobenthos separation and taxonomy

On board ship, the grab contents were washed in a stream of sea water through two large superimposed metal sieves of respectively 1 and 0.5 mm. The residues were stored in 1 l plastic jars and sufficient amounts of 5% formaldehyde and 0.2% Rose Bengal solution in water were added. In the laboratory, the samples were rinsed with tap water through a 0.5 mm sieve, to remove the liquid and any mud left, and they were preserved in alcohol (75%) prior to storage for subsequent processing.

The identification of the organism was carried out with the assistance of the following works. *Polychaeta*: Mc. Intosh (1922), Fauvel (1923, 1927), Day (1967), Marinov (1977), Fauchald (1977). *Sipuncula and Echiura*: Stephen & Edmonds (1972). *Gastropoda and Vivalvia*: Tadashige (1966), Tetsuaki (1967), Tebble (1966). *Cumacea:* Jones (1976). *Isopoda:* Naylor (1972). *Amphipoda:* Chevreux & Fage (1925). *Decapoda:* Zariquiey Alvarez (1968). *Echinodermata:* Koehler (1921), Tortonese (1965), Demetropoulos & Hadhichristophorou (1976). General: Riedl (1970).

The biomass was determined after drying the biological material in an oven at 90° C for three days.

Sediment analysis

A small portion of the sediment samples was put in plastic bags and stored in deep freeze. To establish the granulometric composition, a method adapted from that of Buchanan (1971) was followed. It consisted of hydrogen peroxide treatment, filtration and wet sieving of the sand fraction (over 62 μm). The remainder was dispersed in water in a 1 litre cylinder and 20 ml were taken at a depth of 20 cm immediately after shaking, to estimate the amounts of silt and clay. A further 20 ml were pipetted at a depth of 10 cm after 2h 3 min at 20° C, for measuring the quantity of clay (under 4 μm).

The determination of organic carbon was performed on sediment dried and crushed in a mortar to pass through a 0.45 mm sieve. The procedure involved oxidising with a heated mixture of dichromate and conc. sulphuric acid and back titrating with ammonium ferrous sulphate, using diphenylamine as indicator (Gaudette *et al.,* 1974).

Water analysis

The sea water in the vicinity of the sampling point was analysed for dissolved oxygen using the Winkler method as modified by Carritt and Carpenter (1966). It was also examined for dissolved inorganic nutrients on a Technicon CSM 6 auto-analyser. The colourimetric procedures employed in this instrument were based on that of Koroleff (1970) as automated by Slawyk and MacIsaac (1972) for ammonium, that of Murphy and Riley (1962) as automated by Hager *et al.* (1968) for phosphate and that of Armstrong *et al.* (1967) for nitrite, nitrate and silicate. The processing of the samples on the auto-analyser and the mathematical treatment of the chart measurements were effected according to Satsmadjis (1978).

RESULTS AND DISCUSSION

Environmental characteristics

The Pagassitikos Gulf (Fig. 1) belongs to the northern zone of the eastern section of the Mediterranean region, itself part of the Atlanto-Mediterranean benthic province. The sampling location (Fig. 2) had depths in the 50 to 100 m range, except for five shallower ones (17 to 42 m). In Table I, they are listed according to decreasing values of Satsmadjis's (1982) index of coarseness, or "sand equivalent", s', of the substrate, estimated from the relation:

$$s' = s + t / (0.2s + 5) \qquad (1),$$

where s and t indicate the percentages of, respectively, sand and silt. It can be seen that the sediments varied considerably in texture, consisting of from 1 to 80% sand. There was more silt than clay, save in the centre of the gulf, which was richer in clay than near the shore and deeper. The percentage of organic carbon averaged 0.8 and tended to decrease in predominantly sandy deposits.

During the six cruises, the temperature of the water in the proximity of the sea floor had, as shown in Table II, an overall mean of 14.5° C. Though it ranged from 12.4 to 25.1° C, at the majority of the stations (those with depths exceeding 50m), it remained close to 14.5° C. The salinity of the bottom water also was constant, especially below 50 metres: it ranged from 35.8 to 38.8‰ and averaged 38.2‰. On the contrary, the dissolved inorganic nutrient concentrations in the water near the sediments displayed considerable variation: phosphate 0.1-1.5, ammonium 0.0-19.3, nitrite 0.0-14.0, nitrate 0.1-12.1, silicate 0.1-158 μg-at/l. The overall means were respectively 0.22, 1.2, 0.29, 1.4 and 23.8 μg-at/l, denoting unusually high ammonium and silicate contents. The dissolved oxygen in the bottom water, with an overall mean of 5.2 ml/l and a range of 3.6 to 5.9 ml/l, often approached the saturation level.

Composition of the benthic communities

Table III lists all the recorded species and their abundances. On an investigated area of 22.1 m^2, 353 species and 10,662 individuals were found. The most abundant species were by far the Sipunculid *Onchnesoma steenstrupii* (39 ind./m^2), the sedentaria Polychaeta *Tharyx dorsobranchialis* (33 ind./m^2) and *Paraonis gracilis gracilis* (26 ind./m^2), the decapod *Callianassa stebbingi* (22 ind./m^2) and the bivalve *Thyasira flexuosa* (21 ind./m^2). Table IV shows that the great majority of the species (91.9%) belonged to the group of Polychaeta (56.1%), Crustacea (15.8%), Mollusca (14.1%) and Echinodermata (5.9%). The Polychaeta, the Crustacea, the Mollusca and the Sipunculida provided 96% of all the individuals.

TABLE I.
Stations positions, depths and sediment characteristics.

Station	Latitude north	Longitude east	Depth metres	Sediment				
				Sand %	Silt%	Clay %	Sand Equiv.	Org. C. %
35	39°05.4′	023°02.1′	77	79.4	8.6	12.0	79.8	0.13
36	39°03.8′	023°03.9′	72	73.4	12.0	14.5	74.0	0.24
11	39°17.1′	023°00.0′	62	67.2	20.1	12.7	68.3	0.46
4	39°19.1′	022°57.7′	37	62.3	26.8	11.0	63.8	0.40
39	39°00.0′	023°05.1′	65	59.9	9.2	30.9	60.4	0.77
5	39°19.2′	022°59.3′	42	48.9	38.8	12.3	51.5	0.50
3	39°18.7′	022°56.6′	20	37.1	42.9	20.0	40.6	0.56
2	39°20.0′	022°57.8′	31	34.0	49.3	16.7	38.2	0.85
6	39°17.8′	022°57.9′	60	33.7	44.8	21.5	37.5	0.63
34	39°05.4′	023°01.4′	81	31.1	30.1	38.7	33.8	0.67
1	39°20.6′	022°57.4′	17	26.7	46.5	26.8	31.2	0.71
13	39°16.6′	022°53.8′	55	26.5	44.0	29.5	30.8	0.68
19	39°14.0′	022°54.9′	56	22.6	48.2	29.2	27.7	0.59
7	39°17.5′	022°57.0′	58	20.3	50.7	28.9	25.9	0.78
10	39°17.0′	022°57.2′	72	18.5	49.3	32.2	24.2	0.90
12	39°17.1′	023°03.4′	90	15.8	39.2	45.0	20.6	0.77
29	39°08.0′	022°58.4′	74	9.9	58.3	31.8	18.3	0.71
8	39°17.1′	022°54.4′	60	7.7	55.9	36.4	16.2	0.82
38	39°04.4′	023°15.0′	85	6.4	51.3	42.3	14.6	0.68
31	39°08.0′	023°01.9′	83	6.2	48.8	45.0	14.0	0.63
18	39°16.4′	022°56.7′	75	4.4	55.8	39.7	13.9	0.78
17	39°16.3′	022°55.8′	70	4.3	55.6	40.1	13.8	0.78
15	39°16.9′	022°56.4′	70	2.3	59.5	38.3	13.2	0.82
37	39°03.2′	023°09.7′	85	4.5	49.3	46.2	12.9	0.71
9	39°17.2′	022°56.2′	64	1.2	60.3	38.5	12.7	0.80
25	39°11.0′	022°56.4′	66	3.5	52.6	43.9	12.7	0.77
28	39°11.3′	023°08.5′	92	2.5	54.0	43.5	12.3	1.02
16	39°16.6′	022°57.2′	75	2.2	54.1	43.7	12.1	0.85
14	39°16.7′	022°55.8′	66	1.6	55.1	43.3	12.0	0.84
24	39°14.2′	023°09.0′	97	1.1	55.2	43.8	11.7	1.10
20	39°14.1′	022°52.4′	76	3.0	48.0	49.0	11.6	0.79
23	39°14.3′	023°08.2′	96	3.5	44.9	51.6	11.4	0.98
33	39°05.4′	023°00.0′	80	2.2	48.4	49.4	11.1	0.76
32	39°08.7′	023°08.0′	87	1.2	48.3	50.5	10.4	0.98
27	39°11.4′	023°03.2′	88	1.4	41.3	57.3	9.2	0.87
26	39°11.0′	023°00.4′	86	1.2	41.9	58.0	9.2	0.85
30	39°08.0′	023°00.0′	80	1.4	41.0	57.6	9.2	0.65
21	39°14.1′	023°00.0′	90	1.5	36.9	61.6	8.5	0.90
20	39°14.2′	023°03.2′	97	0.9	35.3	63.7	7.7	0.71

TABLE II.
Average parameters of cruises.

	August 1975	Nov. 1975	Feb. 1976	May 1976	August 1976	Dec. 1976	All Cruises
Number of stations	30	28	35	35	32	37	197
Sample area, m^2	5.4	2.8	3.5	3.5	3.2	3.7	22.1
Sum of number of species	141	140	181	141	158	201	353
Sum of number of individuals	1608	1277	1836	1378	1381	3182	10662
Mean of n° species per 0.1 m^2	17.9	19.8	22.2	18.2	18.1	27.4	20.5
Mean of n° indiv. per 0.1 m^2	29.8	45.6	52.5	39.4	43.2	86.0	48.2
Biomass dry g/m^2	0.95	1.20	2.27	1.95	2.68	3.39	2.10
Bottom temperature, °C (*a*)	14.9	15.0	13.7	13.4	14.8	14.9	14.5
Bottom Salinity ‰ (*a*)	38.1	38.2	38.2	38.4	38.2	38.4	38.2
Diss. oxygen, ml/l (*b*)	5.3	5.0	5.4	5.2	5.0	5.0	5.2
Phosphate. µg-at/l (*c*)	0.18	0.21	0.20	0.21	0.31	0.24	0.22
Ammonium. µg-at/l (*c*)	0.8	1.0	0.8	0.7	1.0	3.0	1.2
Nitrite, µg-at/l (*c*)	0.12	0.28	0.26	0.59	0.25	0.24	0.29
Nitrate, µg-at/l (*c*)	0.9	1.0	1.5	1.9	2.0	1.3	1.4
Inorganic N_2, µg-at/l (*c*)	1.82	2.28	2.56	3.19	3.25	4.54	2.89
Silicate, µg-at/l (*c*)	2.6	20.0	100.8	8.6	6.3	4.4	23.8

a. From Gabrielides and Theoharis (1978).
b. From Gabrielides (1978).
c. In bottom sea water.

Table V reveals that the index of coarseness had the most powerful effect on the number of both species, *g*, and individuals, *i*. For closer scrutiny, the 39 locations were divided into three classes, representing coarse, *A*, medium-sized, *B*, and fine, *C*, sediments. These had mean "sand equivalent", *s'*, 47.4, 15.1 and 10.2 and comprised, respectively, the first listed 14 stations (35, 36, 11, 4, 39, 5, 3, 2, 6, 34, 1, 13, 19, 7), the next 14 (10, 12, 29, 8, 38, 31, 18, 17, 15, 37, 9, 25, 28, 16) and the last 11 (14, 24, 20, 23, 33, 32, 27, 26, 30, 21, 20). An extra category, *D*, part of class *A* (mean s'=45.0), was made up of the relatively shallow sites 1, 2, 3, 4 and 5, to elucidate the influence of depth, *h*. In 0.1 m^2 samples, the average figures were: all locations, g=20.2, i=48.2; *D*, g=37.7, i=111.0; *A*, g=34.1, i=89.5; *B*, g=14.1, i=29.1; *C*, g=9.5, i=17.4. Thus, coarse deposits contained nearly four times as many species and five times as many individuals as fine ones. Also, small depths enhanced benthic life. Therefore, *g* and *i* depended on both *s'* and *h*. In the Pagassitikos Gulf, they were given by the reliable equations (Bogdanos and Satsmadjis, in preparation):

$$i = (-0.0187\, s'^2 + 2.63\, s' - 4.0)\ (2.20 - 0.0166\, h) \quad (2),$$

$$g = i/(0.0124\, i + 1.63) \quad (3).$$

Table VI displays average sample compositions estimated according to Satsmadjis (1982). It illuminates the qualitative aspect of the effect of the texture of the substrate on the assemblages. Thus, *Onchnesoma steenstrupii*, the most abundant species in *A*, was absent in *C*. Conversely, *Paraonis gracilis gracilis* and *Callianassa stebbingi* contributed half the individuals in *C*, but just 6% of those in *A*.

Effect of nutrients and oxygen

Table II discloses that the overall averages of the numbers of individuals, *i*, and species, *g*, in a 0.1 m^2 sample varied significantly from cruise to cruise. They did not appear influenced by the season, because the August and December 1976 *i* values (43.2 and 86.0) greatly exceeded the August and November 1975 ones (29.8 and 45.6). On the contrary, they more or less followed the trend of the total dissolved inorganic nitrogen concentration, ΣN. This suggests that the enrichment in nutrients of the bottom sea water, presumably through its favourale action on the phytoplankton multiplication, enhanced the growth of the benthic fauna, raising its biomass, *m*, (correlation coefficient, *r*, with ΣN 0.92), i (r=0.84) and, even, indirectly, *g* (r=0.70).

However, other factors affect life on the sea floor to a much greater extent than the amount of food present there. Thus, although the majority of the species are deposit feeders, the percentage of organic carbon at a certain station did not relate to either *i* or *m*. Moreover, with reference to the mean

TABLE IV.
Comparison of groups

GROUP	Total found		Per square metre		Percentage of total	
	Species	Indiv. or colonies*	Species	Indiv. colonies*	Species	Indiv. colonies
PORIFERA						
Total	**2**	**2**	**0.09**	**0.09**	**0.6**	**0.02**
ANTHOZOA						
Hexacorallia	1	4	0.05	0.18	0.3	0.04
Octo-corallia	1	1*	0.05	0.05*	0.3	0.01*
Total	**2**	**5**	**0.09**	**0.23**	**0.6**	**0.05**
NEMERTINI						
Total	**5**	**88**	**0.23**	**3.98**	**1.4**	**0.83**
POLYCHAETA						
Errantia	78	2593	3.53	117.33	22.1	24.32
Sedentaria	120	4122	5.43	186.52	34.0	38.66
Total	**198**	**6715**	**8.96**	**303.85**	**56.1**	**62.98**
SIPUNCULIDA						
Total	**5**	**966**	**0.23**	**43.71**	**1.4**	**9.06**
BRYOZOA						
Total	**9**	**16***	**0.41**	**0.72***	**2.5**	**0.15***
MOLLUSCA						
Aplacophora	1	5	0.05	0.23	0.3	0.05

GROUP	Total found		Per square metre		Percentage of total	
	Species	Indiv. or colonies*	Species	Indiv. colonies*	Species	Indiv. colonies
Gastropoda	10	104	0.45	4.71	2.8	0.98
Scaphopoda	2	12	0.09	0.54	0.6	0.11
Bivalvia	36	759	1.63	34.34	10.2	7.12
Phoronidea	1	27	0.05	1.22	0.3	0.25
Total	**50**	**907**	**2.26**	**41.04**	**14.1**	**8.51**
CRUSTACEA						
Ostracoda	3	6	0.14	0.27	0.8	0.06
Cirripedia	1	1	0.05	0.09	0.3	0.02
Leptostraca	1	1	0.05	0.05	0.3	0.01
Cumacea	6	63	0.27	2.85	1.7	0.59
Mycidacea	1	39	0.05	1.76	0.3	0.37
Anisopoda	3	198	0.14	8.96	0.8	1.86
Isopoda	6	45	0.27	2.04	1.7	0.42
Amphipoda	20	609	0.90	27.56	5.6	5.71
Decapoda	15	687	0.68	31.09	4.2	6.44
Total	**56**	**1650**	**2.53**	**74.66**	**15.8**	**15.48**
PANDOPODA						
Total	**1**	**3**	**0.05**	**0.14**	**0.3**	**0.03**

GROUP	Total found		Per square metre		Percentage of total	
	Species	Indiv. or colonies*	Species	Indiv. colonies*	Species	Indiv. colonies
ENTEROPNEUSTA						
Total	**1**	**1**	**0.05**	**0.05**	**0.3**	**0.01**
ECHINODERMATA						
Crinoidea	1	1	0.05	0.05	0.3	0.01
Asteroidea	2	4	0.09	0.18	0.6	0.04
Ophiuroidea	6	104	0.27	4.71	1.7	0.98
Echinoidea	4	33	0.18	1.49	1.1	0.31
Holothuroidea	6	158	0.27	7.15	1.7	1.48
Total	**21**	**304**	**0.95**	**13.76**	**5.9**	**2.85**
ASCIDIACEA						
Total	**3**	**5**	**0.14**	**0.23**	**0.8**	**0.05**
GRAND TOTAL	**353**	**10662**	**16.02**	**482.44**	**100.0**	**100.00**

TABLE V.
Species and individuals at each station

Station	Aug. 75		Nov. 75		Feb. 76		May 76		Aug. 76		Dec. 76		Total	
	g	i	g	i	g	i	g	i	g	i	g	i	G	I
35	44	131	33	50	27	67	41	106	16	27	51	177	113	558
36	34	76	33	58	38	66	34	83	15	34	47	142	110	459
11	43	66	30	48	45	93	22	40	45	91	63	189	135	527
4	45	127	46	154	45	156	32	95	34	122	75	387	151	1041
39	—	—	20	28	53	138	27	60	53	145	63	220	108	591
5	31	57	27	102	34	98	13	32	35	116	66	242	117	647
3	30	112	—	—	39	129	—	—	38	130	55	211	105	582
2	33	78	33	89	38	75	39	103	36	104	45	165	119	614
6	27	56	17	37	33	83	31	51	38	70	52	184	102	481
34	—	—	—	—	24	71	38	75	11	12	16	34	59	192
1	—	—	—	—	21	59	31	119	25	76	35	102	71	356
13	25	52	—	—	64	158	43	141	49	119	28	77	130	547
19	—	—	—	—	36	72	21	58	25	52	57	205	84	387
7	29	80	24	69	39	134	18	36	19	26	15	40	83	385
10	20	49	22	65	16	54	14	25	—	—	27	63	53	256
12	19	33	13	24	2	2	7	16	11	13	9	19	34	107
29	—	—	—	—	—	—	—	—	8	16	13	23	18	39
8	17	43	28	93	12	16	21	36	18	33	24	93	59	314
38	20	31	—	—	13	15	11	21	12	17	15	19	36	103
31	—	—	—	—	—	—	—	—	6	14	10	29	14	43
18	19	47	26	59	14	26	18	33	—	—	14	29	47	194
17	23	58	20	40	18	29	17	20	15	21	18	43	54	211

Station	Aug. 75		Nov. 75		Feb. 76		May 76		Aug. 76		Dec. 76		Total	
	g	i	g	i	g	i	g	i	g	i	g	i	G	I
15	21	33	15	31	18	32	14	22	–	–	22	30	48	148
37	27	69	20	34	10	12	16	18	12	26	25	60	60	219
9	28	83	32	80	12	27	18	32	–	–	23	61	65	283
25	15	31	17	33	13	20	9	17	11	21	11	24	46	146
28	–	–	–	–	4	8	4	6	2	4	10	26	10	44
16	16	55	15	22	12	31	11	13	6	10	16	32	42	163
14	17	29	23	63	25	63	11	14	–	–	19	48	53	217
24	10	15	13	19	–	–	–	–	–	–	–	–	25	34
20	14	16	6	9	19	37	20	35	5	11	12	24	44	132
23	–	–	–	–	5	9	7	10	4	8	8	26	13	53
33	18	29	10	13	11	11	10	17	3	9	21	45	46	124
32	–	–	–	–	–	–	5	8	8	18	11	25	16	51
27	17	40	9	15	5	16	6	8	3	7	7	26	27	112
26	10	19	4	16	5	14	10	15	7	9	12	35	33	108
30	19	48	8	16	12	17	7	8	–	–	–	–	28	89
21	15	26	3	3	10	10	4	8	5	9	11	23	29	79
22	8	21	6	10	6	11	6	6	3	5	6	17	20	70

TABLE VI.
Average sample composition.

Species	Number of Individuals				
	Total		A	B	C
	1 m²	0.1 m²	0.1 m²	0.1 m²	0.1 m²
1. Onchnesoma steenstrupii Sip.	52	7	14	2	–
2. Tharyx dorsobranchialis Pol.	43	6	10	3	1
3. Paraonis gracilis gracilis Pol.	34	5	3	5	4
4. Callianassa stebbingi Dec.	28	4	2	4	5
5. Thyasira flexuosa Biv.	27	4	4	4	1
6. Notomastus latericeus Pol.	18	2	6	–	–
7. Glycera convoluta Pol.	18	2	4	1	1
8. Ampelisca diadema Amph.	16	2	3	1	1
9. Paralacydonia paradoxa Pol.	15	2	5	–	–
10. Lumbriconereis gracilis Pol.	14	2	4	–	–
11. Lumbriconereis latreilli Pol.	13	2	4	–	–
12. Lumbriconereis impatiens Pol.	12	2	2	2	1
13. Apseudes latreilli Anis.	10	1	–	2	1
14. Prionospio echlersi Pol.	10	1	2	1	–
15. Eunice vittata Pol.	8	1	3	–	–
16. Harpinia Della-Valei Amph.	8	1	1	1	1
17. Terebelides ströemi Pol.	8	1	1	1	–
18. Hyalinoecia bilineata Pol.	7	1	1	1	–
19. Sternaspis scutata Pol.	7	1	–	1	–
20. Cirratulus sp. Pol.	6	1	2		–

Species	Number of Individuals				
	Total		A	B	C
	1 m^2	0.1 m^2	0.1 m^2	0.1 m^2	0.1 m^2
21. Aricidea fragilis mediterranea Pol.	6		2		–
22. Magelona papilicornis Pol.	6		2		–
23. Melinna palmata Pol.	6		1		–
24. Labidoplax sp. Hol.	5		1		–
25. Nephthys hombergi Pol.	5		–		–
26. Ammotrypane aulogaster Pol.	5		1		–
27. Tharyx marioni Pol.	5		2		–
28. Nephthys hystricis Pol.	5		–		–
29. Processidae Dec.	5		1		–
30. Marphysa bellii Pol.	5		–		–
31. Chrysopetalum debile Pol.	4		1		–
32. Asychis biceps Pol.	4		1		–
33. Podarke pallida Pol.	4		–		–
34. Chaetozone setosa Pol.	4		1		–
35. Aricidea fauveli Pol.	4		1		–
36. Harmothöe lunulata Pol.	4		1		–
37. Amphiura filiformis Oph.	4		1		–
38. Leanira yhleni Pol.	4		–		–
39. Clymene santanderensis Pol.	4		1		–
40. Ancistrosyllis sp. Pol.	4		–		–

Species	Number of Individuals				
	Total		A	B	C
	1 m²	0.1 m²	0.1 m²	0.1 m²	0.1 m²
41. Poecilochaetus serpens Pol.	4		—.		—
42. Pilargis falcata Pol.	4		—		—
43. Cirratulus cirratus Pol.	3		1		—
44. Spiophanes bombyx Pol.	3		—		—
45. Chrysallida sp. Gast.	3		—		—
46. Mystides limbata Pol.	3		1		—
47. Prionospio malmgreni Pol.	3				—
48. Stylarioides plumosa Pol.	3				—
49. Cirratulidae Pol.	3				—
50. Chone filicaudata Pol.	3				—
51. Laonice cirrata Pol.	3				—
52. Vibilidae Amph.					1

TABLE III.
List of species.

	Indiv. or colonies per m²*
PORIFERA	
Suberites carnosus (Johnston)	*0.05*
Sycon raphanus (Schmidt) 1862	*0.05*
ANTHOZOA	
Caryophyllia smithi, (Muller) 1788	*0.18*
OCTOCORALLIA	
Sarcodictyon coralloides Philipi 1842	*0.05**
NEMERTINI 5 un. sp.	*3.98*
POLYCHAETA	
Errantia	
Acrocirrus frontifilis (Grube) 1860	*0.09*
Ancistrosyllis parva (Day) 1963	*0.18*
Ancistrosyllis robusta, Ehlers 1908	*0.27*
Ancistrosyllis sp.	*2.67*
Aphroditidae un. sp.	*0.32*
Arabella iricolor (Montagu) 1804	*0.23*
Chrysopetalum debile (Grube) 1855	*3.44*
Diopatra neapolitana, Delle Chiaje 1841	*0.05*
Eone nordmanni, Malmgren 1866	*0.05*
Eteone shiphonodonta, Delle Chiaje 1822	*0.18*
Eunice vittata (Delle Chiaje) 1868	*6.43*
Euphrosyne myrtosa, Savigny 1818	*0.14*
Exogone hebes (Webster et Benedict) 1884	*0.23*
Gattyana cirrosa (Pallas)	*0.09*
Glycera convoluta, Keferstein 1862	*13.71*
Glycera lapidum, Quatrefages 1865	*1.04*
Glycera papilosa, Grube 1857	*0.05*
Glycera tesselata, Grube 1863	*0.05*
Glycinde nordmannii (Malmgren) 1866	*0.05*
Goniada enerita, Audouin et Milne - Edwards 1833	*0.09*
Goniada maculata, Oersted 1843	*0.81*
Goniada norvegica, Oested 1844	*0.45*
Goniadella gracilis (Verril) 1873	*0.05*
Harmothoe antipolis (Mc. Intosh) 1876	*0.27*
Harmothoe lunulata (Delle Chiaje) 1841	*3.03*

	Indiv. or colonies per m^2*
Hesionidae un. sp.	*0.23*
Hyalinoecia bilineata, Baird 1870	*5.16*
Hyalinoecia brementi, Fauvel 1916	*1.58*
Hyalinoecia tubicola (Muller) 1788	*0.14*
Lacydonia miranta, Marion et Bobretzky 1875	*0.05*
Leanira yhleni, Malmgren 1867	*2.81*
Lepidonotus sp.	*0.05*
Lumbriconereis gracilis (Ehlers) 1868	*10.63*
Lumbiconereis impatiens (Claparede) 1868	*9.32*
Lumbriconereis latreilli, Audouin et M. Edwards 1834	*9.68*
Lumbriconereis Paradoxa, Saint Joseph	*0.14*
Lycidice ninetta, Audouin et Milne - Edwards 1833	*0.18*
Marphysa bellii (Audouin et Milne - Edwards) 1833	*3.67*
Marphysa sanguinea, Montagu 1815	*0.14*
Mystides limbata, Saint - Joseph 1888	*2.22*
Nematonereis unicornis, Schmarda 1861	*1.22*
Nephthys hombergii, Savigny 1818	*4.16*
Nephthys hystricis, Mc. Intosh 1908	*3.80*
Nephthys inermis, Ehlers 1887	*0.50*
Nereis caudata (Delle Chiaje) 1818	*0.05*
Nereis diversicolor (Muller) 1776	*0.14*
Nereis falsa, Quatrefages 1865	*0.14*
Nereis sp.	*0.95*
Notocirrus sp.	*0.14*
Notopygos megalops, Mc. Intosh 1885	*0.05*
Oligognathus boneliae, Spengel 1882	*0.59*
Oxydromus propinquus (Marion et Bobretzky) 1875	*0.05*
Panthalis oerstedii (Kinberg) 1855	*0.41*
Paralacydonia paradoxa, Fauvel 1913	*11.67*
Pholoe dorsipapillata, Marenzeller 1893	*0.05*
Phyllodoce groenlandica, Oersted 1843	*0.18*
Phyllodoce laminosa, Savigny 1818	*0.05*
Phylodoce lineata (Claparede) 1870	*0.45*
Pilargis falcata, Day 1957	*2.71*
Pilargis verrucosa, Saint - Joseph 1899	*0.36*
Pionosyllis sp.	*0.14*
Podarke pallida, Claparede 1864	*3.44*
Polyodontes frons, Hartman 1939	*0.05*
Polyodontes maxillosus (Ranzani) 1817	*0.09*
Protodorvillea biarticulata, Day 1963	*0.05*

	Indiv. or colonies per m^2*
Scalisetosus pellucidus (Ehlers) 1864	*0.09*
Sphaerosyllis bulbosa, Southern 1914	*1.04*
Sphaerosyllis ovigera, Langerhans 1879	*1.18*
Staurocephalus rudolphii, Delle Chiaje 1828	*0.50*
Sthenelais boa (Johnston) 1839	*0.14*
Syllides sp.	*0.09*
Syllis cirropunctata (Michel) 1909	*0.27*
Syllis cornuta (Rathke) 1843	*0.09*
Syllis nigricirris (Gßrube) 1863	*0.05*
Syllis prolifera (Krohn) 1852	*0.09*
Syllis sp.	*1.72*
Syllis spongicola (Gßrube) 1855	*0.68*
Syllis variegata (Grube) 1860	*0.09*
Sedentaria	
Amaea trilobata (Sars) 1863	*0.68*
Amage adspersa (Delle Chiaje) 1828	*0.05*
Ammotrypane aulogaster, Rathke 1843	*3.98*
Ampharete grubei, Malmgren 1865	*0.41*
Ampharetidae un. sp.	*1.13*
Amphitritinae un. sp.	*0.05*
Amphitrite groenlandica, Malmgren 1865	*0.32*
Amphicteis gunneri (Sars) 1835	*0.41*
Anobothrus gracilis (Malmgren) 1865	*0.86*
Aonides paucibranchiata, Southern 1914	*0.54*
Aricia grubei, Mc. Intosh 1910	*0.36*
Aricidae un. sp.	*0.14*
Aricidea capensis, Day 1961	*0.23*
Aricidea curviseta, Day 1963	*1.00*
Aricidea fauveli, Hartman 1957	*3.03*
Aricidea fragilis mediterranea, Laubier 1973	*4.66*
Aricidea jeffreysii, Cerruti 1909	*0.32*
Aricidea longobranchiata, Day 1961	*0.14*
Aricidea suesica simplex, Day 1963	*0.90*
Asyhis biceps (Sars) 1861	*3.26*
Branchioma vesiculosum (Montagu) 1815	*0.09*
Capitella capitata (Fabricius) 1780	*0.09*
Capitellidae un. sp.	*0.05*
Capitella sp.	*0.09*
Chaetopterus variopedatus (Renier) 1804	*0.95*

	Indiv. or colonies per m²*
Chaetozone setosa, Malmgren 1867	*3.12*
Chone collaris, Langerhans 1880	*0.14*
Chone dunneri, Malmgren 1867	*1.86*
Chone filicaudata, Southern 1914	*2.04*
Ciratulidae un. sp.	*2.08*
Cirratullus cirratus (Muller) 1776	*2.44*
Cirratulus sp.	*4.75*
Cirrophorus branchiatus, Ehlers 1908	*0.59*
Clymene affinis (Sars) 1872	*0.45*
Clymene collaris (Claparede) 1868	*0.09*
Clymene gracilis (Sars) 1861	*0.95*
Clymene lophoseta, Orlandi 1898	*0.32*
Clymene oerstrdii, Claparede 1863	*1.00*
Clymene palermitana, Grube 1840	*0.05*
Clymene robusta (Arwidsson) 1906	*0.59*
Clymene santanderensis, Rioja 1917	*2.67*
Clymene sp.	*0.63*
Cossura coasta, Kitamori 1960	*1.86*
Ditrupa arietina (Muller) 1776	*0.05*
Dodecaceria capensis, Day 1961	*0.05*
Dodecaceria concharum, Oersted 1843	*1.36*
Euchone rubrocincta (Sars) 1880	*0.05*
Heterocirrus alatus (Southern) 1914	*0.50*
Hydroides norvegica, Gunnerus 1768	*0.23*
Jasmineira caudata, Langerhans 1880	*0.54*
Johnstonia clymenoides, Quatrefages 1865	*0.09*
Lanice conchilega (Pallas) 1776	*0.09*
Laonice cirrata (Sars) 1851	*1.95*
Leiochone clypeata, Saint-Joseph 1894	*0.81*
Loimia medusa (Savigny) 1820	*0.09*
Macrochaeta clavicornis (Sars) 1835	*0.05*
Magelona papilicornis, Muller 1858	*4.52*
Maldanidae un. sp.	*0.77*
Maldane sarsi, Malmgren 1865	*0.05*
Melinna palmata, Grube 1870	*4.34*
Myriochele heeri, Malmgren 1867	*2.17*
Neosabellides oceanica (Fauvel) 1909	*1.67*
Nerinides tridentata, Southern 1914	*0.14*
Nicomache lumbricalis (Fabricius) 1780	*0.09*
Niocomache maculata, Arwidsson 1911	*0.05*

	Indiv. or colonies per m^2*
Nicomache sp.	*0.32*
Notomastus latericeus, Sars 1851	*13.94*
Notomastus sp.	*1.04*
Ophelia bicornis, Savigny 1820	*0.05*
Ophelina sp.	*0.05*
Oridia armandi (Claparede) 1864	*0.09*
Owenia fusiformis, Delle Chiaje 1844	*0.45*
Palasia cirrata, Kinberg 1867	*0.27*
Paraonidae un. sp.	*1.86*
Paraonis gracilis gracilis (Tauber) 1879	*25.70*
Paraonis lyra (Southern) 1914	*0.05*
Paraonis gracilis oculata, Hartman 1957	*0.09*
Pectinaria auricoma (Muller)	*0.09*
Pectinaria capensis (Pallas) 1776	*0.23*
Pectinaria koreni (Malmgren) 1866	*1.27*
Petaloproctus terricola, Quatrefages 1865	*0.18*
Phyllochaetopterus solitarius, Rioja 1917	*0.18*
Pista cristata (Muller) 1776	*0.63*
Pista sp.	*0.18*
Poecilochaetus serpens, Allen 1904	*2.67*
Poecilochaetus fulgoris, Ehlers 1874	*0.05*
Polycirrus haematodes (Claparede) 1864	*0.05*
Polycirrus medusa, Grube 1855	*0.32*
Polycirrus sp.	*0.32*
Polydora antenata, Claparede 1870	*0.59*
Polydora caeca (Oersted) 1843	*0.09*
Potamilla reniformis (Muller) 1788	*0.05*
Prionospio cirrifera, Wiren 1883	*0.18*
Prionospio cirrobranchiata, Day 1961	*0.05*
Prionospio ehlersi, Fauvel 1936	*7.87*
Prionospio malmgreni (Claparede) 1870	*2.22*
Prionospio steenstrupi, Malmgren 1867	*0.72*
Proclea grafii (Langerhans) 1884	*0.18*
Sabellaridae un. sp.	*0.05*
Sabellidae un. sp.	*0.05*
Sabella pavonina, Savigny 1820	*0.05*
Scalibregma inflatum, Rathke 1843	*0.63*
Scolelepis ciliata (Keferstein) 1862	*0.05*
Scoloplos armiger, O.F. Muller	*0.09*
Serpulidae un. sp.	*0.18*

	Indiv. or colonies* per m^2
Serpula concharum, Langerhans 1880	0.05
Serpula vermicularis, Linne 1767	0.14
Sphaerodorum sp.	0.05
Spionidae un. sp.	0.23
Spiophanes bombyx (Claparede) 1870	2.44
Sternaspis scutata (Renier) 1807	5.16
Streblosoma bairdi (Malmgren) 1866	0.09
Stylariodes plumosa, O.F. Muller	2.13
Terebellides un. sp.	0.41
Terebellides stroemi, Sars 1835	6.11
Tharyx dorsobranchialis (Kirkegaard) 1959	33.12
Tharyx marioni (Saint Joseph) 1894	3.89
Tharyx multibranchis (Grube) 1863	0.14
Trochochaetidae un. sp.	0.05
Vermiliopsis infundibulum (Philippi) 1844	0.50
SIPUNCULIDA	
Aspidosiphon muelleri (Blaiville) 1827	1.72
Golfingia vulgaris (Dé Blainville) 1827	0.63
Onchnesoma steenstrupii, Koren et Danielssen 1868	39.41
Phascolosoma granulatum, Leuckart 1828	1.67
Sipunculus nudus, Linne 1766	0.27
BRYOZOA	
Aetea sp.	0.05*
Beania hirtissima (Heller) 1867	0.09*
Bugulla neritina, Linne	0.05*
Bugula sp.	0.27*
Cellaria fistulosa, Ellis et sol	09*
Mimosela sp.	0.05*
Porella sp.	0.05*
Valkeria uva, Heller 1867	0.05*
Zoobothryon sp.	0.05*
MOLLUSCA	
Aplacophora	
Falcidens gutturosus (Kowaleski) 1901	0.23
Gastropoda	
Bulla sp.	0.27
Calyptreaea chinensis, Linne 1758	0.14

	Indiv. or colonies per m²*
Chrysallida sp.	*2.40*
Mellanella sp.	*0.09*
Murex sp.	*0.09*
Natica sp.	*0.18*
Riscoacea un. sp.	*0.54*
Scaphander lignarius, Linne	*0.68*
Turitella communis, Risso 1826	*0.14*
Turitella triplicata, Monterosato 1877	*0.18*
Schaphopoda	
Dentalium agile, Sars 1872	*0.09*
Dentalium sp.	*0.45*
Bivalvia	
Anomia ephipium, Linne 1758	*0.05*
Arca tetragona, Poli 1795	*0.05*
Beguinea sp.	*0.05*
Cardium echinatum, Linne 1767	*0.32*
Cardium sp.	*0.72*
Corbula gibba (Olivi) 1792	*1.27*
Cultellus pellucidus, Phillipi 1836	*1.31*
Cuspidaria cuspidata (Olivi) 1792	*0.05*
Cuspidaria costellata, Deshayes	*0.23*
Dosinia exoleta (Linne) 1758	*0.05*
Dosinia sp.	*0.14*
Elisia sp.	*0.86*
Kellia suborbicularis (Montagu)	*0.05*
Leda fragilis, Chemnitz 1784	*0.32*
Lima sp.	*0.14*
Loripes lacteus (Linne) 1758	*0.23*
Lucinidae un. sp.	*0.05*
Macoma sp.	*0.09*
Macoma tenuis (Poli) 1795	*0.14*
Modiolus barbatus (Linne) 1758	*0.09*
Nucula nucleus (Linne) 1767	*0.05*
Nucula turgida, Leckenby - Marshall	*1.67*
Pitaria sp.	*0.05*
Psamobia sp.	*1.67*
Saxicava arctica (Linne) 1767	*0.27*
Tellinidae un. sp.	*0.27*

	Indiv. or colonies* per m^2
Tellina pulchella, Lamark 1818	0.95
Tellina serrata, Brocchi 1814	0.18
Tellina sp.	0.14
Tellina tenuis (Da Costa) 1778	0.05
Thracia papyracea (Poli) 1795	0.18
Thracia sp.	0.05
Thyasira flexuosa (Montagu) 1803	20.77
Veneridae un. sp.	0.09
Venus cassina, Linne 1758	1.67
Venus gallina, Linne 1758	0.14
PHORONIDEA	
Phoronis muelleri, Selys Longchamp 1903	1.22
CRUSTACEA	
Ostracoda	
Archiconchoecia sp.	0.05
Cypridina mediterranea	0.09
Cypridina sp.	0.14
Cirripedia	
Scalpelum scalpelum (Linne) 1761	0.09
Leptostraca	
Nebalia bipes (Fabricius) 1780	0.05
Cumacea	
Camplylaspis sp.	0.09
Cumella limicola, Sars 1879	0.27
Cumella sp.	0.45
Iphinoe serrata, Norman 1867	1.54
Leucon sp.	0.45
Pseudocuma sp.	0.05
Mycidacea un. sp	1.76
Anisopoda	
Apseudes latreilli (Milne Edwards) 1828	1.96
Leptochellia savignyii (Kroyer) 1842	0.72
Tanais cavolinii, Milne Edwards 1829	0.27
Isopoda	
Anthura gracilis (Montagu) 1808	0.63

	Indiv. or colonies per m^2*
Cirolana borealis, Lilljeborg 1851	*0.05*
Cirolana sp.	*0.23*
Euridice sp.	*0.09*
Gnathia phallonajopsis, Monod 1926	*0.68*
Phryxus abdominalis (Kroyer) 1840	*0.36*
Amphipoda	
Ampelisca diadema (Costa)	*12.49*
Amphilochus sp.	*0.14*
Argissa sp.	*0.09*
Dulilchiidae un. sp.	*0.09*
Gammaridae un. sp.	*0.09*
Gammarus olivii, M. Edwards	*0.54*
Harpinia Della-Valei, Chevreux	*6.24*
Hippomedon bidentatus, Chevreux 1903	*0.14*
Hippomedon oculatus, Chevreux et Fage 1925	*0.14*
Leucothoe spinicarpu (Abild.)	*1.00*
Lyssianassa longicarnis, Lucas	*1.18*
Metaphoxus sp.	*1.27*
Monoculodes sp.	*0.68*
Niphargus sp.	*0.09*
Nototropis guttatus (Costa)	*0.23*
Phoxocephalidae un. sp.	*0.09*
Podoprion bolivari, Chevreux 1891	*0.23*
Pthisica marina, Slabber 1749	*0.81*
Vibilidae un. sp.	*1.72*
Westwoodilla rectirostris, Della Valle 1893	*0.32*
Decapoda	
Alpheus glaber, Olivi 1792	*0.14*
Callianassidae un. sp.	*0.23*
Callianasa stebbingi, Petagna 1792	*21.72*
Ebalia cranchi, Leach 1817	*0.05*
Galathea sp.	*0.63*
Goneplax rhomboides, Linne 1758	*1.04*
Jaxea nocturna, Nardo 1847	*0.21*
Macropodia longirostris, Forticius 1775	*0.05*
Maiide un. sp.	*0.05*
Natadia un. sp.	*0.09*
Portunus depurator (Linne)	*0.05*
Portunus pussilus, Leach 1816	*0.27*

	Indiv. or colonies* per m^2
Processidae un. sp.	3.80
Upogebia sp.	0.86
PANDOPODA	
Nymphon sp.	0.14
ENTEROPNEUSTA	
Glossobalanus minutus, Kowalesky 1866	0.05
ECHINODERMATA	
Crinoidea	
Ampedone sp.	0.05
Asteroidea	
Asterina gibbosa, Pennant 1777	0.05
Astropecten spinulosus, Philippi 1837	0.14
Ophiuroidea	
Amphiura chiajei, Forbes 1843	1.09
Amphiura filiformis, Muller 1776	3.03
Ophiothrix fragilis, Abild	0.05
Ophiothrix quinquemaculata, Delle Chiaje 1828	0.18
Ophiura albida, Forbes 1839	0.32
Ophiura sp.	0.05
Echinoidea	
Brisopsis lurifera, Forbes 1841	0.05
Brissus unicolor, Leske 1778	0.81
Echinocyamus pussilus, Muller 1776	0.59
Spatangus purpureus (Muller) 1776	0.05
Holothuroidea	
Cucumaria elongata (Duben et Koren) 1844	0.09
Cucumaria tergestina (Sars) 1857	0.90
Labidoplax digitata (Montagu) 1815	1.13
Labidoplax sp.	4.16
Thyone fusus (Muller) 1788	0.09
Thyone sp.	0.77
ASCIDIACEA	
Ascidia virginea (Muller) 1776	0.09
Microcosmus sulcatus (Coquebert) 1797	0.09
Phallusia mammilata, Savigny 1816	0.05

figures for the classes of stations *D, A, B* and *C*, ΣN (1.90, 2.26, 3.07 and 3.77 μg-at/l) denoted a strongly negative correlation with *i* (111.0, 89.5, 29.1 and 17.4) and *m* (3.31, 3.49, 1.76 and 0.77 g/m^2). This is because the concentrations of organic carbon and nutrients tended to rise with the fineness of the sediment, which, together with depth, as we have seen in the previous paragraph, exerts a most detrimental influence on benthos.

Large sand particles and empty shells, by increasing the space available per unit area, undoubtedly allow greater abundance and diversity. But they cannot account for the dramatic qualitative changes observed in the biocoenoses when the index of coarseness, *s'*, diminishes. Considering the extreme dependency of marine animals on dissolved oxygen, it must be inferred that the overriding influence of *s'* results from its effect on the flow of oxygen within the few centimetres above or below the surface of the substrate. Fine particles imply weak currents and retard gas exchange. Shallow waters mean proximity to the atmosphere, along with greater phytoplankton activity and, hence, on the spot oxygen production; also, they suggest agitation. The level of the dissolved oxygen in the water one or more metres above the bottom (5.2, 5.3, 5.2 and 4.9 ml/l for *D, A, B* and *C*) does not reflect the quantity of the gas available to benthos, unless it be substantially lower than normal.

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