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A Phytoplankton Study of Southern Adriatic Waters near Dubrovnik for the Period from June 1979 to July 1980.

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ABSTRACT

The spatial and temporal dynamics of populations, as well as the biomass expressed as the total cell volume of particular size and taxonomical categories of phytoplankton in the southern Adriatic near Dubrovnik were investigated. All analyses were based on 100 plankton net samples and 310 Nansen bottle samples taken at 9 stations. The phytoplankton parameters, such as distribution of species, distribution of phytoplankton cell density and biomass, as well as species diversity were used for the ecological characterization of the investigated area. A total of 284 microplankton taxons were determined. The microplankton quantity ranged from 2.2×10^2 to 4.0×10^6 cells/l, and 9.2×10^5 to 7.6×10^9 $\mu m^3/l$ respectively. The nanoplankton cell density ranged between 6.2×10^4 and 5.2×10^6 cells/l, and cell volume between 3.9×10^6 and 9.1×10^8 $\mu m^3/l$. The most frequent values of the Shannon and Weaver diversity index ranged between 3 and 4 at open sea stations and between 2 and 3 at coastal stations.

Introduction

To date there is insufficient data on the phytoplankton of the southern Adriatic. The first investigations were performed in the open sea during the expeditions of "Najade" (Schiller 1912; 1913 a, b, c; 1925 a, b; Schussnig 1915) and "Thor" (Jörgensen 1920, 1923) but they referred almost exclusively to the taxonomy of net phytoplankton. The phytoplankton cell density in offshore waters of the southern Adriatic was later analysed by Pucher-Petković (1957) and Denisenko (1963) and the biomass in terms of chlorophyll a concentrations by Revelante and Gilmartin (1977). In the neritic area, the phytoplankton quantity was determined as cell density (Ercegović 1938; Pucher-Petković 1957, 1960; Buljan et al. 1973), the rate of primary production (Marasović and Pucher-Petković 1981) and the biomass in terms of total cell volume (Viličić 1981, 1983; Viličić and Balenović 1982). Revelante and Gilmartin (1977) presented the relative contribution of microplankton to total community cell volume in the Adriatic Sea from September to October 1974.

In this paper, the results of the spatial and temporal dynamics of populations, as well as the biomass in terms of the total cell volume of the particular size and taxonomical categories of phytoplankton in the southern Adriatic near Dubrovnik are presented.

About four fifths of the Adriatic Sea bottom is less than 200m deep. The southern Adriatic region with the South Adriatic Pit is the deepest (1243 m) and widest part of the Adriatic and contains nearly four times more volume of water than the middle and the north Adriatic. Through the Otranto Strait the southern Adriatic is connected with the Ionian Sea and with the eastern Mediterranean. A strong continental influence on the Adriatic Sea and its connection with the eastern Mediterranean results in the specific rhythm of the exchange of water masses between these two systems (Zore 1956, Buljan and Zore-Armanda 1976). The differences in temperature and in salinity distribution, and hence in density distribution, result in an incoming surface (to the depth of about 40 m) current prevailing in winter and an outgoing surface current prevailing in summer. The winter incoming current is more pronounced along the eastern coast and the summer outgoing current along the western Adriatic coast. Besides the surface layer, a middle (intermediate) and bottom layer can be differentiated in the southern Adriatic waters. The main currents are more or less parallel with the Adriatic coasts, but besides these and the vertical currents, there are also transversal currents which go mainly from the east to the west coast and which are more pronounced in spring and in autumn (Vučak 1956, Zore-Armanda 1968).

Along the eastern Adriatic coast, the meteorological and hydrographical conditions are specific. The strong north and south winds, especially in winter, influence the exchange between the deeper, open sea and the neritic waters.

The continental area nearer to the coast is composed of a high permeable limestone mass having specific hydrogeological characteristics. The groundwater drainage towards the sea and the underground connections between ponors (swallow holes) and vruljas (submarine springs) is intensive especially during the rainy periods. These characteristics are important for the salinity and temperature régime of neritic waters.

Samples for the phytoplankton analysis and basic hydrographical measurements were taken at the stations arranged along two profiles (Fig. 1) The first profile starts from the open sea and ends in the Gruž Bay where the harbour of Dubrovnik is situated (Stations 1-4). Station 1 is situated 25 nautical miles from Dubrovnik in the southwest direction, in the area of the South Adriatic Pit and at a depth of about 1000 m. The positions of Stations 2 and 3 are above the isobaths of 300 and 100 m respectively. Station 4 is in the Bay of Gruž which is influenced by the sewage waters of the town and by the fresh waters of the river Ombla which empty into the sea at its source on the north side of the town. The second profile connects the stations in the Mali Ston Bay (Stations 5-9). The area is scarcely inhabited, unpolluted and is well known as an oyster and mussel farming region. The significant coastal indentation and the dense cover of vegetation, as well as the mouth of the river Neretva on the outer part of the Bay, are the main sources of natural eutrophication.

The nutrient salt concentrations in the investigated region were measured during some of the previous investigations. The phosphate and nitrate concentrations in the

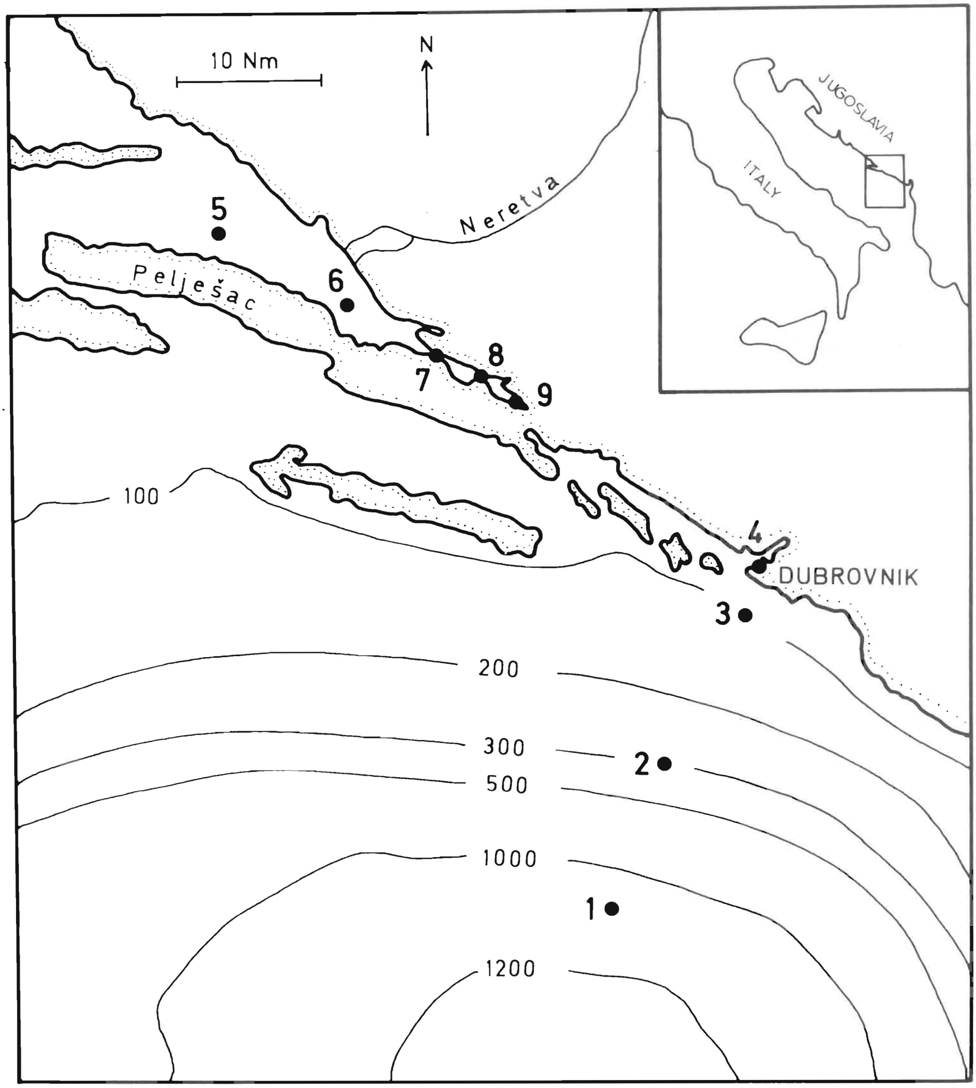

Fig. 1. Map of the area investigated with location of stations.

South Adriatic Pit region (in the layer 0-200 m) amounted to 0.09-0.10 μg-at PO_4-P/l and 0.42-0.92 μg-at NO_3-N/l, respectively (Stojanoski 1975, Buljan et al. 1975). In the coastal waters near Dubrovnik, the values of 0.03-0.20 μg-at PO_4-P/l and 0.11-0.55 μg-at NO_3-N/l respectively, were the most frequently obtained (Buljan et al. 1973, Buljan and Zore-Armanda 1979). The silicate concentrations in the coastal region varied from 2.50 to 16.86 μg-at SiO_2-Si/l.

Material and Methods

The position of the stations shown in Figure 1 and the program of sample collection has been defined considering the predictable ecological conditions in the investigated south Adriatic area.

Detailed qualitative microplankton analyses were based on 100 samples obtained by a plankton net having 53 μm mesh netting. At the neritic stations, where the depth was not more than 50 m, the vertical hauls were made from the bottom up to the surface. At the open sea stations, the samples were taken by a closing net in layers (200-100, 100-50 and 50-0 m). The microplankton species composition was analysed by the use of the ordinary brightfield and phase contrast microscope under magnifications of 100, 240 and 480 X. The classification of phytoplankton was made according to the modified Pascher's system (Ettl 1980). Taxonomic nomenclature was adapted in accordance to Gemeinhardt (1930) for Chrysophyceae; Schiller (1930) for Haptophyceae; A. Travers and M. Travers (1975), Hendey (1974) for Bacillariophyceae and Prasinophyceae; A. Travers and M. Travers (op. cit.) and Schiller (1933, 1937) for Dinophyta.

Samples for the quantitative analysis of the phytoplankton and for the salinity determinations were taken by Nansen reversing bottles at the depths of 0, 5, 10, 20 m at the neritic stations, and at 0, 10, 20, 50 and 100 m at the open sea stations. Totally, 310 Nansen bottle samples were taken and analysed during the investigation. All net samples and Nansen bottle samples were preserved with a two per cent neutralized formaldehyde solution. The phytoplankton cell counts were obtained by the inverted microscope method (Utermöhl 1958). Samples of 25, 50 or 100 ml were analysed microscopically after a sedimentation time of 24 hours. The phytoplankton cells smaller than 15 μm (maximal length) were designated as nanoplankton and cells longer than 15 μm as microplankton. The cells smaller than 15 μm but which made longer colonies, as well as the cells whose length was longer than 15 μm due to the presence of hair-like spines, were also included with microplankton. The counting of microplankton cells was performed under magnifications of 200 and 80 X. For the smaller, more abundant cells, transects across the central part of the counting chamber base plate were made with a higher-power lens. Nanoplankton cells were counted in 20-50 randomly selected fields of vision along the counting chamber bottom plate under the magnification of 320 X. Precision of the counting methods was about $\pm$ 10 per cent. Data on the composition and distribution of phytoplankton species were completed with the information about species dominance. This is represented by the figures + to 6 indicating the orientational values of the population density, as follows:

figure	**cells/l**
+	$<10^1$
1	10^1 - 10^2
2	10^2 - 10^3
3	10^3 - 10^4
4	10^4 - 10^5
5	10^5 - 10^6
6	$> 10^6$

Figure + indicates the population present only in the net samples, but not counted with the inverted microscope.

Assuming that the biomass was equal to the total cell volume, the latter was calculated according to Smayda (1978). Cell volumes of various species was measured according to the cell models constructed by means of photomicrographs and drawings. To decrease the error in total cell volume estimations because of the cell size variability, the measuring of cell dimensions was performed simultaneously with the cell countings. Hair-like spines and setae of diatoms were not included in cell volume values.

The mean value of phytoplankton quantity (cell number, cell volume) was calculated in the whole water column at the neritic stations and in the layer from 100 m to the surface at the open sea stations, according to Riley (1957).

The diversity of the microplankton was estimated according to Shannon and Weaver (1963).

Salinity was determined by the arginometric titration method (Knudsen 1901, Oxner 1920) standardized against Copenhagen standard sea water. Temperatures were measured with reversing thermometers, and seawater transparency with a Secchi disc of 30 cm diameter.

Results and Discussion

The investigated stations differed in salinity, temperature and water transparency (Fig. 2). The salinity values in the open sea (Stations 1 and 2) were high during the whole year, with small annual variations (37.09-38.96°/oo). Approaching the coast, the salinity variations increased and were 35.71-38.90°/oo at Station 3, 28.80-38.70°/oo at Station 4, and 19.00-38.38°/oo at Stations 5, 6, 7, 8 and 9. The lowest salinity values were registered along the coastal region at the surface, especially during the periods of intensified precipitation. The water transparency depended upon the phytoplankton quantity as well as on the allochthonous matter carried to the system by surface and subsurface drainage, characteristic for the carst region. Secchi disc visibility ranged from 27 to 32 meters in the open sea and from 3 to 10 meters in the neritic region. The yearly variations in temperature in the open sea varied from 13.8 to 24.1°C and in the coastal region from 10.3 to 24.6°C.

After the analysis of 410 samples, performed by the ordinary and inverted microscope, a total of 284 phytoplankton taxons were determined, of which 276 were species (Table 1). To the division Chrysophyta belong 161 species (Bacillariophyceae 144, Haptophyceae 14, Chrysophyceae 3) and to Dinophyta 122 species. The division

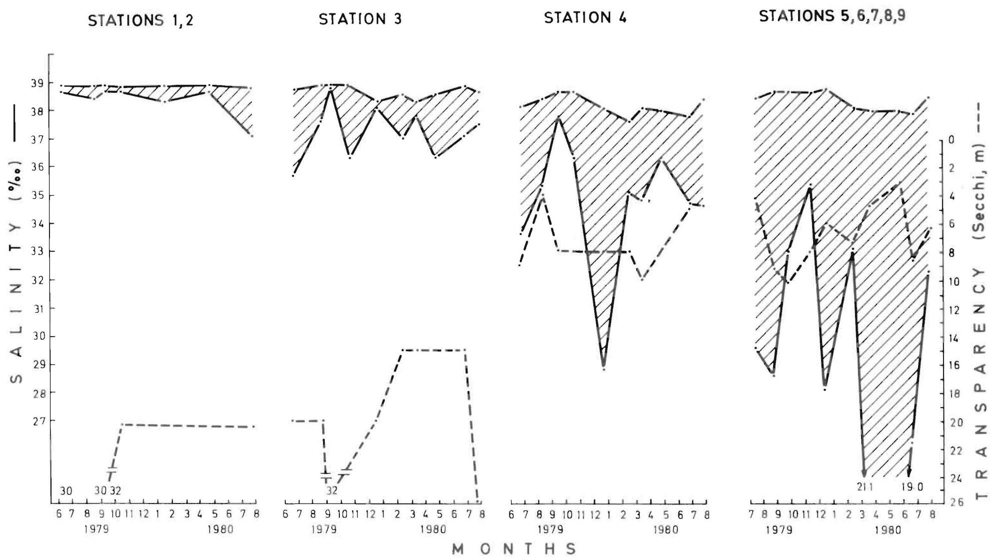

Fig. 2. Variations in salinity and transparency at the investigated stations.

Table 1. List of determined species and their mean cell density determined at all investigated stations (1-9) from August (8) 1979 to July (7) 1980.

months and stations	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
CHRYSOPHYCEAE +	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
HAPTOPHYCEAE												
Acanthoica sp.	....	....	...	....	.1....	+	.....	....	....	+....	....	....
Calciosolenia granii	....	++.....+.	++2	+.11122	+12332	1	.221.	..++++.	.++.	.....	...+...	+........
C. murrayii	....	....	...	....	......	1	.+..+	....	...+	.....	....	....
Calyptrosphaera oblonga	.1......	11111.1.2	1++	+.+....	......	.	...+.	..1+...	....	.....	....	++1..+.1.
Coccolithus pelagicus	....	.++...++.	+..	....	......	.	.....	....	....	+....	..+.+..	++.......
Dictyocha fibula	++.1....	+1.+.....	++1	2.++1++	+2++21	1	+++12	+.+....	11++	.....	....	+++......
D. speculum	....	..+......	...	...+1+.	..+.+1	.	...1.	....	+...	.....	....	....
Dinobryon sp.	....	....	...	....	......	.	.....	....	....	.++11	+.+....	....+++..
Discosphaera thomsonii	.1......	++.......	+..	....	......	.	.....	....	....	.....	....	+........
D. tubifera	....	+.1......	...	....	......	+	.....	....	....	.....	....	....
Rhabdosphaera clavigera	+.......	.+..1++.1	+..	....	......	.	.....	....	....	.....	....	+........
R. hispida	....	....	+..	....	......	.	.....	....	....	.....	....	......+..
R. stylifera	1++12+++	+++.1....	++.	....	......	.	.....	....	....	.....	....	....
R. tignifer	....	+++..1+++	++.	..++...	.+....	+	.....	...+...	++++	+....	....	++..+....
Scyphosphaera apsteinii	....	++.......	+..	....	......	+	.....	....	....	.....	.+.....	....
Syracosphaera pulchra	1+++.+1.	112122212	1+1	+.11121	.112.2	1	.22+.	+......	+...	+....	+......	1+.+.+...
Thorosphaera elegans	+.......	.+.......	+..	....	......	.	.....	....	....	.....	....	....
BACILLARIOPHYCEAE												
Achnanthes longipes	..+.....	..++.+...	..+	....	.+....	.	+....	.....++	....	.....	++.....	....
Actynocyclus octonarius	.+....+.	....	...	....	......	.	+..+.	...+...	+...	+....	....	+........
A. octonarius var. tenella	+.......	....	...	....	......	.	.....	....	....	.....	....	....
Amphora ostrearia	....	....	.+.	.+.....	......	.	.....	....	..+.	.....	.+.....	..+......
Amphiprora alata	....	....	...	+......	......	.	.....	....	....	.....	....	....
A. decussata	....	....	...	.....+.	......	.	.....	....	....	.....	..+..+.	....
A. pulchra	....	....+....	...	....	......	.	.....	....	....	.....	....	....
A. sulcata	....	....	.+.	++.....	......	.	.....	....	..+.	.....	..+....	..+......
Asterionella bleakeleyii	....	....	...	....	......	.	.....	+..+.2+	..+.	.+...	.....+.	....
A. japonica	....+11+	...+.....	...	++.....	+2....	+	+++..	+..++1.	+.+.	.....	....	+........
Asteromphalus heptactis	+.......	++.......	++.	...+...	+.....	+	.....	....	....	.....	....+..	+.....+..
A. flabellatus	.+......	....	...	....	......	+	.....	....	....	.....	....	....
Asterolampra marylandica	++.+....	+++......	++.	+++....	++++..	+	+.+..	+..+...	+++.	++...	..+++..	++.+.....
A. grevilleii	+.......	....	...	....	......	+	.....	....	++..	.....	.+.....	....
Auricula adriatica	....	....	...	....	......	.	.....	....	..+.	.....	....	....
A. insecta	....	....	...	....	......	.	+....	...+...	....	.....	+......	....
Bacillaria paradoxa	....	..+......	.+.	+++....	+.+...	+	.....	+......	..+.	.....	....	....
Bacteriastrum biconicum	....	....	+..	....	+.+...	.	.....	....	....	.....	....	....
B. delicatulum	++++112+	+++1+11+2	+.+	...+++.	++++++	+	+1+1+	+122232	1+24	12+11	+2132+.	1+1+24442
B. elegans	..+.....	....	...	....	......	.	.....	....	....	.....	....	....
B. elongatum	1+......	+++......	+..	....	......	+	.....	+..+...	++++	.....	....	+.+......
B. hyalinum	....	........+	+..	....	++....	.	++++.	..23332	++13	+..+.	....	+........
Biddulphia mobiliensis	....	..+......	...	+......	.+..+.	.	+....	....	..+.	.....	....	....
B. pulchella	....	....	...	....	......	.	.....	....	..+.	.....	....	....
B. titiana	....	....	...	....	......	.	.....	....	..+.	.....	+......	....
Campylodiscus thuretii	....	......+..	...	.+...+.	.+....	.	.....	....	....	.....	....	....
Cerataulina pelagica	+.++2+23	+++++1+.+	.+.	++.++++	++++12	.	+++++	++2122+	1+13	11111	+22122.	++++22321
Cerataulus smithii	....	....	...	.+.....	......	.	.....	....	....	.....	....	....

	months and stations											
	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
Chaetoceros affinis	++++++++	+++.+++++	+++	++.++++	++1+++	+	+1121	+223132	++22	11++1	.....+.	+++++++++
C. anastomosans	+++++...	+++++....	+..	++.....	++....	.	.....	...+...	+++.	++.++	..+++1.	+...23343
C. atlanticus	++......	+++......	+..	.+.....	......	.	.+...	+.++...	+.+.	.....	....	+.+..+.+.
C. brevis	....	+.+.+.+++	++.	...++++	.+++++	.	+1...	+..+...	..+.	++.1+	.+1+22.	+++134434
C. coarctatus	.+......	.+.......	.+.	+..++..	+.+.+.	.	.....	..+....	..+.	.....	....	.+.....+.
C. compressus	2++21233	+111144++	+..	+.+++++	++++++	+	+1+1+	++22343	1++3	22+++	++43432	1++444554
C. convolutus	++......	+++.+....	+.+	++.++++	++++++	+	....+	++.+++.	++++	++...	....	1++113.1.
C. costatus	....	....	...	....	.+....	+	+++..	..++.1.	+...	.....	....	....
C. curvisetus	++.+.+++	+++.2++..	++.	++.++++	+++.+1	.	+1231	1+2222+	1+23	++.+.	+.1+.+.	+++4+....
C. dadayii	....	.+.+.++..	...	++.....	++....	+	.....	..+....	....	.....	....	1++++....
C. danicus	....	....+....	.+.	++.+..+	+.+...	.	.....	....	....	.....	.+.....	....
C. decipiens	++++++++	+++.+3112	++.	+++++++	++1+++	+	+1121	++21121	++11	++...	+++++..	+++2+1+12
C. delicatulus	....	....	...	....	..++++	+	.+...	....	....	.....	...+.+.	....
C. densus	...+....	....	..+	....	......	+	.....	....	....	.....	....	....
C. didymus	++......	....	...	....	......	.	...+.	.....+.	+...	.....	....	+....+...
C. diversus	++++++++	++++++11+	+++	+1+++++	++1+++	+	+++++	..++...	.++2	2+.++	+111121	+++.11231
C. lauderii	....	+++.+...+	.+.	+.....+	+.....	+	++++.	+......	..++	.....	++.....	..++++1+.
C. lorenzianus	++....+.	++...++++	...	....	......	.	.....	....	+++1	.+...	....	+........
C. messanensis	++......	+++......	++.	....	......	+	..++.	.....+.	+...	.....	....	....
C. perpusillus	....	+......+.	...	....	+.+...	.	.....	.+.....	....	+1222	.+.1+..	...1.....
C. peruvianus	....	+++......	...	....	......	.	...+.	....	....	.....	....	+........
C. rostratus	..+++++.	+.+.++.+2	1+2	+++++.+	++1+++	1	+.112	+.+++++	.++.	.+...	+++1+..	+.....+..
C. simplex	....	+++.+...+	++.	.+.+..+	+.+...	+	.....	....	++.+	++.++	.+12+1.	+++......
C. tetrastichon	.++.1++.	+++......	...	....	......	.	.....	.+.....	..+.	.....	++.....	.+++..1+1
C. tortissimus	...++++.	..++.++++	...	...++++	++1+++	+	+++..	+.++1++	.++.	++.+.	++++++.	.+...2...
C. vixvisibilis	++....+.	+++.+4444	++.	.....++	+....+	+	+....	..13341	++11	43321	++44443	2+1244554
C. wighamii	++......	.....++.+	++.	....	......	.	.....	..++...	+++2	++..+	..1++..	....1++1.
Cocconeis scutellum	....	....	...	.1+....	......	.	.....	.1.....	...+	.....	.1.....	...++..+.
Coscinodiscus granii	....	++.......	...	....	......	.	.....	....	+...	.....	....	+........
C. janischii	....	..+......	...	..++...	......	.	.....	+...+..	+...	.....	....	....
C. lineatus	++......	+........	+..	....	......	+	.....	....	++..	.....	....	+........
C. perforatus	....	....	+++	+.+..+.	......	.	+.+.+	..+..+.	++.1	.....	....+..	+.....+..
C. stellaris	.+......	++.......	+..	....	......	+	.....	....	++..	.....	....	++.......
C. thorii	.+......	....	...	...++++	..+.++	.	..+.+	+..+.+.	..+.	1....	.+.+++.	++++.....
Cyclotella sp.	.++.2323	.+..1....	.+.	....	......	.	.....	+.+.+11	.++.	2+131	.+3+233	++...+111
Dactyliosolen mediterraneus	++++...+	++++22++.	+++	+++++++	1+++++	+	+++..	+.++.++	++++	++.++	+++.++.	+++1+1.11
Diploneis bombus	.+++....	+.+1+..+.	+.1	.1+.132	+2++21	1	.+12.	+.+++1.	++.1	+.+1.	+......	+11.+.+..
D. crabro	..+.....	....	...	....	......	.	.....	....	....	.....	....	....
D. smithii	..+.....	....	...	....	......	.	.....	....	....	.....	....	....
Donkinia recta	....	....	...	....	.+....	.	.....	....	....	.....	....	....
Eucampia cornuta	....	......+..	...	...++++	.+++++	+	.....	......+	+..+	.....	....	....
Fragillaria sp.	....	.+.......	...	+...+..	+.....	.	+....	....	....	.....	....	...+.....
Gossleriella tropica	.+......	++.......	...	....	......	+	.....	....	....	.....	....	++.......
Grammatophora marina	..+...+.	....	...	....	......	.	+....	....	..+.	+....	....	....
Guinardia blavyana	....	+.+..+...	+.+	++.+..+	+++...	+	+....	+..+...	++11	++++.	+.++++.	1++++1++.
G. flaccida	++1++121	+++1122+2	+++	++.++++	++11++	+	+++.+	+.1+++1	+++1	++11+	++++211	1++++1++1
Gyrosigma balticum	....	....	...	....	......	.	.....	+......	....	.....	....	....

m o n t h s   a n d   s t a t i o n s

	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
Hemiaulus hauckii	+++1111+	++++11111	+++	+++++++	+1+++.	+	+++++	++3+.+.	++++	2+12+	+12212.	11111212+
H. sinensis	....	....+.+.+	..+	++....+	+++.+.	+	.++22	..+2223	++++	1+11+	+++2+1.	+...+1++.
Leptocylindrus adriaticus	....	......+..	...	.+.....	.+..+.	.	...+.	...2112	+.++	1+22+	..+2+1.	.....+...
Leptocylindrus danicus	1++++122	+++++21++	++2	+++++++	++++++	+	+..++	..21232	1113	21221	131222.	+.+123443
L. minimus	..+.....	....	...	......+	......	.	.....	.+.....	..++	.....	....	....
Licomophora ehrenbergii	....	....	...	....	......	.	.....	....	....	.....	...+...	....
L. flabellata	....	.+..+++.1	.+.	...++..	......	.	+....	+......	..++	.....	....++.	....
L. gracilis	....	....	...	....	......	.	.....	.+.....	...+	.+..+	.+..++.	.......+.
L. lyngbyeii	....	....	...	....	......	.	.....	....	..+.	.....	....	....
L. paradoxa	....	....	...	....	......	.	+....	....	+...	.....	....	....
L. reichardtii	....	....	...	....	......	.	.....	....	....	.....	.+.....	....
Lithodesmium undulatum	....	.++3.....	..2	+1.....	+...+.	.	+....	+......	.+.+	.....	....	...+.....
Melosira moniliformis	....	....	...	....	.+....	.	+....	....	....	.....	++.....	....
M. nummuloides	....	....	...	.+.....	......	.	.....	....	+...	....+	....+1.	...+.....
M. sulcata	++......	+........	+++	.+.+..+	.+....	+	+..++	+......	++.+	.....	.+.....	+........
Navicula cancellata	....	....	...	.+.....	......	.	.....	11..+..	....	.....	1.++...	....
N. lyra	....	....	...	.+.....	......	.	.....	....	....	.....	....	....
N. distans	....	....	...	....	......	.	..+11	....	....	.....	....	...+.....
Nitzschia closterium	.+2.+.11	.++1132+.	.+1	..++1+.	..++.2	1	++++.	+1112+1	..+.	1+211	+++1231	+++.++121
N. delicatissima	++.12343	+++123334	.12	+++1+.1	++1+12	+	.+.1.	.+23221	+++3	44443	+144443	+++223443
N. incerta	....	....	...	..+..++	..+.+.	.	.+..+	.....++	....	..11.	.....+.	......1+.
N. longissima	.+1++122	+++111222	.+1	++11+21	+++.12	1	+++1.	+.++122	+112	11232	1.2223+	1+1+11211
N. lorenziana	....	....	...	.+.+.+.	......	.	.....	....	....	.....	....	....
N. panduriformis	....	..+....++	.+.	.1+.1+.	...+..	.	..+1.	.....+.	....	..++.	....	1
N. seriata	.....++.	+.+.33334	212	...++++	++11+1	1	+1222	..33344	++13	32332	+244443	2223+3121
Orthoneis fimbriata	....	....	...	....	......	.	.....	....	.+..	.....	....	....
Planktoniella sol	....	++.......	+..	....	......	.	.....	....	.+..	.....	....	+.+......
Pleurosigma angulatum	..+1.++.	..+1+..++	.+1	111++12	+++.++	+	+112+	1+1+121	11.+	++11.	+++.1+.	....++1+1
P. attenuatum	....	....	...	.+...++	......	.	.....	....	....	.....	....	....
P. axsul	....	....	...	...+...	......	.	.....	...+...	....	.....	....	....
Pleurosigma elongatum	....	....	.+.	....	......	.	.....	++.....	+...	.....	....	...+.....
P. formosum	....	........+	...	+.+..+.	......	.	.....	....	....	.....	....	....
P. macrum	....	....	...	..+....	.+....	.	.....	....	..+.	....+	....	....
Rhabdonema adriaticum	....	....	...	....	......	.	.....	....	..+.	.....	....	.+.......
Rhizosolenia acuminata	.+......	....	...	....	......	+	.....	....	....	.....	....	.++......
R. alata f. gracillima	11112232	111122323	323	++2+++.	++++++	+	+...+	++++++1	+++2	21221	1222222	222223332
R. alata f. indica	+++.++.+	+++++++.2	+++	.+++++.	+.+++.	.	+++++	+.++1++	.++.	++.11	..+++1.	..+.++...
R. calcar-avis	++++11++	++11+++++	+++	+.+..++	+++++.	+	++.+.	+++++++	++++	++...	+.+++..	++++++12+
R. castracaneii	+.+.....	.++......	...	....	......	+	.....	....	....	.....	....	+........
R. fragilissima	..+...+.	1213	..+	.....++	++21+.	.	.....	..11221	.+1+	111.+	.112111	1.+.23221
R. imbricata	1+1+1222	+++.+1+12	1++	...++++	+.++++	+	+..+1	+.+112+	1++1	22222	1222231	2+22221+1
R. robusta	.+++.+..	.++.++.+.	++.	++++...	+.++..	.	++++.	+..+...	.+++	.....	.++....	..+...+..
R. stolterfothii	+++12232	.+1132342	++2	+++++1+	++2++1	+	++.24	+++++1.	1+12	++22+	++1221.	1+1222222
Schroederella delicatula	++.....+	++.......	+..	....	......	+	.+++.	...+.++	+...	.....	....	+........
Skeletonema costatum	.......+	.++1+....	.+1	++.....	++..+.	.	++++.	....	..+3	..+..	.113222	..+5.113.
Striatella interrupta	....	....	...	....	......	.	.....	....	....	.....	....	+........
S. unipunctata	..++..++	....+..+.	+.+	.....+.	......	.	+.+.+	+.++.++	..++	++.++	+++..+.	..++....+
Surirella gemma	....	....	..1	.+.....	......	.	.....	....	....	.....	....	....

Vilicić

	months and stations											
	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
Surirella sp.	....	+........	.+.	....	.+....	.	.....	....	.++.	.....	+......	+........
Synedra crystallina	....	...+.....	...	....	......	.	.....	....	....	.....	....	...+.....
S. fulgens	....+...	...+.....	..+	.+...+.	......	.	.....	+......	..+.	.....	++.....	.++......
S. longissima	....	....	...	....	......	.	.....	....	....	.....	...+...	....
S. toxoneides	....	...+.....	...	....	......	.	.....	....	...+	.....	..+....	....
S. undulata	....	....+...+	...	.+...++	+.....	.	+....	....	..+.	.....	.+.+.+.	....
Thalassionema nitzschioides	21112222	1122+1++2	...	+1++++2	+++2+2	2	+2211	2+12122	+212	2222+	1222222	1221111+2
Thalassiosira decipiens	....	...+.+1+2	..2	....+..	+.....	+	.++++	+......	....	.+...	..+....	....+.1..
T. nordenskioeldii	....	....	...	....	......	.	.....	....	....	.+...	....	....
Thalassiothrix frauenfeldii	21112222	122222213	212	1232211	2222+2	1	+1223	1222222	+122	2222+	1322222	211212233
T. mediterranea	...+....	.++.....+	...	++.++.+	+1++.1	1	++++.	+.+++.+	+...	.....	1......	333.21112
T. longissima	....	....	...	....	......	.	.....	..+....	....	.....	....	....
Toxonidea balearica	....	....	...	.....+.	......	.	.....	....	....	.....	....	....
Triceratium shadboltianum	...+....	.....+...	...	....	......	.	.....	....	....	.....	.+.....	....
Tropidoneis lepidoptera	....	....	...	.+...+.	.+....	.	.....	....	....	.....	....	...+.+...
PRASINOPHYCEAE												
Halosphaera viridis	++......	++++.....	++.	++...+.	+++...	+	+....	+......	+++.	.....	++.....	+++......
CHLOROPHYCEAE												
Carteria sp.	....	....	...	....	......	.	...+.	.+.....	....	.....	+++1+.1	+++......
CYANOPHYCEAE												
Oscillatoria sp.	.+......	++.......	..+	.+.....	++....	+	.....	+......	++..	.....	.+.....	+........
EUGLENOPHYCEAE												
Eutreptiella sp.	...++...	....	...	....	......	.	.....	....	....	.....	....	....
DINOPHYCEAE + DESMOPHYCEAE												
Amphidinium acutissimum	....	....	...	....	......	.	.....	....	....	.....	+......	....
Amphisolenia spinulosa	....	+........	...	....	......	.	.....	....	....	.....	....	....
A. bidentata	....	.+.+.....	...	.+.....	......	.	.....	....	....	.....	....	.+.......
A. globifera	....	....	...	....	......	+	.....	....	....	.....	....	....
Centrodinium eminens	.+......	+........	+..	....	......	.	.....	....	....	.....	....	....
Ceratocorys armata	.+......	....	+..	....	+.....	.	.....	....	+...	.....	+......	.++......
C. gourretii	+.......	+++......	+++	+++....	+.....	+	+....	....	....	.....	++.....	++.......
C. horrida	....	....	...	++.....	......	.	.....	....	....	.....	....	....
Ceratium arietinum	+++.....	+++......	++.	+......	++....	+	+....	+..+...	++++	.....	+......	++....+..
C. buceros	....	....+....	...	+++++++	.+++++	+	.++21	+.++.++	+++.	.+++.	++.....	.++......
C. concilians	....	....	+..	....	+.....	+	.....	....	++..	.....	....	....
C. candelabrum	++..++..	.++..++.+	+++	++.+...	++....	+	+....	+..+..+	+++.	+....	++....+	+++++....
C. carriense f. volans	++++.+..	+++++++..	+++	.+++...	++++..	+	.....	....	..+.	...+.	.+.....	+++...+..
C. euarcuatum	....	++.+.....	...	.+.++..	++.+..	.	.....	....	....	.....	....	....
C. extensum	+++...+.	.+.+++++.	+++	+++.+..	+.++.+	+	..+.+	......+	.++.	....+	+.....+	++.+.....
C. furca	+++++111	+++.+1+11	+++	++++121	+++1++	+	.+111	+.+++++	++++	++111	+++1+++	+++++++11
C. fusus	++++++1+	+++++1+++	+++	+++++12	++.+.1	+	++.++	+.+++++	++++	++++1	+++++++	1+++++++1
C. gibberum	....	.+.......	.+.	+.++...	+++...	.	+....	+......	..+.	.....	+......	+++......
C. gravidum	....	+........	+..	....	+.....	+	.....	....	++..	.....	....	++.......

months and stations

	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
C. hexacanthum	.+.++...	+++.+....	+++	+++.+..	.++...	+	+....	+......	+++.	.....	+++++..	+++++....
C. karstenii	+.......	+++.+.+..	..+	++++...	++....	+	+.+..	+.++...	++..	++...	+.++++.	.+++.....
C. kofoidii	....	....	...	++.....	......	.	.....	....	..++	.....	....	....
C. longirostrum	....	++..++..+	...	+.+++++	+.++..	+	.+...	..++..1	..+.	...+.	.+..+..	+..+.....
C. macroceros	++++++..	+++++++..	+++	+++++++	++++..	+	+.+..	+..+...	++++	++...	+..++..	+++.+....
C. massiliense	.+++++++	+++++.+++	+++	+++....	+.....	+	++.+.	+..+...	+++.	++...	+++++.+	++++.....
C. pavillardii	....	+.+......	...	....	......	.	+....	....	....	.....	+......	++.......
C. pentagonum	1+++.+..	++.+.....	+++	++.+...	++....	+	+....	+......	+++.	.+...	..+.+..	+........
C. platycorne	....	....	...	....	......	.	.....	....	.+..	.....	....	....
C. ranipes	....	..+......	.+.	..++.+.	+++...	.	.+...	+......	+++.	.....	+......	+++......
C. setaceum	....	....	+.+	+......	......	+	.....	....	++..	.....	+......	.+.......
C. symetricum	++++.+..	+++......	+++	++.+...	+++...	+	++++.	+.++...	+++.	.....	+..+...	+++......
C. teres	....	+...+....	+..	+....+.	+.....	+	+....	+......	.+..	.+...	+......	....
C. trichoceros	+++++1..	+++.+++++	+++	+++++..	++....	+	+..+.	+......	++++	.....	+.+++..	++++++..+
C. tripos	+...++1+	++..+++++	.++	..++.++	..++..	+	.++..	++.+...	++.+	++111	+.+1+11	.+++.++++
C. tripos var. pulchellum	.++..+..	+++......	+..	+.+..++	++....	+	+....	+.++.+1	+++.	.....	.++.+..	++...+...
C. vultur	....	....	...	....	......	.	.....	....	.+..	.....	....	....
Cladopyxis brachiolata	....	++.......	...	....	......	.	.....	....	....	.....	....	+........
C. caryophyllum	....	+++......	+..	+......	+.....	.	.....	....	....	.....	....	++.......
Dinophysis acuminata	....	....	...	....	......	.	.....	....	....	.....	....	...+.....
D. acuta	....	....	...	......+	......	.	.....	+......	++++	+....	....	....
D. caudata	.++.+.++	...++++++	+.+	+.+++++	++++++	.	.++++	..++.++	+...	++.++	.++.+++	++++..+..
D. hastata	+.......	+.+......	+..	+......	+.....	+	.....	+......	....	....+	+...+..	....
D. schuetti	....	.+.......	...	....	......	.	.....	....	..+.	.....	....	+++......
D. sphaerica	++...++.	......+..	+..	...+1++	..++11	.	...2+	.+.++++	+...	...++	+...+..	....
D. tripos	....	.++......	.+.	....	+.....	+	.....	+......	+++.	.....	+..+...	..+......
D. uracantha	....	++.......	...	....	......	.	.....	....	++..	.....	....	....
Goniaulax birostris	....	+........	...	....	......	.	.....	....	....	.....	....	....
G. diacantha	....	....	...	+....+.	....2.	.	.....	...+...	....	++...	....+.1	....
G. digitale	.+......	.++......	+..	....	......	.	...+.	....	....	..+..	....	....
G. gracillis	..+.....	..+......	.+.	1.1....	.++1+.	.	.....	.+++.+1	++++	32333	+131222	2..+++..1
G. fragilis	....	....	...	....	......	.	.....	....	....	.....	.....+.	....
G. hyalina	++......	+........	++.	...+...	......	.	.....	+......	....	.....	++.+...	+++.+....
G. kofoidii	.+......	....	...	....	......	.	.....	....	....	.....	....	....
G. polyedra	....	...+.....	..+	....	......	.	.....	....	....	.++..	.+.....	...+.....
G. polygramma	....	++++..+..	+++	+....+.	..+.+.	+	++++.	..++.++	+.++	+++++	++1++++	++......+
G. sp.	....1...	....	..+	....1.1	.+.++.	+	.11.+	...+...	++.+	11++1	+..1+21	....1+.1.
Goniodoma polyedricum	++++++1+	+++.+++++	++.	++.++++	++++..	.	++++.	+.++.++	+++.	+++++	+++++++	+++++++.+
Gymnodinium cucumis	....	....	+..	....	......	.	.....	....	....	.....	....	....
G. "simplex"	+1+11222	1+1222322	+1.	2223332	.11233	2	.2232	2232332	2223	33333	2233332	222333233
Gyrodinium fusiformis	....	....	...	....	......	+	.....	....	....	.....	....	....
Heterodinium richardii	....	....	...	....	......	+	.....	....	....	.....	....	....
H. milnerii	++......	.+.......	+..	....	......	.	.....	....	....	.....	....	....
Histioneis joergensenii	....	.....+...	+.+	.+.....	......	.	.....	....	....	.....	....	....
Kofoidinium velelloides	++......	+.+++....	++.	+.+....	++....	+	+....	+......	+++.	++...	++.....	+..+.....
Noctiluca miliaris	....	....	...	+......	......	+	+....	+......	.++.	.....	....+..	....
Ornithocercus carolinae	....	....	...	....	+.....	.	.....	....	....	.....	....	....
O. heteroporus	....	....	...	....	......	.	.....	+......	....	.....	....	....
O. magnificus	....	....	...	....	......	.	.....	....	....	.....	...+.+.	.+.......

	months and stations											
	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
Ornithocercus quadratus	++......	++.......	++.	+.++...	+.....	+	+....	....	++..	.....	+......	.++......
O. steinii	....	....	...	+......	+.....	.	.....	....	....	.....	....	....
Oxytoxum adriaticum	....	....	..+	....	......	.	.....	....	....	.....	....	....
O. caudatum	....	....	...	....	......	.	.....	...+...	....	.....	.+.++..	....
O. constrictum	++......	....	+..	....	......	.	.....	....	...+	.+...	....	....
O. elegans	....	.+.......	.+.	.+.....	......	.	.....	....	....	.....	....	....
O. gladiolus	....	..+.+....	...	....	......	.	.....	....	....	.....	....	....
O. laticeps	....	....	...	....	.+....	.	.....	....	....	.....	....	....
O. longiceps	....	....	...	....++.	...+13	.	...+.	..++..1	+...	..++2	....++.	....
O. reticulatum	....	+++...+..	++.	....	......	.	.....	....	.+..	.....	....	+........
O. scolopax	+++...+.	+++...+..	+..	...+...	....+.	+	.....	....	+...	..++.	....	....+....
O. sphaeroideum	++......	+.+.+....	+..	...+..+	..+..1	+	.....	..+....	++.+	+.+..	+.+++2.	+++......
O. variabile	....	....	...	....	..+...	.	.....	....	....	+....	.+1....	.+1......
Peridinium brochii	+.......	..+......	+..	....+..	......	.	.....	....	....	.....	.+.....	..+.+....
P. conicum	..++..++	.....+++.	...	++.+.++	.+....	+	.....	......+	....	.+...	.+...++	...+....+
P. crassipes	+.......	+....+++.	+++	.++++++	..+++.	+	.+++.	..+++++	++..	+++..	+.+.+..	.++++++++
P. depressum	.+...+1+	++..+++++	...	++.++++	.+.++.	+	+++1.	+..++.+	+++.	.+.++	++++++1	++++.+.++
P. diabolus	.....++.	.++.++.+.	..+	......+	.+..+1	.	....+	.....++	+..+	+..++	.++++++	...+...+.
P. divergens	.+...+1+	...++.+++	...	++..+++	.+.++.	.	+++1.	+..++.+	+++.	.+.++	..+.+++	+++++.+++
P. globulus	++++++++	+++.+++++	+++	++.++++	+1+.1+	+	++++.	+.++.++	++++	++.+.	+++++++	+++1+++++
P. leonis	....	..+....++	+.+	.....+.	..+..+	+	...++	++...++	.+..	....+	+......	.+.......
P. oceanicum	....	....++.++	+.+	++.+.+.	++...+	+	++...	+.....+	+...	....+	.+.+.++	....
P. pallidum	+++....+	....	+..	...+.+.	......	+	+++..	+......	++..	.+...	+++.+..	+........
P. paulsenii	....	....	...	....	......	.	.....	....	....	.....	.+....+	....
P. pellucidum	....	++.+....+	+.+	+..+...	......	.	+....	...+...	++..	++...	+..+...	+.++.....
P. pyriforme	...+++++	.+..+++++	.+.	.+.....	..+...	.	++...	....	....	.....	.++.++.	...++....
P. spiniferum	......+.	.....++++	...	.....+.	......	.	.....	..+....	....	.....	....	.....++++
P. steinii	.....+..	....	+..	+......	+.....	.	.....	....	+.++	....+	+......	+++++....
P. tuba	....	....	...	..1+...	.+++++	.	...+.	...+...	....	.+...	..+++..	1...++.+.
P. willeii	.....+..	....	...	....	......	.	.....	....	....	.....	....	....
Phalacroma argus	....	....	+..	....	..+...	.	.....	....	....	.....	....	....
P. acutum	.+......	....	++.	....	......	+	.....	....	....	.....	....	..+......
P. circumsutum	+.......	....	...	....	......	.	.....	....	....	.....	....	....
P. mitra	....	++..+.+..	+++	+..+.+.	+.+...	+	.+...	....	....	.....	....	....
P. parvulum	....++..	.+.......	+++	.+.....	......	.	.....	......+	.+..	.....	...+...	++.......
P. reticulatum	.+....+.	+........	+..	+......	......	.	.....	....	....	.....	....	....
P. rotundatum	....	....	...	....	......	.	.....	....	++..	.....	....	....
P. striatum	....	....	...	....	......	.	.....	....	.+..	.....	....	....
Podolampas bipes	++...+..	++.......	+++	+..+...	+.....	+	+....	+.++...	..+.	++...	+......	+++......
P. elegans	....	++.+..+..	+..	....	...+..	+	..+..	+......	.+..	.....	....	....
P. palmipes	.+......	....	++.	+......	..+...	+	.....	....	+...	.....	....	.+.......
Porella perforata	....	....	.+.	..+....	......	.	.....	....	....	.....	....	....
Prorocentrum compressum	....	....	++.	..+....	......	.	.....	....	+...	.....	....	+.+...+..
P. micans	+.+2+.2+	+.+2+1112	+.1	...+112	.+.+21	.	..+.1	...+.11	..++	++..+	+2+2222	1++1+21+1
P. scutellum	......+.	..+.....+	+..	+......	......	.	.....	....	++..	.....	....	....
P. triestinum	....	....+....	...	+......	.+....	.	.....	....	...+	.....	.....++	....
Pyrocystis elegans	....	....+....	+..	....	......	.	.....	..+....	.+.+	.....	....	....

	months and stations											
	1979					1980						
	8	9	10	11	12	1	2	3	4	5	6	7
	12345689	123456789	124	3456789	345689	1	45689	1456789	1234	56789	3456789	123456789
Pyrocystis lunula	..++....	.+.......	...	....	......	.	.....	....	....	.....	.+.....	....
P. robusta	....	.+.......	...	....	......	.	+....	....	....	.....	....	....
Pyrophacus horologicum	++...+.+	+.+++++.+	+.+	++..+++	+++..+	.	.+.+.	..++...	...+	.+..+	...++++	..+.+.+..
P. horologicum var. steinii	....	+.....+++	...	....	......	.	.....	....	....	.....	....	....
Spiraulax jollifeii	+.......	....	...	....	......	.	.....	....	....	.....	....	....
S. kofoidii	..+.....	+++......	+..	....	......	.	.....	....	....	.....	....	....
Triposolenia bicornis	.+......	....	...	....	......	.	.....	....	....	.....	....	....
T. truncata	....	....	...	....	......	.	.....	....	....	.....	....	+........

Chlorophyta (with 3 species), Cyanophyta and Euglenophyta (with 1 species each) were less represented in the flora of the investigated region. According to the number of microplankton species, the most represented genera (with 10 or more species) were as follows: *Ceratium* (28), *Chaetoceros* (27), *Peridinium* (17), *Oxytoxum* (11), *Rhizosolenia* (10) and *Goniaulax* (10). Comparing the floristic composition of phytoplankton in the Mediterranean, Denisenko (1964) found more species in the Adriatic (181) than inthe Ionian (98), Aegean (93) and Black Sea (87). The number of species found in one region increases if the data obtained by means of the inverted microscope is completed with the list of net phytoplankton species, as well as if the length of the investigation is extended. Regarding the Mediterranean, A. Travers and M. Travers (1975) determined about 600 microplankton species after eight years of investigation. Considering diatoms, Rampi (1942) registered 355, Marino and Modigh (1981) 181, and Economou-Amilli (1980) 81 species. During the investigation in the southern Adriatic, especially during the counting of cells by means of the inverted microscope, some species could not be correctly determined at times. This refers mainly to the species of the following genera: *Syracosphaera, Leptocylindrus, Pleurosigma* and *Cyclotella.* Difficulties in determination were frequent when the differentiation between *Thalassionema nitzschioides* and *Thalassiothrix frauenfeldii* (because of the similarity of their valve pole shape) had to be made. In this paper, two species, *Nitzchia seriata* and *N. delicatissima* are mentioned as usual, although Hasle (1965) considers them to be some related species. Regarding the Dinophyta, the most complicated determinations referred to the unarmoured forms, but determination of small thecate forms were also frequently difficult. Often, many small cells were unjustifiably assigned to *"Gymnodinium simplex".*

The spatial and temporal distribution of phytoplankton species also provided information about the species dominance, expressed by means of the orientational values of the population density (Table 1). Bacillariophyceae comprised the greater number of quantitatively significant species (with $> 10^1$ cells/1) rather than the Dinophyta. However, the total number of Dinophyta species was also large because of net samples analyses and the registration of rare species (signed +).

Seasonal changes in the cell number of species were best shown in the Mali Ston Bay where the sampling was most frequent (Table 2). The characteristic species for the warmer part of the year in this region were as follows: *Chaetoceros anastomosans, C. tetrastichon, C. compressus, C. brevis, C. diversus, C. simplex, Skeletonema costatum* and *Melosira nummuloides.* During the cold season, the most frequent species were:

Table 2. Seasonal variations in cell density of 39 microplankton species determined at Stations 5, 6, 7, 8 and 9.

		1979																		1980																							
	months and stations	8				9					11					12				2				3					5					6					7				
	Species	5	6	8	9	5	6	7	8	9	5	6	7	8	9	5	6	8	9	5	6	8	9	5	6	7	8	9	5	6	7	8	9	5	6	7	8	9	5	6	7	8	9
I	Chaetoceros compressus	1	2	3	3	1	4	4	+	+	+	+	+	+	+	+	+	+	+	1	+	1	+	2	2	3	4	3	2	2	+	+	+	4	3	4	3	2	4	4	5	5	4
	Chaetoceros brevis					+		+	+	+		+	+	+	+	+	+	+	+	1				+					+	+		1	+	1	+	2	2		3	4	4	3	4
	Chaetoceros diversus	+	+	+	+	+	+	1	1	+	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+				2	+		+	+	1	1	1	2	1	1	1	2	3	1
	Skeletonema costatum				+	+												+		+	+	+								+				1	3	2	2	2		1	1	3	
II	Chaetoceros anastomosans	+				+																			+				+	+		+	+	+	+	+	1		2	3	3	4	3
	Chaetoceros tetrastichon	1	+	+																																					1	+	1
	Rhabdosphaera stylifera	2	+	+	+	1																																					
	Rhabdosphaera clavigera					1	+	+		1																																	
	Peridinium spiniferum			+			+	+	+	+					+									+																+	+	+	+
III	Syracosphaera pulchra		+		+	2	2	2	1	2	1	1	1	2	1	1	2		2	2	2	+							+											+			
	Calciosolenia granii								+		1	1	1	2	2	2	3	3	2	2	2	1		+	+	+	+							+									
	Dictyocha fibula										+	+	1	+	+	+	+	2	1	+	+	1	2	+																			
	Dictyocha speculum											+	1	+		+		+	1			1																					
	Dinophysis sphaerica		+	+				+				+	1	+	+	+	+	1	1			2	+		+	+	+	+				+	+			+							
	Eucampia cornuta							+				+	+	+	+	+	+	+	+									+															
	Ceratium ranipes										+	+		+		+					+																						
	Phalacroma mitra					+		+				+		+		+				+																							
	Calciosolenia murrayii																			+			+																				
IV	Diploneis bombus					+			+		+		1	3	2	+	+	2	1	+	1	2		+	+	+	1		+		+	1							+		+		
	Oxytoxum longipes												+	+			+	1	3			+		+	+			1			+	+	2			+	+						
	Chaetoceros affinis	+	+	+	+	+	+	+	+	+		+	+	+	+	1	+	+	+	1	1	2	1	2	3	1	3	2	1	1	+	+	1				+			+	+	+	+
	Chaetoceros curvisetus		+	+	+	2	+	+				+	+	+	+	+		+	1	1	2	3	1	2	2	2	2	+	+	+		+		1	+		+			+			
	Ceratium buceros					+					+	+	+	+	+	+	+	+	+	+	+	2	1	+	+		+	+		+	+	+											
	Navicula distans																				+	1	1																				
	Bacteriastrum hyalinum									+										+	+	+		2	3	3	3	2	+			+											
	Chaetoceros costatus																			+	+			+	+		1																
	Hemiaulus sinensis					+		+		+					+		+	+		+	+	2	2	+	2	2	2	3	1	+	2	2	+	+	2	+	1			+	1	+	+
	Ceratium longirostrum					+	+			+	+	+	+	+	+	+	+			+				+	+			1				+				+							
	Coscinodiscus thorii											+	+	+	+	+		+	+		+		+						1						+	+	+						
	Peridinium leonis								+	+				+		+			+			+	+				+	+					+										
	Asterolampra marylandica										+					+	+				+				+				+	+				+	+	+							
	Peridinium oceanicum					+	+		+	+		+		+					+	+								+					+		+		+	+					
V	Goniaulax gracillis										1					+	1	+						+	+		+	1	3	2	3	3	3	3	1	2	2	2	+	+			1
	Asterionella bleakeleyii																								+		2	+		+							+						
	Chaetoceros perpusillus								+							+													+	1	2	2	2		1	+							
	Chaetoceros simplex					+				+		+			+	+													+	+		+	+	1	2	+	1						
	Goniaulax polygramma							+						+		+		+		+	+	+	+	+	+		+	+	+	+	+	+	+	1	+	+	+	+					+
	Melosira nummuloides																																+			+	1						

Calciosolenia granii, Dictyocha fibula, D. speculum, Chaetoceros affinis, C. curvisetus, Diploneis bombus, Asterionella bleakeleii, Dinophysis sphaerica, Oxytoxum longiceps and *Ceratium buceros.* The duration of the significant increase and decrease in population density of the mentioned species varied most frequently from one to four months. However, the population density of many species was more or less equal throughout the year, and was comprised by quantitatively significant species as well as by species found only in net samples (Table 3).

Table 3. List of 28 microplankton species with more or less uniform population density determined throughout the year, at Stations 5, 6, 7, 8 and 9.

	months and stations								
	1979				1980				
species	8	9	11	12	2	3	5	6	7
	5689	56789	56789	5689	5689	56789	56789	56789	56789
Gymnodinium "simplex"	1222	22322	13332	1233	2232	32332	33333	33332	33233
Nitzschia delicatissima	2343	23334	+1+ 1	1+12	+ 1	23221	44443	44443	23443
Nitzschia seriata	++	33334	++++	11+1	1222	33344	32332	44443	+3121
Thalassionema nitzschioides	2222	22213	32211	22+2	1223	22222	2222+	22222	12233
Rhizosolenia alata f. grac.	2232	22323	2+++	++++	1	++++1	21221	22222	23332
Rhizosolenia stolterfothii	2232	32342	+++1+	2++1	+ 24	+++1	++22+	1221	22222
Nitzschia longissima	+122	11222	11+21	+ 12	++1	++122	11232	2223+	11211
Bacteriastrum delicatulum	112+	+11+2	+++	++++	1+1+	22232	12+11	132+	24442
Rhizosolenia imbricata	1222	+1+12	++++	+1	+112		22222	22231	221+1
Cerataulina pelagica	2+23	+1+ +	++++	++12	++++	2122+	11111	2122	22321
Rhizosolenia fragilissima	+	1213	++	21+		11221	111 +	12111	23221
Nitzschia closterium	+ 11	132+	++1+	++ 2	+++	112+1	1+211	+1231	++121
Prorocentrum micans	+ 2+	+1112	+112	+21	+ 1	+ 11	++ +	+2222	+21+1
Chaetoceros decipiens	++++	+3112	+++++	1+++	1121	21121	++	+++	+1+12
Guinardia flaccida	+121	122+2	++++	11++	++ +	1+++1	++11+	++211	+1++1
Ceratium furca	+111	+1+11	++121	+1++	+111	+++++	++111	+1+++	+++11
Ceratium fusus	++1+	+1+++	+++12	+ 1	+ ++	+++++	++++1	+++++	++++1
Chaetoceros rostratus	+++	++ +2	+++ +	1+++	112	+++++	+	+1+	+
Dactyliosolen mediterraneus	+ +	22++	+++++	++++	++	++ ++	++ ++	+ ++	+1 11
Ceratium tripos	++1+	+++++	++ ++	++	++	+	++111	+1+11	++++
Rhizosolenia alata f. ind.	++ +	+++ 2	++++	+++	++++	++1++	++ 11	+++1	++
Rhizosolenia calcar-avis	11++	+++++	+ ++	+++	+ +	+++++	++	+++	++12+
Chaetoceros tortissimus	+++	++++	++++	1+++	++	++1++	++ +	++++	2
Goniodoma polyedricum	++1+	+++++	++++	++	+++	++ ++	+++++	+++++	+++ +
Peridinium diabolus	++	++ +	+	+1	+	++	+++++	++++	+
Peridinium globulus	++++	+++++	++++	+ 1	+++	++ ++	++ +	+++++	+++++
Dinophysis caudata	+ ++	+++++	+++++	++++	++++	++ ++	++ ++	++++	+
Peridinium crassipes		+++	+++++	+++	+++	+++++	+++	+ +	+++++
Pyrophacus horologicum	+ +	+++ +	+++	+ +	+	++	+ +	++++	+ +

The spatial and temporal distribution of microplankton and of the total phytoplankton quantity was expressed by means of cell number and biomass, i.e. the mean values of these parameters (Fig. 3). To define the ecological properties of the analysed ecosystems it was very important to define the distribution of the minimal and maximal phytoplankton quantities (Table 4). The cell number and the biomass of the microplankton and nanoplankton increased from the open sea towards the coastal region. The intensive development of the total phytoplankton biomass was registered in the spring-summer period and in autumn at all stations. The annual mean phytoplankton biomass in the Mali Ston Bay (Stations 5, 6, 7, 8, 9) was 11.4 times higher than in the open sea, and 1.1 times higher than in the Gruž Bay (Station 4). The span of the phytoplankton quantities in the Gruž Bay was higher than in the Mali Ston Bay because of the more intensive exchange between the influence of sewage and the eutrophication on the one hand and the strong influence of the open sea water on the other. This points to the greater ecological stability of the Mali Ston Bay, in spite of the great salinity fluctuations there (low salinity values are present only in the top surface layer).

The contribution of the nanoplankton biomass to the total phytoplankton biomass increased most frequently during winter. The significance of this increase is only relative because of the microplankton biomass decrease in winter (Fig. 4). The nanoplankton biomass absolute values were in general lower in winter and increased in the spring and autumn. The span between the minimal and maximal nanoplankton biomass was not so clearly expressed as with the microplankton.

The relationship between the cell number and the biomass was not always parallel because of the spatial and temporal differences in species composition and cell size. The cell volume data of the dominate microplankton species estimated in the period of investigation will be presented elsewhere (Viličić in press). The phytoplankton cell size varies in different seas (Smayda 1965, Mullin et al. 1966, Bernhard et al. 1969, Travers 1975). It depends upon the species' own genetics, but also upon the abiotic ecological factors, the population growth phase, or on consumer "pressure". Methods for the accurate determination of the biomass of individual cells, currently requires microscopical measurements of the total cell volumes with subsequent corrections for the volume of the cell vacuole (Smayda 1965, Zeitzschel 1970). By analysing the plasma volume of the discoid and solenoid diatoms Hitchcock (1983) makes the conclusion that as the cell volume increases, the estimated fraction of the total cell volume occupied by the cytoplasm also decreases exponentially, but only until the cell volume is greater than 10^3 μm^3. During the research in the southern Adriatic, all analyses were performed on preserved material. Therefore, plasma volume measurements could not be effected, but only the measurements of whole cell volumes. To avoid any error during the phytoplankton total cell volume estimation, which can be due to cell size variations, frequent cell dimension measurements were performed, simultaneously with the cell counting. Cell volume estimation is only one of the methods suitable for showing the differentiation between the biomass of the various phytoplankton taxonomical categories.

The biomass value of the main taxonomical categories of microplankton increased from the open sea toward the coastal region. The biomass increase of the Bacillariophyceae was greater than the biomass of the Dinophyta and especially greater than both the Chrysophyceae and Haptophyceae (Fig. 5). The biomass of the Bacillariophyceae as the main part of microplankton followed the curve of the total phytoplankton biomass. The biomass of the Dinophyta was rarely greater than the biomass of the Bacillariophyceae, and the peak values were attained in the coastal region in spring. The relative contribution of the Chrysophyceae and Haptophyceae in the total microplankton biomass was small and was larger in the open sea than in the coastal region. However, it was the result of the decrease in the biomass of the Bacillariophyceae in the open sea. Similarly, the relative contribution of nanoplankton in the total phytoplankton biomass depended upon the microplankton biomass variations. The curve of the absolute biomass of the Chyrsophyceae and Haptophyceae at all stations had a more or less monotonous seasonal course. The mean annual biomass for this category was 5.8 times greater in the coastal region (at Stations 5, 6, 7, 8 and 9) than in the open sea. Due to very good correlation between the relative contribution of the coccotithophorides (Haptophyceae) in microplankton and salinity, this group can be used as an indicator of the increased inflow of eastern Mediterranean intermediary waters in the Adriatic Sea (Pucher-Petković et al. 1971, Zore-Armanda and Pucher-Petković 1976).

Besides cell density, the microplankton species diversity was a very important parameter for the estimation of ecosystem eutrophication. According to findings by Revelante and Gilmartin (1979), the Shannon and Weaver diversity index is independent of sample volume, and it was therefore used during the investigations in the southern Adriatic. The most frequent values of this index obtained at Stations 1, 2, 3 and 4 ranged between 3 and 4, and at Stations 5, 6, 7, 8 and 9 between 2 and 3 (Fig. 6). The mean diversity index decreased from 3.13 in the open sea to 2.61 in the Mali Ston Bay, which agreed with the previous findings about the distribution of the same index in the Adriatic Sea (Revelante and Gilmartin 1980).

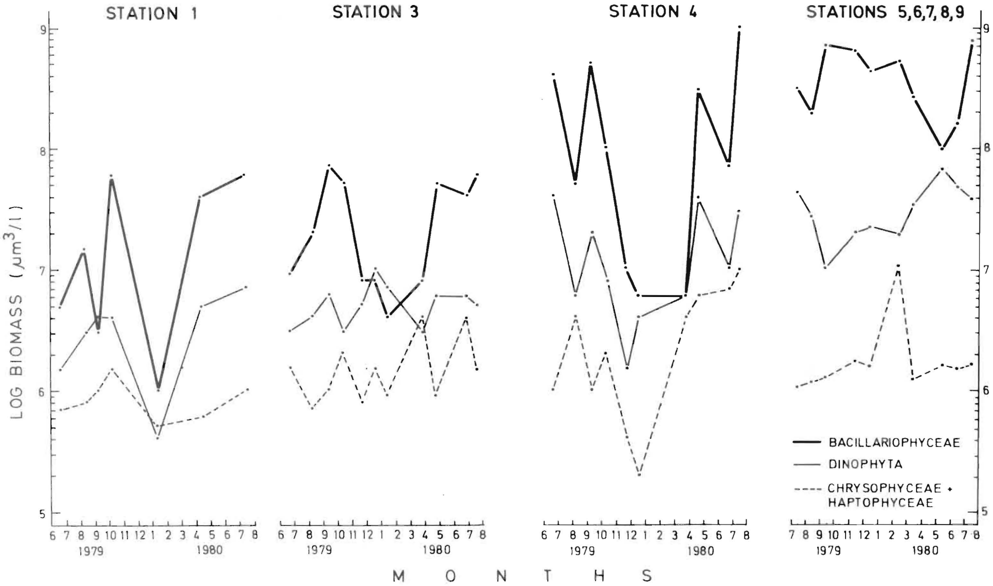

Fig. 5. Seasonal variations in the biomass of three taxonomical categories of microplankton at investigated stations.

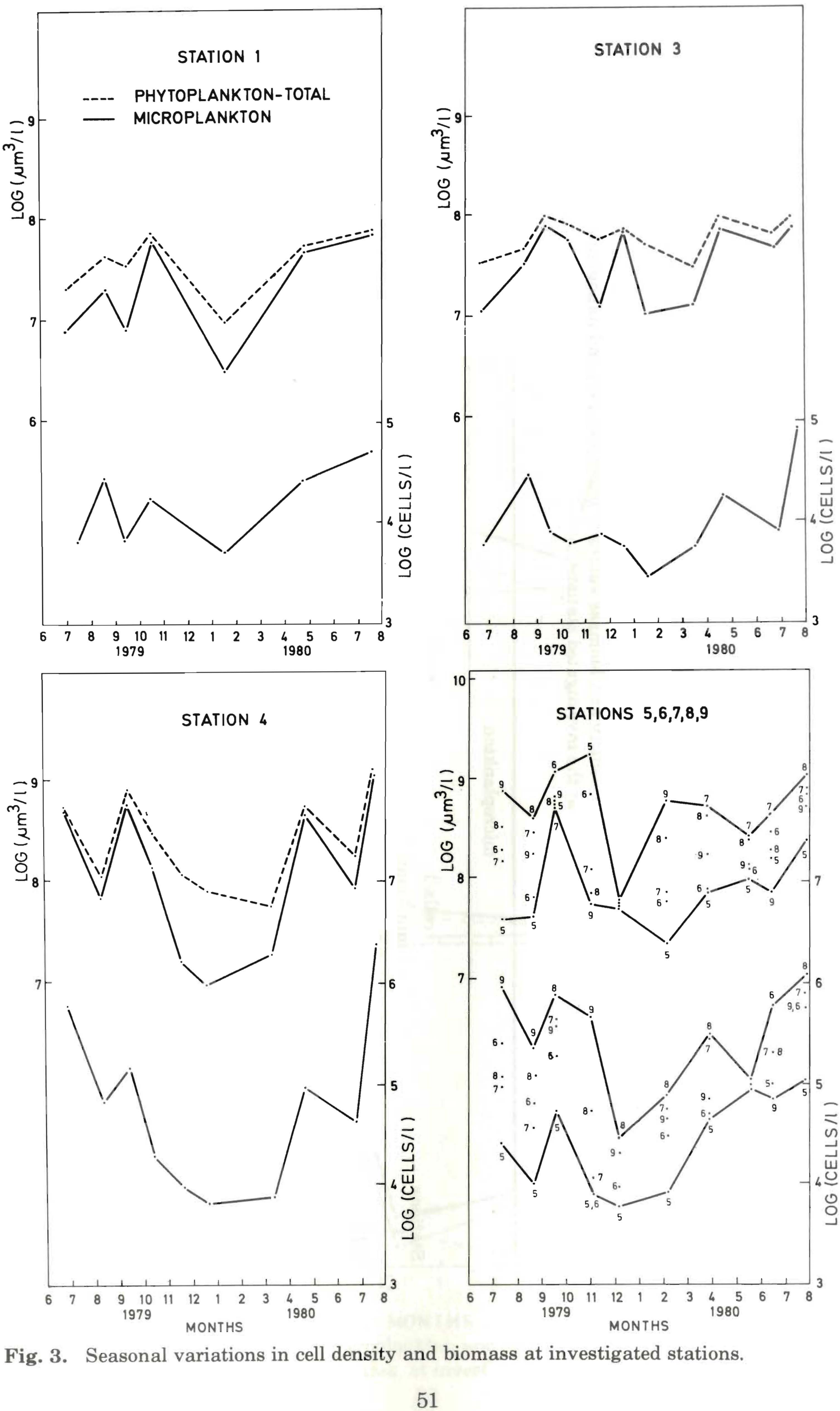

Fig. 3. Seasonal variations in cell density and biomass at investigated stations.

Table 4. Minimal and maximal cell density and biomass values of microplankton and nanoplankton at the investigated stations.

Stations	microplankton		nanoplankton	
	cells/l min - max	$\mu m^3/l$ min - max	cells/l min - max	$\mu m^3/l$ min - max
1,2	2.2×10^2 - 3.6×10^4	9.2×10^5 - 1.5×10^8	6.2×10^4 - 8.5×10^5	3.9×10^6 - 3.5×10^7
3	5.2×10^2 - 1.8×10^5	3.5×10^6 - 1.2×10^8	1.1×10^5 - 1.5×10^6	3.9×10^6 - 1.0×10^8
4	3.1×10^3 - 4.0×10^6	4.1×10^6 - 1.7×10^9	9.5×10^5 - 5.1×10^6	9.4×10^6 - 1.6×10^8
5, 6, 7, 8, 9.	1.7×10^3 - 2.1×10^6	3.4×10^6 - 7.6×10^9	1.5×10^5 - 5.2×10^6	5.5×10^6 - 9.1×10^8

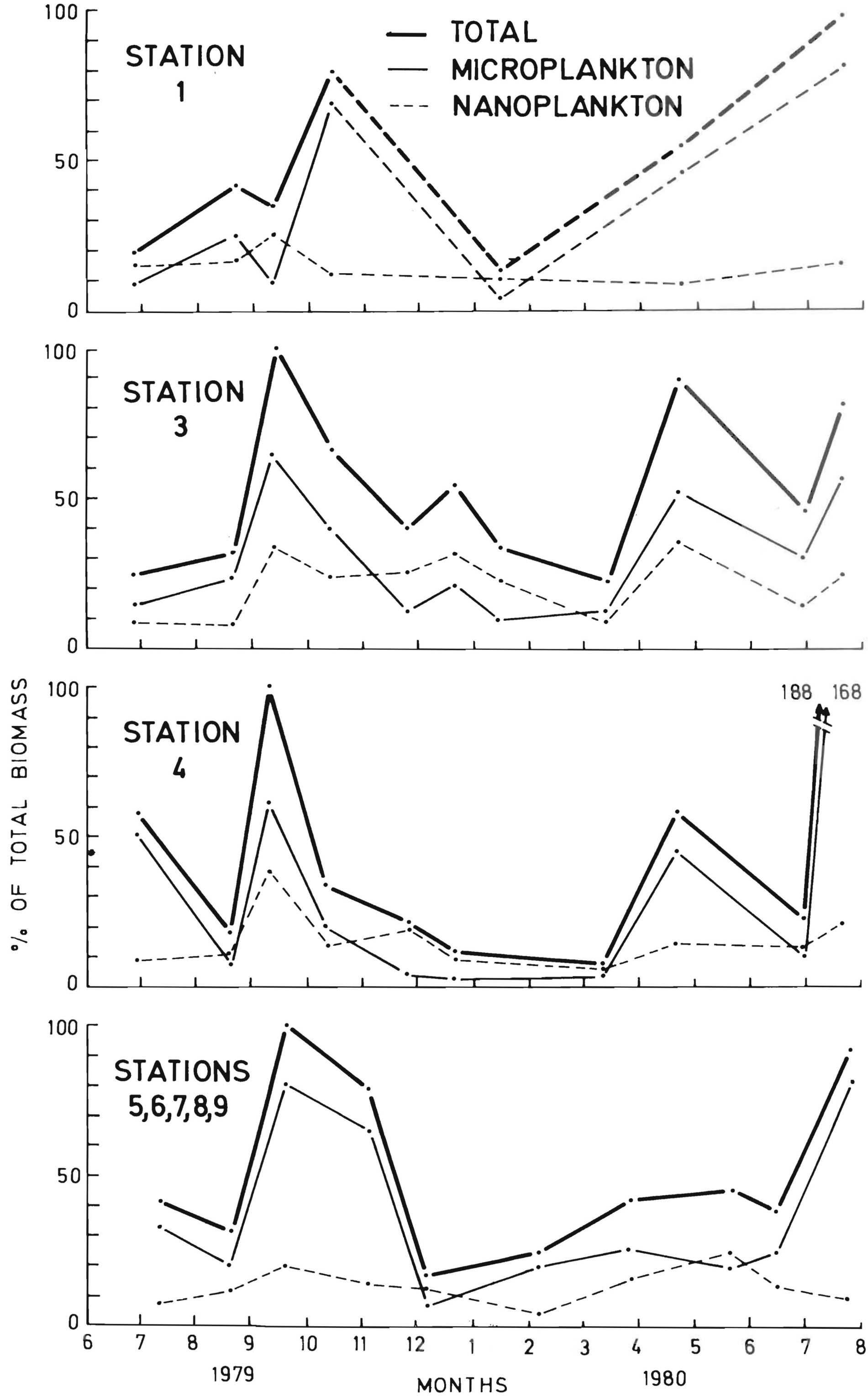

Fig. 4. Seasonal variations in the microplankton and nanoplankton biomass and its relative contribution to total phytoplankton biomass, at investigated stations.

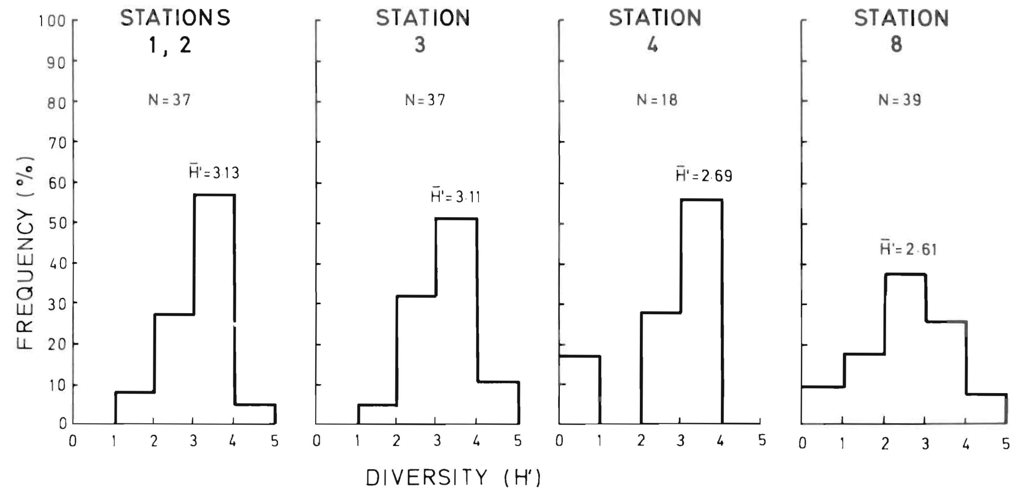

Fig. 6. Frequency distribution of the Shannon-Weaver diversity index of microplankton species determined at Stations 1, 2, 3, 4, and 8.

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