SEASONAL FLUCTUATIONS OF THE PHYTOPLANKTON BIOMASS IN THE CENTRAL ADRIATIC COASTAL AREA

SEZONSKE PROMJENE BIOMASE FITOPLANKTONA U OBALNOM SREDNJEM JADRANU

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INTRODUCTION

The phytoplankton investigations carried out up to now in the central Adriatic were mainly concerned with the density estimations and species composition (Ercegović, 1936; Pucher-Petković, 1957, 1960). Seasonal variations in phytoplankton, relative abundance of individual groups as well as environmental factors influencing phytoplankton were, therefore, intensively studied (Pucher-Petković, 1963, 1964, 1965, 1968). Special attention was given to diatom ecology (Pucher-Petković, 1966). Measurements of organic production were also made by ^{14}C method (Cviić, 1963, 1964; Pucher-Petković, 1969, 1970) as well as of the contribution of micro- and nannoplankton to primary production (Pucher-Petković, 1973).

The present survey was carried out to obtain the data on the size and principal components of the Kaštela Bay phytoplankton biomass. Therefore, photosynthetic pigment concentrations and total phytoplankton density were studied as well as systematic groups and dominant species, with the emphasis on size fractions of phytoplankton community. It was also attempted to establish the rate of zooplankton grazing influence on the phytoplankton annual cycle. Present investigation is the first one of this kind in the central Adriatic.

MATERIAL AND METHODS

The studies of variations in phytoplankton species composition and abundance were carried out in the central Adriatic coastal zone (Kaštela Bay) at Station P_{25} (43°31'N — 16°22'E) (Fig. 1). For may years the Institute of Oceanography and Fisheries in Split has investigated both biotic and abiotic ecological factors and their interrelations at this fixed station. Phytoplankton studies have been a part of these investigations.

Seawater samples were collected on a monthly basis from February 1974 to January 1975. Sampling was carried out by plastic reversing »Mécabolier« bottles at standard depths of 0, 5, 10, 20, and 35 m, between 9 and 11 o'clock a.m. Samples for biochemical studies were worked out within one to two

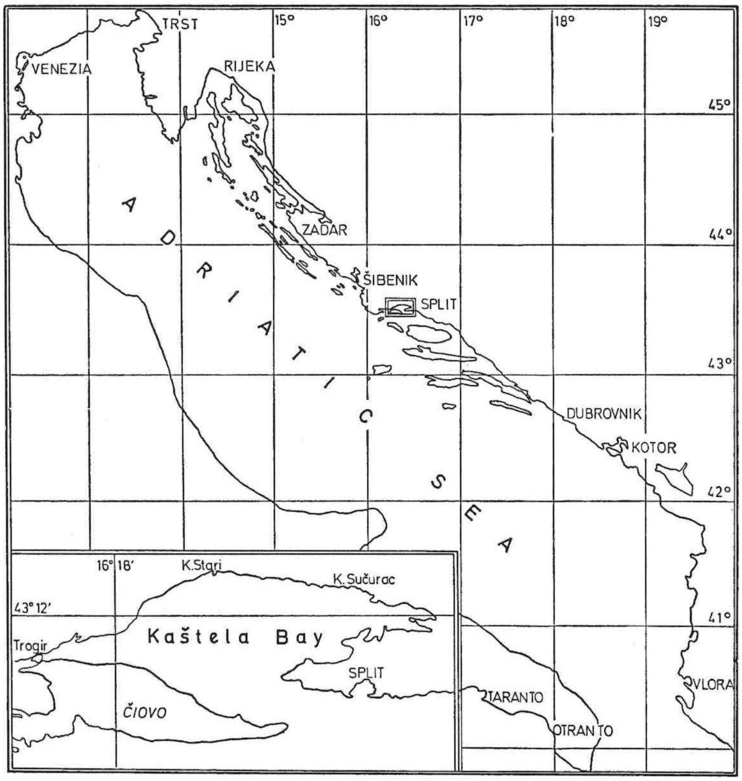

Fig. 1. Geographical position of the area studied

hours after collection and those for cell counts and taxonomic studies immediately preserved.

Concentrations of chlorophyll *a*, *b*, and *c*, phaeopigments and nonastacin type carotenoids were estimated by the threechromatic method (Strickland and Parsons, 1968) in »Unicam SP 600« spectrophotometer. Chlorophylls and phaeopigments were calculated using the equations of Strickland and Parsons (1968) and carotenoids according to Richards and Thompson (1952). Chlorophyll and phaeopigment concentrations are expressed in mg m^{-3}, and carotenoids in m-SPU m^{-3} (m-SPU is the unit almost equal to 1 g wet pigment). Since chlorophyll *b* concentrations were predominantly within the limits of methodological error they were not taken into account.

Photosynthetic pigment concentrations of nannoplankton were measured after filtering the samples through a phytoplankton net with 50 μ mesh size. Pigment concentrations of microplankton were obtained from the difference in pigment concentrations between the total phytoplankton and nannoplankton.

The overall quantity of each individual pigment within the water column, expressed in mg m^{-2}, was obtained by integrating the values between 35 m and the surface.

Grazing pressure index was calculated as the ratio of phaeopigment to chlorophyll *a* throughout the water column down to depth of 1% light penetration (approximately Secchi depth X 2.5) and expressed as Σ phaeopigment/ Σ chlorophyll *a* under m^2 (Lorenzen, 1967).

Samples for phytoplankton quantitative and gualitative analysis were preserved in 2.5% formol previously neutralized by sodium borate. Material was left to sediment for 24 hours in chambers of 25 ccm and afterwards counted in an inverted Utermöhl microscope. Depending on the standing crop the cauntings were made either of the whole chamber area of one its part. Phytoplankton density was expressed as cell numbers per liter of seawater corrected for formalin.

Number of nannoplankton organisms was determined after filtering the samples through phytoplankton net with 50 μ mesh size. Microplankton density was obtained from the difference in density between the total phytoplankton and nannoplankton.

Being the predominant group included in phytoplankton, diatoms were determined up to the level of species an placed in two groups: Centricae and Pennatae. The rest of phytoplankton groups were identified as Coccolithophorids, Silicoflagellates, Dinoflagellates, and »Microflagellates« (which included nannoplankton flagellates). Nannoplankton species were not determined but placed with phytoplankton principal groups.

Diatom identification was made according to Hustedt (1927—1937), Cupp (1943), Proškina-Lavrenko (1955) and Hendey (1964).

RESULTS

Vertical distribution of photosynthetic pigments

In the Kaštela Bay photosynthetic pigments showed considerable fluctuations in quantity with respect to depth (Figs. 2 and 3).

In the winter (February, March 1974) photosynthetic pigment concentrations decreased with depth (Fig. 2). In February values of chlorophyll *a* ranged from 1.12 mg m^{-3} at the surface to 0.26 mg m^{-3} at 35 m depth (bottom). Phaeopigment concentrations showed an increase between the surface (0.59 mg m^{-3}) and 10 m (0.75 mg m^{-3}), and at 10 m began to decrease reaching 0.12 mg m^{-3} at 35 m.

In March chlorophyll *a* concentrations were 1.08 mg m^{-3} at the surface and decreased to 0.47 mg m^{-3} at 10 m with a slight increase towards the bottom. Similar distribution was recorded for chlorophyll *c* and carotenoids. Phaeopigment concentrations decreased with depth ranging from 0.69 and 0.12 mg m^{-3}.

Maximum concentrations of chlorophyll *a* (1.55 mg m^{-3}) and phaeopigments (0.47 mg m^{3-}) were recorded at 10 m (Fig. 3) in January 1975. At the same time the peaks in chlorophyll *c* and carotenoid concentrations were recorded at the surface (0.96 and 0.97 mg m^{-3} respectively).

At the beginning of the spring, in April, distribution of both chlorophyll *a* and carotenoids was rather homogeneous, with maximum chlorophyll *a* con-

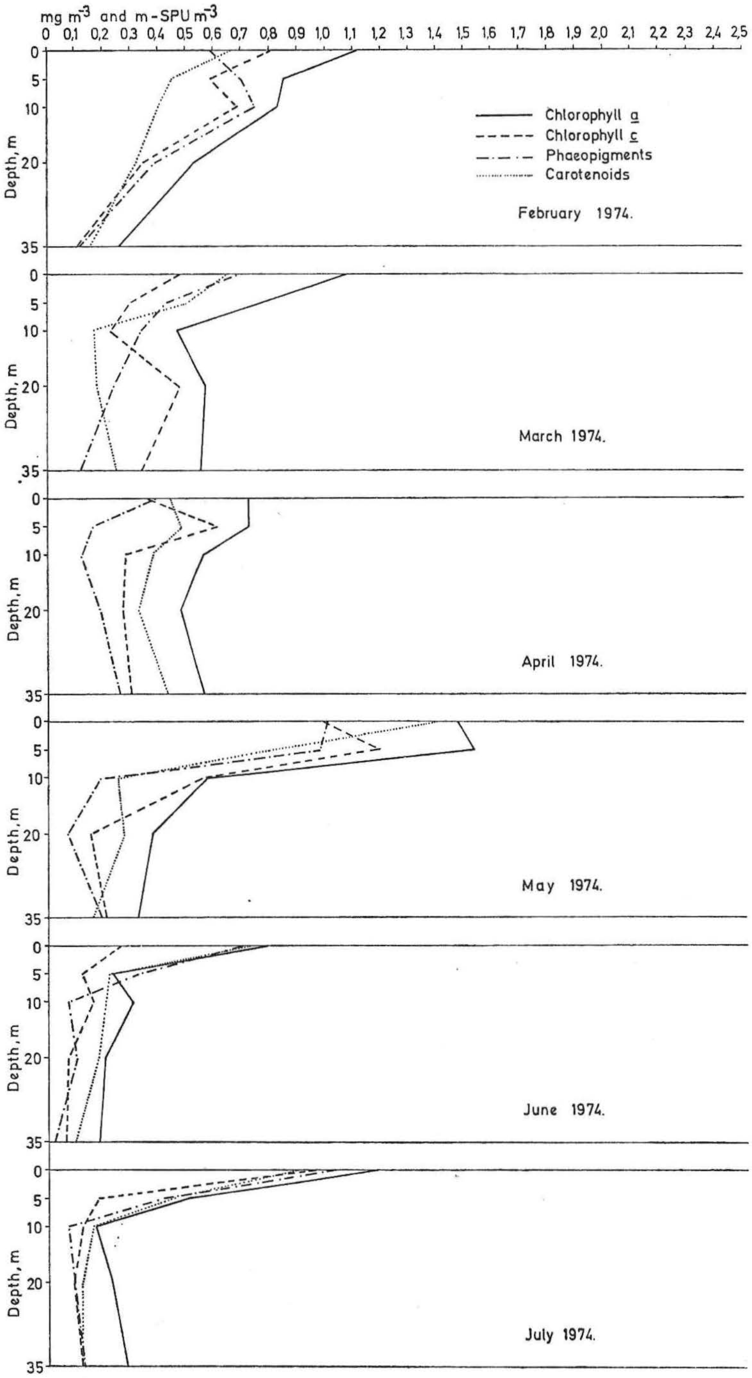

Fig. 2. Vertical distribution of photosynthetic pigments of the Kaštela Bay total phytoplankton (February—July 1974)

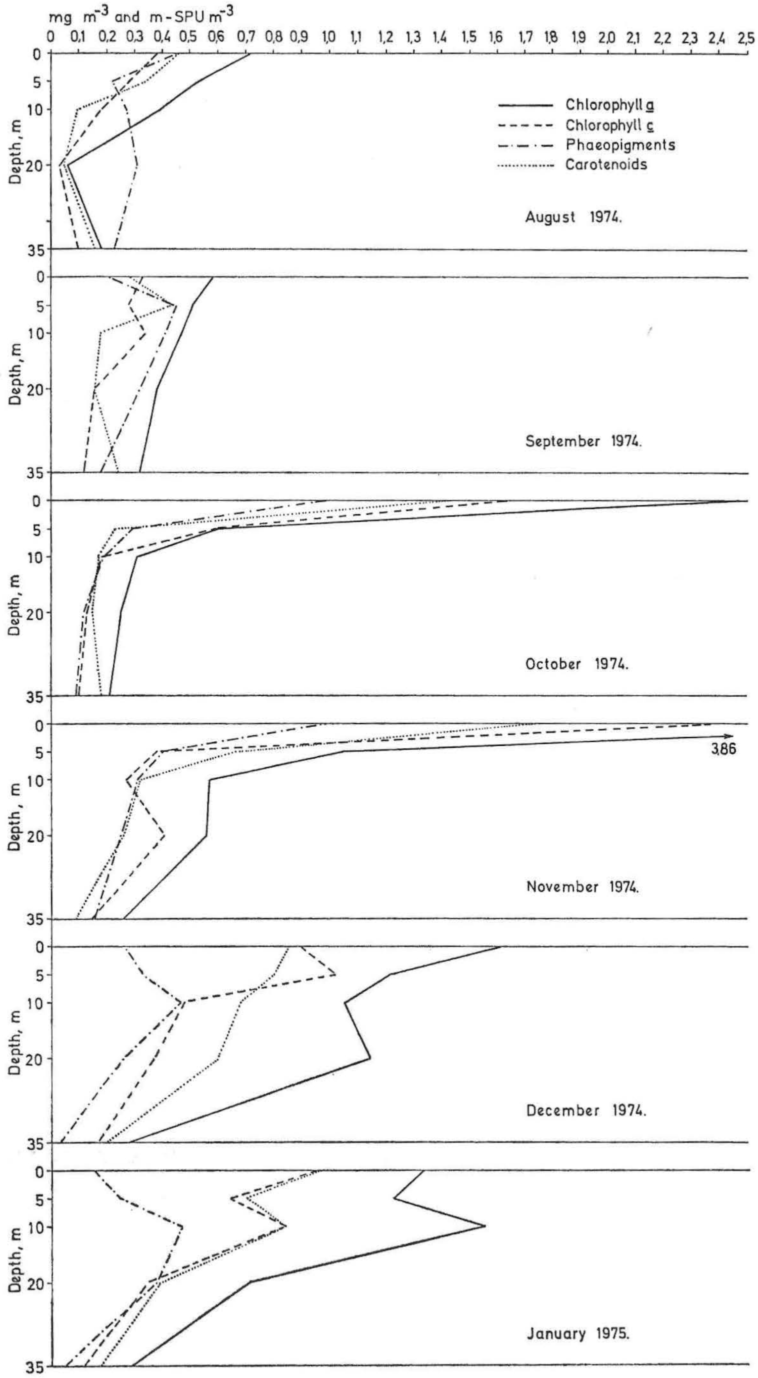

Fig. 3. Vertical distribution of photosynthetic pigments of the Kaštela Bay total phytoplankton (August 1974 — January 1975)

centrations in 0—5 m layer (0.72 mg m^{-3}) and minimum at 20 m (0.48 mg m^{-3}). Higher fluctuations were recorded der chlorophyll *c*. Phaeopigment concentrations varied from 0.38 mg m^{-3} at the surface to 0.12 mg m^{-3} at 10 m and showed an increase with depth.

In May maximum concentrations were recorded from 0—5 m layer, with rapid decrease with depth. Maximum concentrations of chlorophyll *a* (1.53 mg m^{-3}) and chlorophyll *c* (1.19 mg m^{-3}) were found at 5 m depth, whereas those of phaeopigments and carotenoids were found at the surface.

The records from June showed maximum concentrations confined to the surface layer with rapid decrease with depth. The exceptions were chlorophyll *c* concentrations which had somewhat more homogeneous distribution within the water column. Relative increase in phaeopigment concentrations (0.32 mg m^{-3}) was observed at 5 m.

In July and August the highest concentrations of pigments were recorded at the surface with rapid decrease with depth (Figs. 2 and 3). Minimum concentrations of all the pigments were at 10 m in July and at 20 m in August. The exceptions were very high relative concentrations of phaeopigments (with peak recorded at 20 m in August) whose values exceeded to a considerable extent those of chlorophyll *a*.

In September chlorophyll *a* and *c* concentrations had almost homogeneous distribution with maximum at the surface and slight decrease with depth. Maximum concentrations of phaeopigments and carotenoids were found at 5 m (Fig. 3).

Concentrations of photosynthetic pigments recorded in October and November were extremely high at the surface, with a high rate of decrease down to depth of 5 m. In November chlorophyll *a* concenttrations ranged between 3.86 mg m^{-3} at the surface to 0.23 mg m^{-3} at 35 m (Fig. 3).

In December photosynthetic pigments were found in relatively high concentrations throughout the water column down to 20 m with marked decrease towards the bottom.

Annual mean concentrations of photosynthetic pigments showed a typical vertical distribution, with the maximum at the surface and decrease with depth (Fig. 13). The values of chlorophyll *a* ranged from 1.40 to 0.30 mg m^{-3}; of chlorophyll *c* from 0.87 to 0.15 mg m^{-3}; of phaeopigments from 0.62 to 0.13 mg m^{-3}, of carotenoids from 0.87 mg to 0.19 mg m^{-3}.

Seasonal fluctuations in photosynthetic pigments within the water column

Seasonal fluctuations in chlorophyll *a* quantities were most marked in the 0—5 m layer (Fig. 4). There were also recorded maximum concentrations. The exception was January 1975 when maximum chlorophyll *a* concentrations were recorded at 10 m.

The spring maximum recorded in May was confined to the surface layer with the highest chlorophyll *a* concentration (1.53 mg m^{-3}) at 5 m.

The autumn-winter maximum concentrations of chlorophyll *a* (the highest value 3.86 mg m^{-3}) occured at the surface in October-November. Even though these values rapidly decreased in December 1974 and January 1975 they were still relatively high.

The autumn-winter maximum at 5 m was first recorded in October 1974 with a slight rate of increase by January 1975.

Relatively high chlorophyll *a* concentrations confined exclusively to the surface were recorded in February (1.12 mg m^{-3}) and July 1974 (1.17 mg m^{-3}).

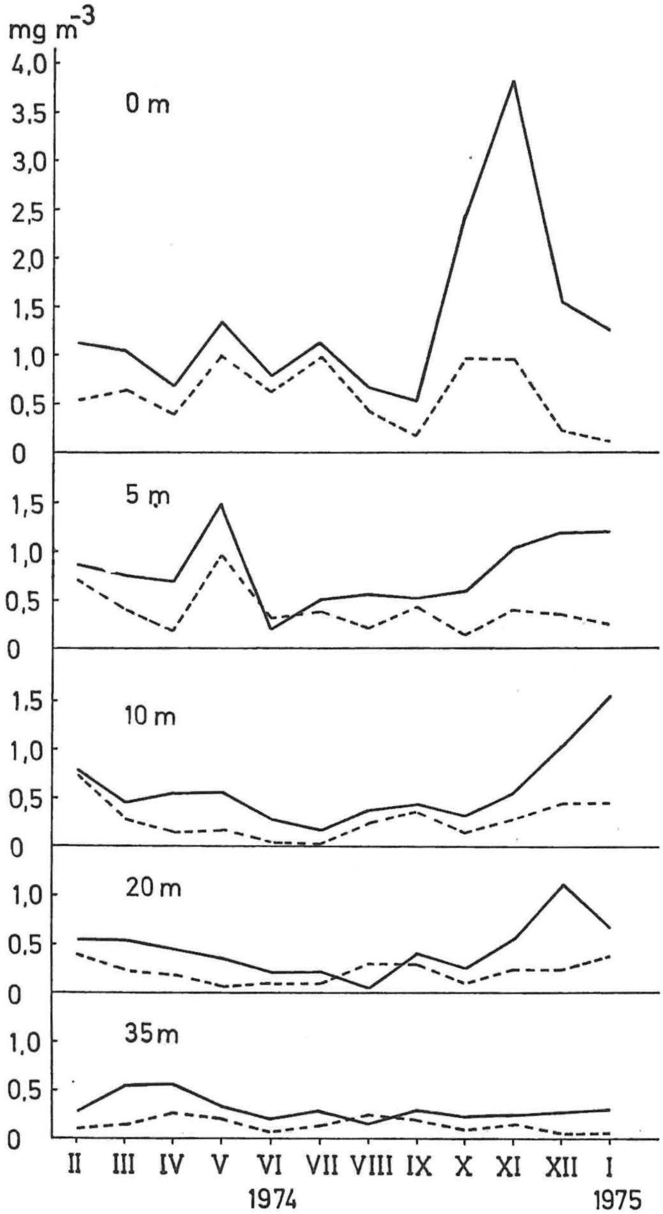

Fig. 4. Seasonal variations in chlorophyll *a* (solid line) and phaeopigments (dashed line) of the Kaštela Bay total phytoplankton

Variations in chlorophyll *a* concentrations were considerably smaller in the 10—35 m layer than they were in the surface layer (Fig. 4). These concentrations were relatively low and almost constant as far as September when an increase was recorded at all depths with a maximum 1.55 mg m^{-3} at 10 m in January 1975. Minimum amounts of chlorophyll *a* in the 10—35 m layer were recorded in June—August.

Variations in chlorophyll *a* exceeded to a considerable extent the variations in phaeopigments. Maximum phaeopigment concentrations were recorded at the surface in May (1.00 mg m^{-3}), July (1.01 mg m^{-3}) and October (0.99 mg m^{-3}). Minimum concentratiaons recorded mainly at 20 and 35 m varied between 0.02 and 0.09 mg m^{-3}.

In most cases an increase in chlorophyll *a* concentrations was accompanied by the increase in phaeopigment quantity with the exception for autumn-winter period when the increase in the former was not followed by the appropriate increase in the latter.

Integrated values of photosynthetic pigment concentrations throughout the water column (0—35 m) expressed in mg m^{-3} are given in Fig. 5.

The increase in chlorophyll *a* concentrations was most prominent in October—December with maximum 34.30 mg m^{-2} in December. During the winter-

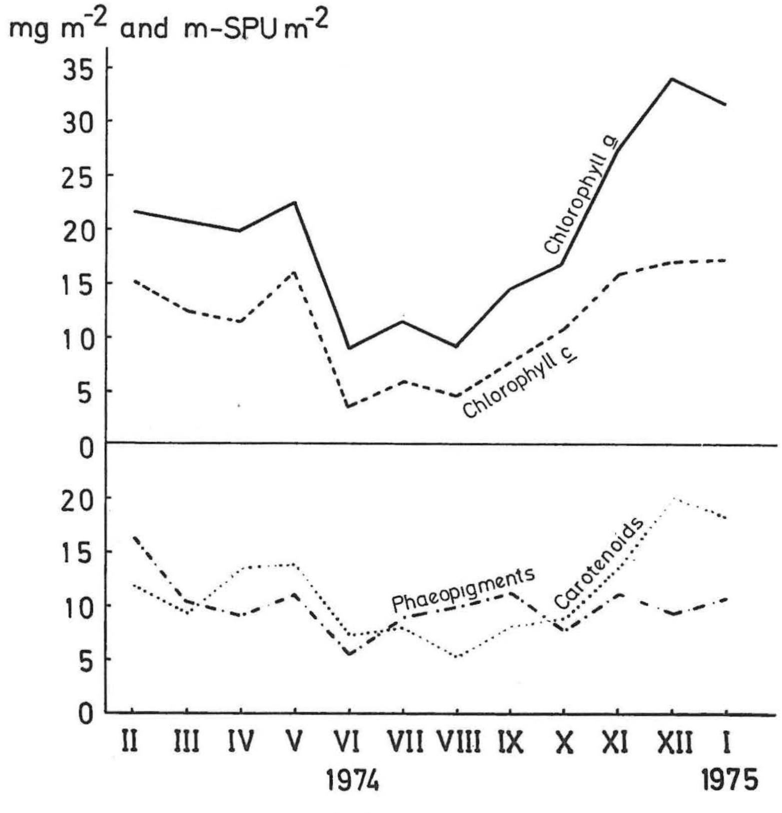

Fig. 5. Seasonal variations in the total phytoplankton photosynthetic pigments within the sea water column

-spring period (February—May) chlorophyll *a* concentrations were high with a peak in May (22.55 mg m^{-3}). The lowest concentrations were recorded in June and August (9.15 and 9.40 mg m^{-2}).

Seasonal variations in phaeopigment quantities within the water column were relatively small. The highest concentration was recorded in February (16.25 mg m^{-2}) and the lowest one in June (5.15 mg m^{-2}).

Seasonal variations in chlorophyll *c* and nonastacin type carotenoid concentrations were positively related to variations in chlorophyll *a* concentrations. Maximum chlorophyll *c* concentrations were found in May (16.05 mg m^{-2}) and January 1975 (17.18 mg m^{-2}), and minimum ones in June. Integrated values of carotenoid concentrations showed maximum in December and April-May.

Contribution of nannoplankton to the total concentrations of chlorophyll a and phaeopigments

Seasonal variations in chlorophyll *a* and phaeopigments of the total phytoplankton (means for 0 and 10 m) are presented in Fig. 6.

During the year the concentrations of chlorophyll *a* in the upper 10 m varied between 0.11 and 1.24 mg m^{-3}, and of phaeopigments between 0.03 and 0.33 mg m^{-3}. At the same time seasonal variations in chlorophyll *a* concentrations of nannoplankton were relatively small with maximum 1.18 mg m^{-3} recorded in Januaru 1975. Two not so marked maxima occurred in Fabruary (0.76 mg m^{-3}) and November (0.98 mg m^{-3}) and minimum in April.

There were recorded four maxima in the nannoplankton phaeopigment concentrations. The marked one was that of July (0.47 mg m^{-3}) whereas minimum was also recorded in April.

Relative seasonal contribution of nannoplankton to the total concentrations of chlorophyll *a* and phaeopigments predominantly exceeded that of microplankton. Nannoplankton constituted between 66.4 and 81.9 percent of the total chlorophyll *a* concentrations, and between 61.9 and 92.1 percent of the total phaeopigment ones (Fig. 7).

During March—April the contributions of both nannoplankton and microplankton to the total chlorophyll *a* were about equal whereas in May and October—November the concentrations of the latter exceeded slightly those of the former.

Phaeopigment concentrations of nannoplankton were mainly larger than those of microplankton. The ratio of nannoplankton phaeopigment concentrations to microplankton ones was 50.8 to 49.2 percent in February. However, microplankton was markedly predominant in April constituting 88 percent of the total phaeopigment concentration.

Seasonal variations in relative grazing pressure index

Variations in ratio of phaeopigment to chlorophyll *a* concentrations down to depth of 1 percent light penetration of the water column are given in Fig. 18.

Observations of predation index as rough indicator of zooplankton grazing intensity according to Lorenzen, distinguished three different stages of the Kaštel Bay zooplankton grazing. Predation intensity was relatively high

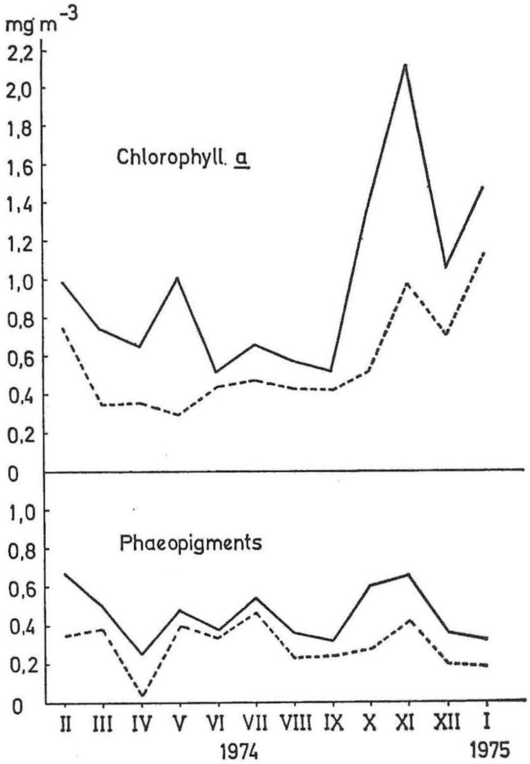

Fig. 6. Seasonal variations in chlorophyll *a* and phaeopigment concentrations of the total phytoplankton (solid line) and nannoplankton (dashed line) in the Kaštela Bay (means for 0 and 10 m)

in February 1974 showing a decrease till the beginning of the spring. In the spring-summer (May—August) period index values increased reaching the absolute peak in Auglust. This stage was followed by a continous decrease to as far as January 1975.

Bathymetric distribution of the total phytoplankton density

Low densities and uniform vertical distribution of phytoplankton was a feature of the winter months (February, March) 1974 with the highest values recorded at the surface, and at 10 m in January 1975.

In April and May 1974 maximum densities were recorded at 5 m. They decreased with depth reaching a minimum at 20 m.

The summer-autumn period, between June and November, was characterized by the highest phytoplankton concentrations in 0—5 m layer, with maximum at the surface. The only exception was September when a peak

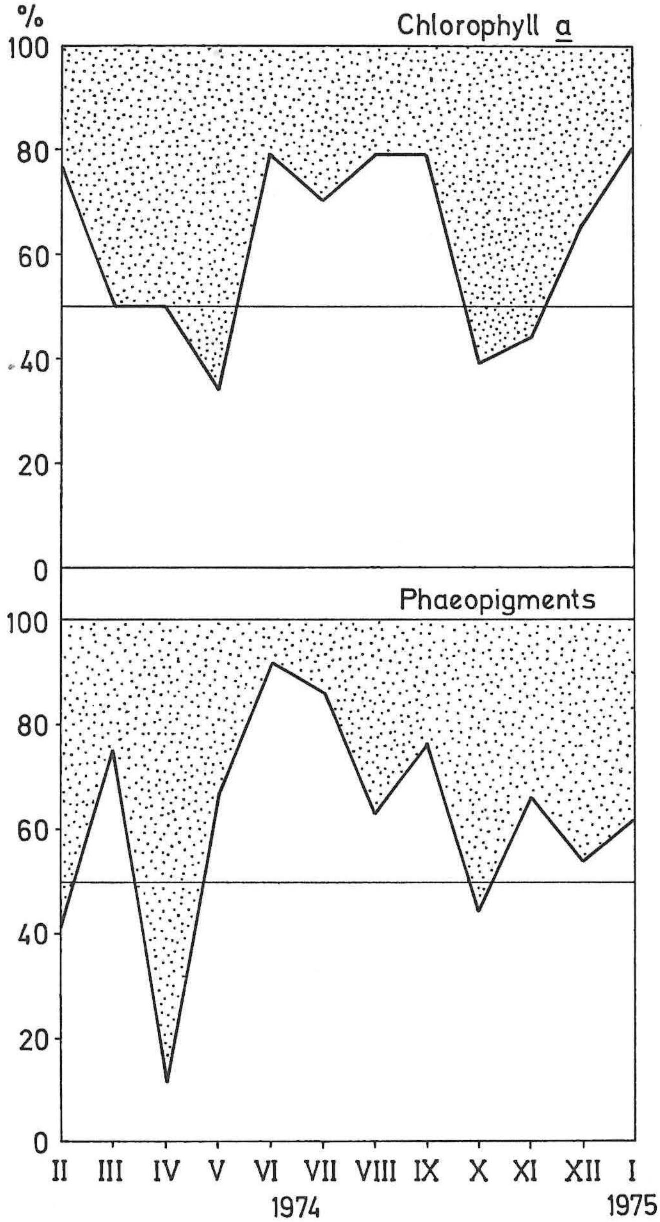

Fig. 7. Relative significance of microplankton (dotted area) and nannoplankton (white area) components of the total phytoplankton (means of chlorophyll *a* and phaeopigments for 0 and 10 m)

was recorded at 5 m. Particularly high rate of decrease with depth was recorded during whole this period.

In December, density of phytoplankton showed a rather uniform distribution throughout the 0—20 m hayer. The decrease with depth was relatively high.

As it can be seen in the Table 1. the Kaštela Bay phytoplankton is characterized by the high concentrations at the surface, i. e. in the 0—5 m layer with marked decrease with depth. This is particularly applicable to the May—November period. Even though the vertical distribution of phytoplankton was much more uniform during February—April and December—January 1975 yet the density decrease with depth was observed.

Table 1. Vertical distribution of the phytoplankton density (cells/1) over the February 1974 — January 1975 period

Month	O m	5 m	10 m	20 m	35 m
II	303 740	284 160	266 700	208 040	123 080
III	290 640	219 120	277 620	260 400	138 600
IV	564 480	664 440	469 980	317 520	401 520
V	1 646 820	1 856 820	988 680	424 200	130 020
VI	3 228 960	813 960	764 400	376 320	163 800
VII	4 368 840	1 194 480	489 660	122 220	92 400
VIII	1 601 460	738 360	194 040	102 060	104 160
IX	838 320	1 219 680	598 080	399 000	374 640
X	1 254 120	214 200	164 640	53 760	33 600
XI	1 500 240	708 120	254 100	221 760	64 260
XII	429 240	336 000	365 400	386 400	84 840
I	349 440	308 600	627 480	178 920	118 440

Percentage rations between groups phytoplankton are given in Fig. 15. Boundaries between months are presented by thick lines and those between 0, 5, 10, 20, and 35 m depths by thin lines (left - right direction). As it can be seen diatoms predominanted in all the seasons and at all depts (except for 35 m in June). Percentage proportion of diatoms decreased with depth where coccolithophorids and dinoflagellates made up the bulk of the total phytoplankton biomass.

Bathymetric distribution of annual means of the total phytoplankton density (Fig. 14) showed maximum at the surface and minimum at bottom. Densities ranged from about 1 300 000 to 150 000 cells per liter i. e. the surface concentrations were slightly less than ninefold those of the bottom. The rate of decrease was higher in 0—10 m layer.

Seasonal variations in density and species composition of phytoplankton communities within the water column

One of the properties of the Kaštela Bay phytoplankton are considerable variations in density, particularly in the 0—5 m layer. Maximum densities were about fifteenfold the minimum ones.

Seasonal cycle of phytoplankton density at the surface showed two maxima, in July and November (Fig. 8). High densities recorded in May-August varied between 1 600 000 and 4 000 000 cells per liter with a peak in July. Diatoms were absolutely predominant in this period comprising as much as

86.2—97.0 percent of the total phytoplankton. Diatom flora was dominated by the species *Skeletonema costatum, Leptocylindrus danicus, L. adriaticus,* and *Nitzschia seriata,* and the species of genus *Chaetoceros* with the most important *Ch. affinis* and *Ch. curvisetus.* The marked increase in number of *S. costatum* was observed. In May this species constituted 1 percent of diatom population, in June 32.8 percent, in July 64.1 percent whereas in August its absolute predominance was shown by as much as 83.4 percent. Diatom species such as *Hemiaulus haucki, Cerataulina bergoni,* and *Eucampia cornuta* (Appendix tables 4—7) occurred in smaller proportions. Coccolithophorids made up 1.3—6.4 percent, dinoflagellates 1.1—5.7 percent, and »microflagellates« 1.2—2.3 percent of the total phytoplankton.

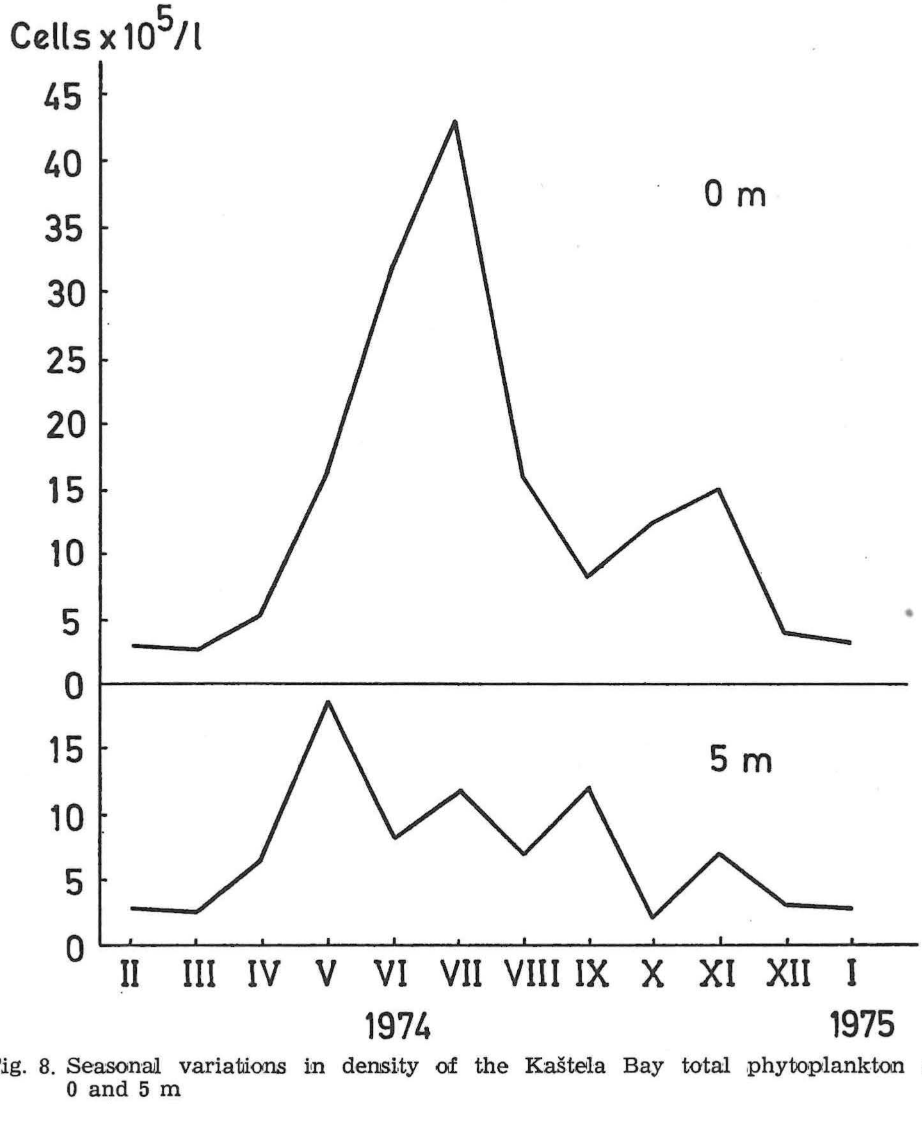

Fig. 8. Seasonal variations in density of the Kaštela Bay total phytoplankton at 0 and 5 m

Maximum recorded in the autumn, about 1 200 000 cells per liter in October and somewhat higher number in November (about 1 300 000) was much lower than that of July. Diatoms were also predominant constituting 95.7 percent of the total phytoplankton. The *Ch. curvisetus* species of the genus *Chaetoceros* was the major element (50.9 percent) of diatom fraction. Contribution of species *Cerataulina bergoni* and *Nitzschia seriata* was also significant. Presence of other phytoplankton groups was of minor importance (Appendix tables 8—11).

The phytoplankton reached minimum density of 300 000 cells per liter in February and March. Diatoms also made up the bulk of the phytoplankton population with 74.8 and 65.9 percent respectively. Species of genus *Chaetoceros* such as *Ch. curvisetus, Ch. didyms, Ch. lorenzianus,* and *Ch. compressus* constituted the major part of diatom population (40.1 and 54.4 percent). The occurrence of species *Nitzschia seriata, Skeletonema costatum,* and *Lauderia borealis* was also significant. The following groups made a less important contribution to the total phytoplankton: coccolithophorids 12.9 and 15.9 percent, dinoflagellates 10.4 and 11 percent, and »microflagellates« 1.6 and 7.2 percent. The occassional occurrence of silicoflagellates in February was almost insignificant, 0.3 percent of the total phytoplankton (Appendix tables 1 and 2).

Phytoplankton density was low in January 1975, as well. Predominance of diatoms (80 percent) was chiefly due to *Nitzschia seriata* and *Leptocylindrus adriaticus* (Appendix table 12).

Several seasonal density maxima were recorded at 5 m (Fig. 8). The most marked maximum occurred in May (about 1 800 000 cells per liter). Dominance of diatoms (86.2 percent) including species *Nitzschia seriata* and *Leptocylindrus danicus* was observed (Appendix table 4). Successive maxima occurred in July and September. The number of organisms was 1 200 000 cells per liter. In July, the most common species of predominating diatoms (about 93 and 97 percent) were *Skeletonema costatum* (55.2 percent), *Leptocylindrus adriaticus* (14.9 percent) and species of genus *Chaetoceros* (16 percent). In September *S. costatum* was the only dominant diatom (86 percent). The rest of the phytoplankton groups were of minor importance (Appendix tables 6 and 8).

The lowest densities at 5 m were recorded in October (200 000 cells per liter) with the predominance of diatoms.

Fluctuations in density between 10 and 35 m of the water column exceeded those between 0 and 5 m (Fig. 9). Seasonal variations in phytoplankton groups in the 0—35 m layer are given in Appendix tables 1—12.

At 10 m somewhat more marked maximum, 980 000 cells per liter, was observed in May. Diatoms also predominated comprising as much as 91.9 percent. The major representative of diatoms was *Nitzschia seriata* species. During the other months cell numbers per liter varied from 150 000 to almost 620 000 with diatoms ranging from 56.7—94.8 percent.

Variations in the number of organisms at 20 m ranged from 100 000 to 420 000 cells per liter during the year except for October when density was 53 000 cells per liter. Diatoms consistently formed a major component of phytoplankton ranging from 53.9—93.2 percent.

Two density maxima, in April and September, occurred at 35 m. Diatoms were predominant all the year through with the exception for June when they comprised not more than 45.1 percent. At that time coccolithophorids constituted 28.7 percent of the total phytoplankton, dinoflagellates 19.5 percent, and

»microflagellates« 6.7 percent. The most common diatom species were *Leptocylindrus adriaticus*, *Nitzschia seriata*, *Skeletonema costatum*, and species of genus *Chaetoceros*.

The spring maximum was recorded at all three levels (at 10 and 20 m in May and at 35 m in April) and the other maximum in September. Several

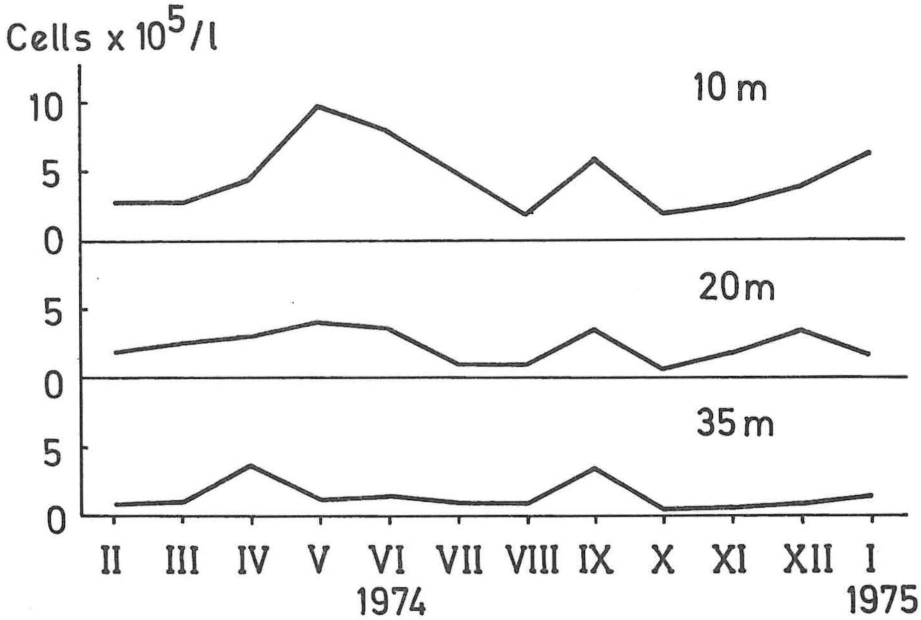

Fig. 9. Seasonal variations in density of the Kaštela Bay total phytoplankton at 10, 20, and 35 m

irregularly timed additional peaks were also found. Minimum densities were reached in the summer (July—August) and autumn (October).

Curve of phytoplankton density means (Fig. 10) showed May—July 1974 to be the period of the highest values. Number of cells varied from about 1 000 000 per liter to about 1 200 000 but throughout the spring-summer numerical values were relatively high. The autumn maximum occurred in November (more than 540 000 cells per liter).

The winter was a period of the lowest phytoplankton densities, with a range of 230 000—320 000 cells per liter.

Fig. 10. shows that the seasonal cycle of the total phytoplankton in the Kaštela Bay was determined by the quantitative contribution of diatom species. Mean percentages of diatom contribution ranged from 65.5—95.8 percent.

The spring-summer increase in density was followed by predominance of several diatom species in a succession as follows: the best represented was *Skeletonema costatum*, then *Leptocylindrus adriaticus*, *L. danicus*, *Nitzschia seriata*, and genus *Chaetoceros* with species *Ch. curvisetus* and *Ch. affinis*.

Predominant organisms during the autumn maximum in November were species of genus *Chaetoceros*, *Ch. curvisetus* and *Ch. laciniosus*.

Contribution of *Cerataulina bergoni*, *Nitzschia seriata*, and *Thalassionema nitzschioides*, was also significant.

Fluctuations in percentage contribution of other phytoplankton groups were moderate except for the winter months when proportion of coccolitho-

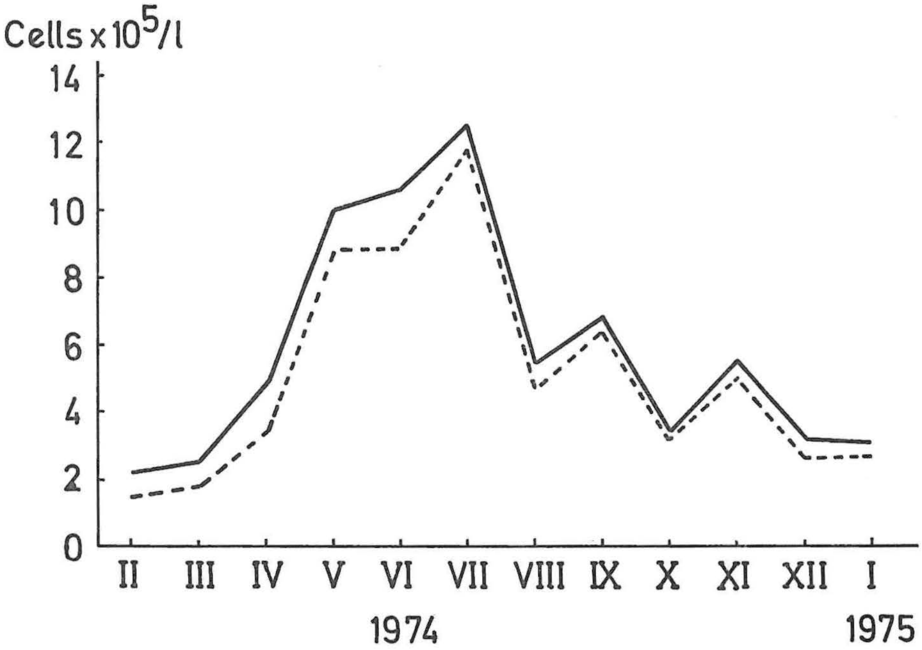

Fig. 10. Seasonal variations in density of the total phytoplankton (solid line) and diatoms (dashed line) in the Kaštela Bay (means of cell numbers per liter at depths surveyed)

phorids and dinoflagellates was somewhat more important. However, they never made up more than 20 percent of the total phytoplankton community (expressed in mean percentages).

Diatoms are, in general, predominant component of the total phytoplankton community and lower densities are mainly due to the decrease in diatom population.

Seasonal cycle of density and size composition of the phytoplankton community in the upper euphotic layer

During present investigation a special attention was given to the seasonal variations in density of the total phytoplankton and nannoplankton in the upper 10 m layer (means for 0 and 10 m).

Values of phytoplankton density varied between the extremes of 280 000 and 2 400 000 cells per liter whereas nannoplankton densities ranged from 190 000 and 1 700 000 cells per liter (Fig. 11).

Seasonal cycle of nannoplankton density follows that of the total phytoplankton. An increase in density of phytoplankton communities was in most cases due to the icrease in the number of nannoplankton organisms, and vice versa.

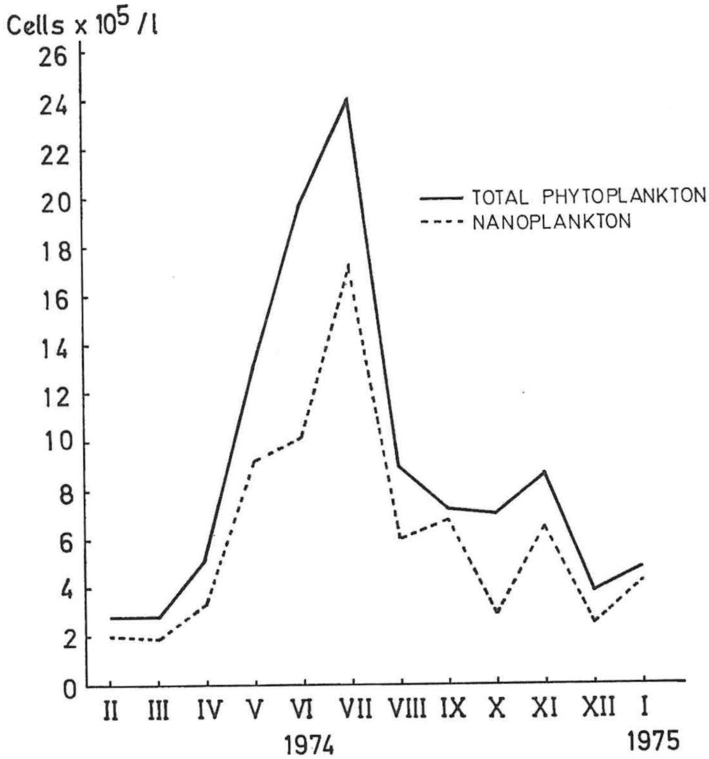

Fig. 11. Seasonal cycle of the total phytoplankton and nannoplankton density (means for 0 and 10 m)

The only exception was recorded in September when nannoplankton density increased during the decrease in the total phytoplankton. Small deviations from the usual pattern were found in June and October. They were probably due to differences in contribution of micro- and nannoplankton to the total phytoplankton community. Fig. 12 illustrates that, with respect to density, nannoplankton component was predominant in almost all the seasons making up 63.2—94.9 percent of the total phytoplankton. The quantities of both the fractions were almost equal in June thus that microplankton: nannoplankton ratio was 48.9 : 51.1 percent. Microplankton only predominated in October comprising 58.9 percent of the total phytoplankton community.

Species composition of micro- and nannoplankton was not separately studied. But since diatoms predominated in total phytoplankton their contribution to these two fractions was observed. Diatom range was in microplankton 52—97.6 percent of the total cell number and in nannoplankton 55.6—75.5 percent. Besides diatoms, dinoflagellates were the second principal contributor to microplankton, and coccolithophorids and »microflagellates« to nannoplankton together with minute dinoflagellates.

On an average, microplankton included somewhat higher percentage numbers of diatoms whereas they were also the significant component of nannoplankton.

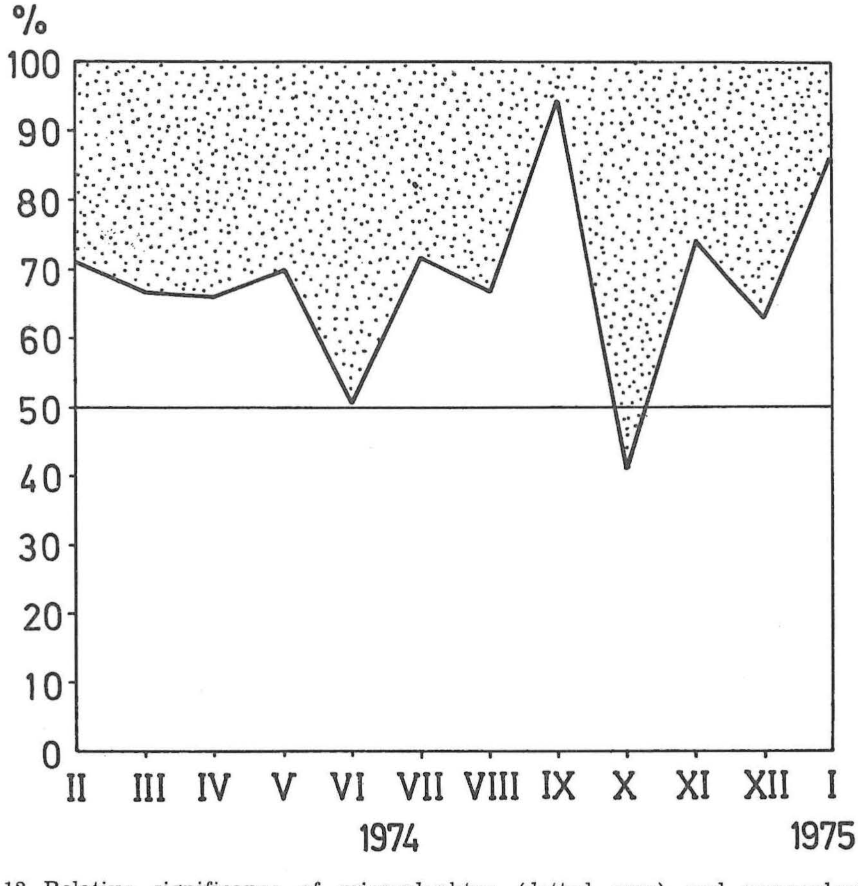

Fig. 12. Relative significance of microplankton (dotted area) and nannoplankton (white area) size fractions in the phytoplankton community of the Kaštela Bay (means for 0 and 10 m)

DISCUSSION

Seasonal vertical distribution of phytoplankton

Vertical distribution of phytoplankton iz dependent on a number of factors such as the availability of nutrients and light, vertical distribution on temperature and salinity i. e. seawater density.

Primary production as well as phytoplankton biomass are confined mainly to the upper, euphotic layer, where light conditions permit the photosynthesis. In general, the supply of nutrients in the euphotic layer is held to be the principal factor regulating the magnitude of annual organic production in most sea areas. In addition, organic production is controlled by such factors as light and zooplankton grazing.

The supply of nutrients as well as some other factors which influence the phytoplankton growth (vitamins, hormones, trace metals) in the euphotic layer of the shalflow coastal areas are due to fresh water draining from the nearby land and to vertical mixing. Zooplankton excretion is also of importance for nutrients regeneration. Zooplankton quickly regenerates phosphates; major proportion is excreted in the euphotic layer and consumed directly by phytoplankton (Kexchum, 1962). Hargrave and Geen (1968) found the faeces of zooplankton to contain 75 percent of organic phosphates which are easily decomposed into orthophosphates by bacteria or enzymes. Bacteria are of primary importance in nitrogen regeneration (Riley and Chester, 1971). Martin (1968) emphasized the importance of zooplankton excretion of ammonia as the main source of nitrogen, particularly under the summer stratification conditions.

The former data on the bathymetric distribution of the Kaštela Bay phytoplankton based on phytoplankton density estimations showed that most of phytoplankton biomass was found in the surface layer. In addition to light, low salinity due to the coastal freshwater influxes plays also an outstanding role here. Ercegović (1936) found that the spring and winter increase in phytoplankton coincided with the marked reduction in salinity. Pucher-Petković (1966) assumed that the phytoplankton surface concentrations were not directly related to salinity and that low salinity only indicated that nutrients were brought to the surface layer. According to the same author this way of nutrient supply in the surface layer is more important than mechanical circulation. Pucher-Petković, found diatoms almost homogeneously distributed at all depths only in the autumn and spring. The results of the primary production investigations led this author to conclude (1970) that most of the organic matter in the Kaštela Bay was produced in the upper 10 m.

The data of our investigations of photosynthetic pigments vertical distribution and phytoplankton density carried out between February 1974 and January 1975, showed that phytoplankton was mainly concentrated in the upper euphotic layer, either at the surface or at 5 m (Figs. 13 and 14).

In the winter and spring, rather uniform vertical distribution of phytoplankton with a slight accumulation in the surface layer, where salinity is somewhat lower, is caused by almost homogeneous distribution of temperature and salinity. Phytoplankton distribution is markedly uniform whereas photosynthetic pigments show some variations. Phytoplankton bloom occurs in the spring owing to the more intense light. Stabilization of surface conditions with warmer and less dense water of relatively low salinity is due to the spring temperature increase. In spite of the higher summer salinity an thermal stratification the phytoplankton surface concentrations were particularly high throughout the May—August. Since the summer was known to be the period of phytoplankton stagnation Pucher-Petković (1975) ascribed this distribution to organic pollution. In the summer, nutrients are supplied in the surface

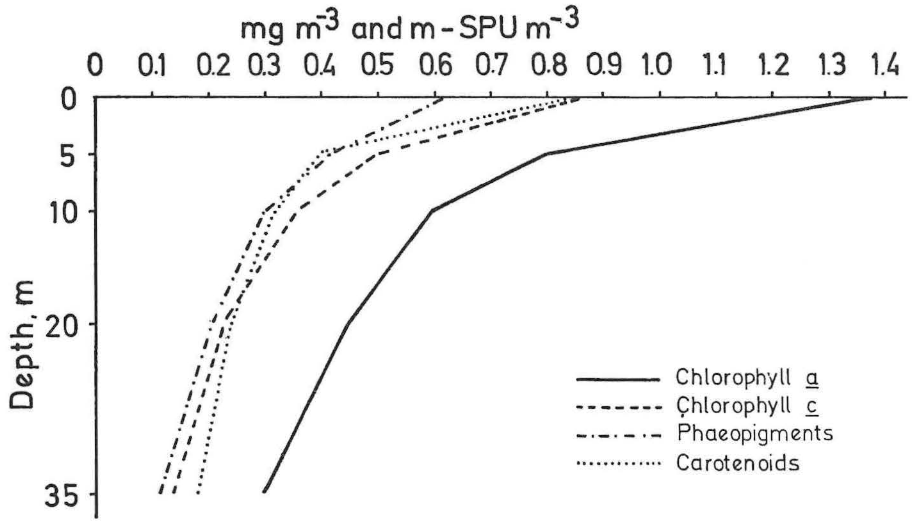

Fig. 13. Vertical distribution of photosynthetic pigments of the total phytoplankton (annual means for depths surveyed)

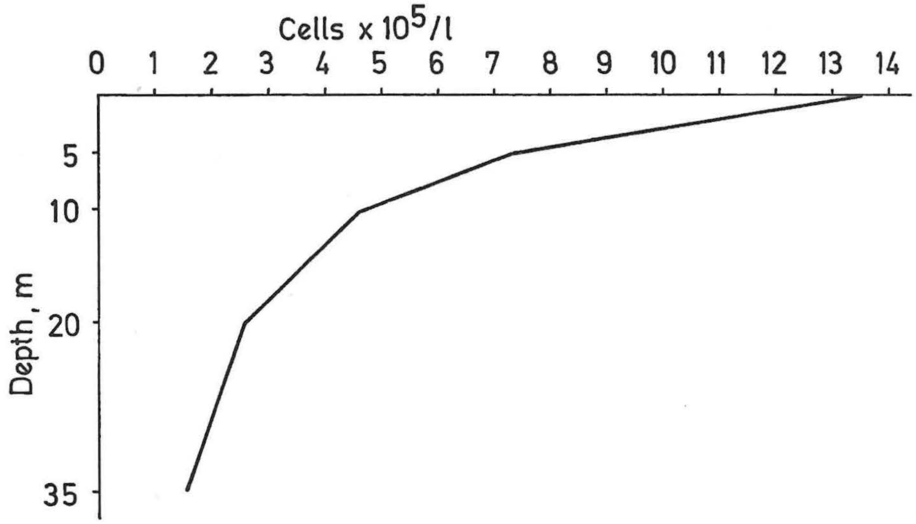

Fig. 14. Vertical distribution of the total phytoplankton density (annual means for depths surveyed)

layer by town waste water discharges. However, the summer regeneration of nutrients by means of zooplankton excretion must not be neglected. Increase in zooplankton concentrations in August and also relatively high concentrations of rather homogeneously distributed phosphates led us to such a conclusion.

Phytoplankton biomass was considerably reduced at that time. Large phaeopigment concentrations at 20 and 35 m in August indicated zooplankton grazing (Lorenzen, 1967). According to Saijo *et al.* (1969) relatively low concentrations of the surface phaeopigments may be the result of their decomposition under the influence of intense light. However, concentration of phaeopigments in the bottom layer was possibly caused by sinking of zooplankton faeces (Yentsch, 1965).

More homogeneous distribution of phytoplankton biomass in September was the result of sinking of thermocline to lower depths. However, throughout the autumn months the highest phytoplankton biomass was recorded in the surface layer. This was due to the nutrient supplies resulting from freshwater influxes, and to the optimum light conditions too. Vertical mixing was, as well, responsible for the surface layer nutrient enrichment in the autumn.

Annual means of photosynthetic pigments and phytoplankton density are given in Figs. 13 and 14. It may be seen that phytoplankton density gradient was similar to those of chlorophyll *a* and other photosynthetic pigments. Characteristic vertical distribution of phytoplankton biomass indicates the supply of nutrients in the surface layer by freshwater influxes. Organic pollution, probably together with the regeneration of nutrients by zooplankton excretion, was the significant factor influencing phytoplankton in the summer.

Phytoplankton species composition characterized by the numerical predominance of diatoms showed characteristic vertical distribution in all the seasons with the majority of diatoms in the surface layer (Fig. 15). Diatoms constituted about 86 percent of the surface community, and on an average about 69 percent at 35 m. Gran and Thompson (1930) considered diatom maintenance at the same depth for several months to be due to the optimum conditions for their growth.

Seasonal fluctuations in the biomass and species composition of phytoplankton

During the study of seasonal changes in the biomass of the Kaštela Bay phytoplankton special attention was given to the fluctuations in concentrations of chlorophyll *a* and its degradation products, phaeopigments. Humphrey (1970) stated that chlorophyll *a* was dominant cell pigment. However, Vernon (1960) suggested that absorption spectres of chlorophyll *a* and phaeopigments were similar what might have led to wrong estimations of the biomass magnitude in cases of large phaeopigment concentrations.

Phaeopigments are producet in a number of different ways. They may be produced by phytoplankton cells moving past zooplankton intestines, in dark, of by bacterial activity. They are fastly produced by zooplankton grazing. The ratio of zooplankter numbers within the water column to phaeopigment quantities in the euphotic layer was established. This the relationship between phaeopigment and chrorophyll *a* quantities appears to indicate the herbivore zooplankton grazing activity (Lorenzen, 1967).

In the Kaštela Bay seasonal fluctuations in quantity of the phaeopigments are rather smal. Maximum phaeopigment concentrations coincided with the biomass maxima. No positive relationship between the phaeopigment quantities an the number of zooplankton organisms was found. It was found only in

August when increasing copepod biomass and decreasing phytoplankton biomass were followed by the increase in the ratio of Σ phaeopigment to Σ chlouophyll *a* m^{-2} (Fig. 18).

Fluctuations in photosynthetic pigments such as chlorophyll c and carotenoids were more or less similar to those in chorophyll *a*. Recent chromatographis investigations (Jeffrey, 1974) have showed that nonliving algae

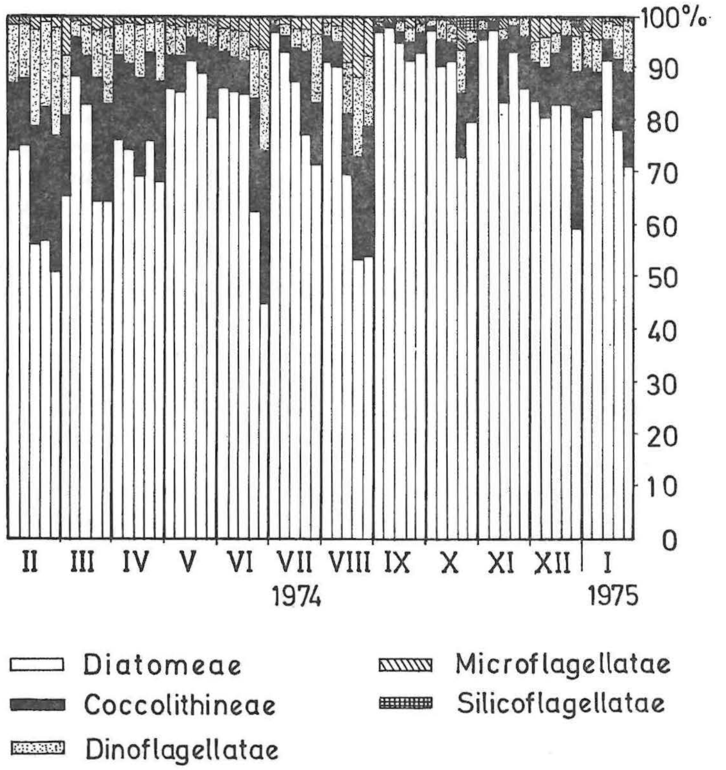

Fig. 15. Seasonal variations in the composition of the Kaštela Bay phytoplankton community at 0, 5, 10, 20, and 35 m (percentage relations between groups)

contain more chlorophyll c than chlorophyll *a* and also that high chlorophyll *a*: chlorophyll c ratio is indicative of high concentratios of nonliving detritus of plant origin within the waer column. However, as emphasized by Strickland and Parsons (1968), chlorophyll c measurements by three-chromatic method at low standing crop did not give satisfactory results. These authors, therefore, developed the method of chlorophyll c separation by by n-hexane. Unfortunately, this method proved to take a rather long time and unsuitable for the routine analysis. No relatively higher concentration of chlorophyll c in relation to chlorophyll *a* was found during our observations. Ketchum *et al.* (1958) suggested that chlorophyll *a* to carotenoids ratio might be indicative of the physiological state of phytoplankton community. As indicated by the above mentioned authors phytoplankton organisms aging would appear to be the principal factor influencing the changes in cell pigment concentrations. This aging was probably due to the shortage of available nutrients and it did not only change pigment total concentrations but also their relative proportions. For example, chlorophyll *a* concentrations in the older cells are reduced faster than carotenoid ones. Therefore, low values of chlorophyll *a* to carotenoids ratio probably indicate the chlorotic population. In the Kaštela Bay this ratio was rather uniform varying between 10.7 and 2.26.

Investigations of photosynthetic pigments concentrations in the Adriatic plankton have not started long ago. Surveying the western Adriatic coast Franko (1967) found maxium chlorophyll *a* concentration to be 1.9 mg m^{-3}. Kveder *et al.* (1971) recorded maximum chlorophyll $a + c$ concentrations (about 3 mg m^{-3}) at the coastal station near Rovinj in December. At the same station Revelante (1975) found the highest chlorophyll *a* concentrations (3 mg m^{-3}) in October—November. Surface waters of the northern Adriatic in the vicinity of the River Po contained much higher chlorophyll *a* concentration (14.7 mg m^{-3}).

Margalef and Ballester (1967) reported for the Mediterranean (i. e. Costa Catalana) the chrolophyll *a* concentrations to vary from 0.02 to 2.50 mg m^{-3} during phytoplankton bloom. Travers (1962) found maximum chlorophyll *a* concentration (1.20 mg m^{-3}) during phytoplankton winter bloom in the Gulf of Lion.

Maximum concentration of chlorophyll *a* recorded during the autumn phytoplankton bloom in the Kaštela Bay was 3.86 mg m^{-3} at the surface. The values recorded during the spring maximum in May were somewhat lower, 1.53 mg m^{-3}. As compared with the above mentioned ones, our results indicate thet the surveyed area of the central Adriatic is rather rich in phytoplankton pigments.

Seasonal fluctuations in phytoplankton biomass were most marked in the 0—5 m layer where also the factors influencing phytoplankton growth and development vary most. As shown by some earlier investigations the spring bloom occurred in May—June and the winter one in January—February (Ercegović, 1936). Pucher-Petković (1966) found that the spring bloom occurrence was not confined to any particular time as compared with the regular pattern of the autumn bloom occurrence.

Relatively high chlorophyll *a* concentrations were measured in winter 1974 together with a lower number of cells and relatively large quantities of nutrients. Low primary production level at that time was probably inhibited by the insufficient light.

The first spring bloom occurred in May and was observed as the increase in chlorophyll *a* concentrations and phytoplynkton density as well as high primary production (1389.6 mg m^{-2} day^{-1}). Diatoms predominated with the species *Leptocylindrus danicus* and *Nitzschia seriata*. The increasing phytoplankton density in June was not followed by the adequate increase in chlorophyll *a* concentrations. The explosive density increase in July (about 4 300 000 cells per liter) was mainly due to the summer form of *Skeletonema costatum*. This increase, however, did not cause chlorophyll *a* concentrations to increase a lot. The reduction in phytoplankton biomass in August was probably the result of zooplankton grazing. The reasons for such a conclusions were mentioned above.

Chlorophyll *a* content per cell (Fig. 16) decreased from a rather high values of about 3.5×10^{-6} μg chlorophyll *a* (winter) through 0.89×10^{-6} (spring) to a rather low ones of 0.25×10^{-6} μg chlorophyll *a* (summer). After reaching a minimum in the summer chlorophyll *a* started to increase during the autumn bloom (about 4×10^{-6} μg chlorophyll *a* per cell). Experiment with *Peridinium trochoideum* carried out by Jensen and Sakshaug (1973) showed that low light intensity and low temperatures affected cells such as to increase their chlorophyll content. It was recorded from the Trondheimsfjord that cell chlorophyll content was reduced with the bloom progression and that it reached a minimum during the last stage of the bloom. They also recorded the accumulation of chlorophyll in algal cells during the winter, early spring, and autumn. These records agree with ours. They differ only with respect to species composition which was constant in case of Trond-

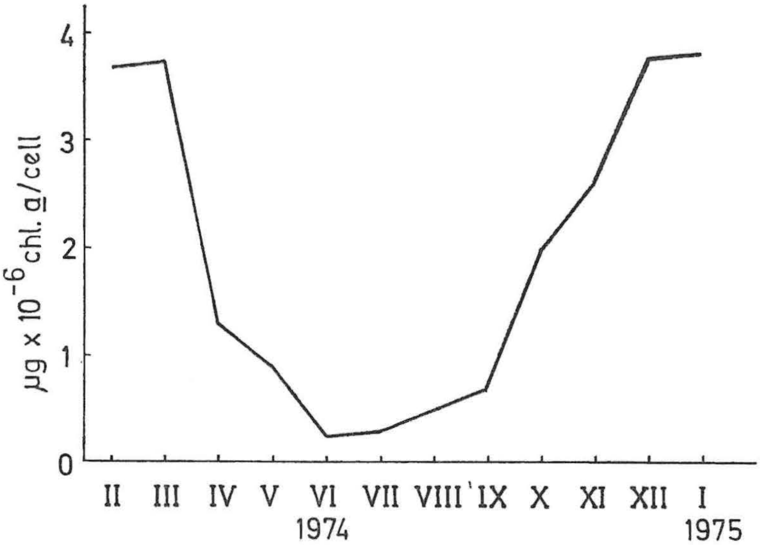

Fig. 16. Seasonal variations in chlorophyll *a* quantity per cell of the surface phytoplankton in the Kaštela Bay

heimsfjord whereas the Kaštela Bay summer population was characterized by the *Skeletonema costatum* dominance. *S. costatum* occurred in the long chains of unusually small cells. Voltolina (1971) emphasized the meaning of this species dominance helding it to be an indicator of a river eutrophication influence. We should not agree with this account since the dominance of small summer form of this species is prominent in the summer in warm waters of high salinity. The account of Conover (1956) that *S. costatum* prefered warmer waters and more intense light agrees with the data presented in this paper. Smayda (1973) reported that *S. costatum* multiplied more intensively at higher temperatures. Density of *S. costatum* cells showed high sensitivity to even low concentrations of phosphate, silicate, and vitamin B_{12}, and somewhat less to nitrogen. At the shortage of these nutrients cell size increased (Berland *et al.*, 1973). Braarud and Bursa (1939) held it to be mesosaprobe type of organism whose distribution was limited by the combined influence of light and nutrition factors. Everything that has been said may account for the presence of a large number of this species cells in the summer.

Increase in nutrients brought into the sea by fresh water from the land and vertical mixing were responsible for the phytoplankton autumn bloom with a very high chlorophyll *a* concentrations and a rather high phytoplankton density at the surface. Large cell diatoms with the species of genus *Chaetoceros* and *Nitzschia seriata* dominated the phytoplankton community. Investigating the Weribee River (Australia) Arnott and Hussainy (1972) also found large chlorophyll *a* concentrations to coincide with the genus *Chaetoceros* bloom. As Eppley (1972) pointed out, diatoms which produce chains were a property of rich waters of temperate areas.

No corresponding increase in primary production to the increase in phytoplankton biomass was recorded. It is probable that light attenuation was limiting production (i. e. reduction in the photosynthetic day).

The observations of seasonal fluctuations in phytoplankton biomass indicate that throughout the year the conditions in the Kaštela Bay are favourable for phytoplankton growth. High biomasses found in the spring-summer and autumn showed small variations. Since there is no previous data on photosynthetic pigments in this area no comparison may be made with the present ones. The phytoplankton surface density annual means were 157 000 cells per liter in 1934, and 210 000 cells per liter in 1962—67. Over the 1968—72 period annual mean density was 790 000 cells per liter with considerably lower fluctuations. Maximum values during these years were only fifteenfold the minimum ones as compared with those of the earlier years when maximum values were twohundredfold the minimum ones (Pucher-Petković, 1975). During the period of our observations annual surface density average was 1 300 000 cells per liter with maximum values being fifteenfold the minimum ones.

In general ,the Kaštela Bay is rich area, with a large phytoplankton biomass and high production where annual fluctuations in biomass are relatively small.

Some new patterns of species composition reflect the recent changes noted in the Kaštela Bay phytoplankton. Thus, some diatom species that earlier occurred either in a quite insignificant quantities or did not occur at all have recently been recorded in large quantites. *Nitzschia seriata* was not recorded during the years prior to our observations and now is consistently present and particularly significant in the spring and summer. Significant autumn and winter diatom *Skeletonema costatum* (Pucher-Petković, 1975) was earlier found to occur only in the spring and autumn (Ercegović, 1940).

Quantitative relations within the phytoplankton community recorded during the period of our observations were similar to those recorded during the previous years. However, there are some differences in seasonal succession and quantitative contribution of individual diatom species and genera. These differences are particularly due to a mass occurrence of *S. costatum* which made the principal contribution to the summer diatom community.

Relative seasonal contribution of microplankton and nannoplankton size fractions to the total phytoplankton biomass

Since the most of the organic matter production is confined to the upper 10 metres (upper euphotic layer) we studied the seasonal changes of phytoplankton size fractions in that layer of the Kaštela Bay. Study of micro- and nannoplankton components (separation made according to Teixeira, 1963) aimed at estimation of the contribution of each of them to the total biomass of the Kaštela Bay plytoplankton. Since te reproduction time of these small cells is shorter and growth is faster their contribution to the total phytoplankton is of importance for the better understanding of the fluctuations in biomass and primary production (Parsons and Takahashi, 1973). In addition, various size fractions behave differently in relation to available nutrients. Half-saturation constants of microplankton organisms are in excess of those of nannoplankton (Eppley *et al.*, 1969). Sinking of larger cells and long chains of diatoms is faster than that of the smaller ones. Absence of large cells in nutrient limited waters is due to their low surface: volume ratio (Munk and Riley, 1952). Size of phytoplankton organisms has also particular significance for the transfer of energy through trophic levels. Food chains with larger plant cells (microplankton) at the beginning are considerably shorter than those with nannoplankton (Ryther, 1969).

According to Yentsch and Ryther (1959) nannoplankton fraction is responsible for the 80 to 100 percent of the total phytoplankton biomass and production of the temperate area seas. Malone (1971) found nannoplankton to be the principal producer in all the sea areas and also that microplankton productivity was considerably higher in the neritic waters than in oceanic ones. As suggested by the same worker microplankton is more important for plant biomass than for the primary production.

Records from the northern Adriatic (Kveder *et al.*, 1971) showed that nannoplankton ($< 20\,\mu$) contained 60—100 percent of the total chlorophyll. Fig. 5 of the same paper indicates that the high level of primary production is also due to nannoplankton. Similar was observed in the same region by Revelante (1975). In the open central Adriatic 51.4—87.7 percent of the primary production was photosynthesized by nannoplankton ($< 50\,\mu$); in the Kaštela Bay (coastal zone) 27.4—90.7 percent, whereas microplankton was responsible for 9.3—72.6 percent of the total coastal area primary production. Microplankton production was more significant in the autumn and winter (Pucher-Petković, 1973).

There is a close agreement between our data and those mentioned above. The Kaštela Bay microplankton was more important for the total phytoplankton biomass only at certain seasons (Figs. 7 and 12). Fig 17, however, shows the higher relative importance of nannoplankton in primary production.

It was recorded that herbivore zooplankton selectively fed on phytoplankton organisms of a given size (Hargrave and Geen, 1970). Selective zooplankton grazing is due to a number of factors such as differences in size, morphology, and chemical composition of phytoplankton species (Mullin, 1963). On the other hand this effects the zooplankton distribution within the water column (Beers and Stewart, 1969) and magnitude of zooplankton excretion (Martin, 1968).

Fig. 6 indicates that microplankton considerably contributed to variations in chlorophyll *a* concentrations, whereas nannoplankton contributed to the increase in the total phytoplankton density (Fig. 11). As shown by Figs. 7 and 18 it appears that zooplankton feed selectively on larger organisms for much of the year. The only exception was the summer when *Skeletonema*

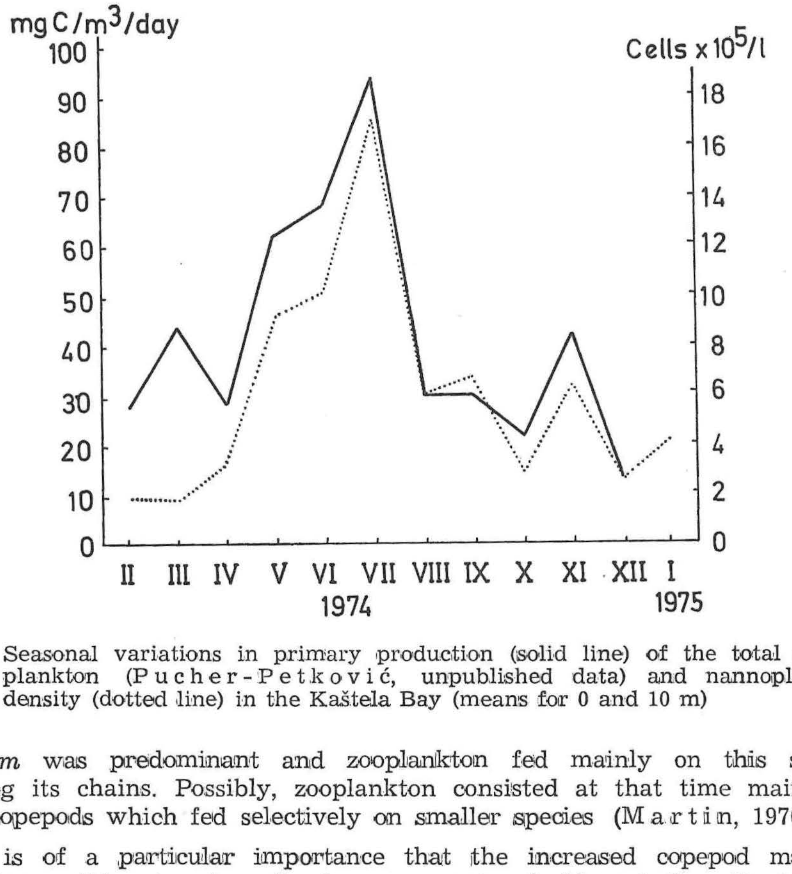

Fig. 17. Seasonal variations in primary production (solid line) of the total phytoplankton (Pucher-Petković, unpublished data) and nannoplankton density (dotted line) in the Kaštela Bay (means for 0 and 10 m)

costatum was predominant and zooplankton fed mainly on this species reducing its chains. Possibly, zooplankton consisted at that time mainly of small copepods which fed selectively on smaller species (Martin, 1970).

It is of a particular importance that the increased copepod mass in the autumn did not reduce the large amounts of chlorophyll *a*. During the autumn *Nitzschia seriata* dominance was accompanied by the species of genus *Chaetoceros* dominance. Zooplankton did not feed on this species probably because of their long setae. Presence of a large number of microplankton species in the euphotic layer in the autumn was probably due to water vertical advection which caused more rapid supply of nutrients from the deeper layers and extended the maintenance of larger cells at the surface.

A positive relation between chlorophyll *a* concentrations in microplankton and copepod biomass (Fig. 18) was found in the Kaštela Bay. Phaeopigment concentrations, however, did not always show positive relations to either the increasing or decreasing copepod amounts. The same was recorded from the Gulf of St. Lawrence by Spence and Steven (1974). In the Kaštela Bay the relative grazing pressure index was not good indicator of zooplankton grazing intensity except for the summer months. In the northern Adriatic pheopigment quantity within the water column was also poor indicator of predation intensity (Revelante, 1975).

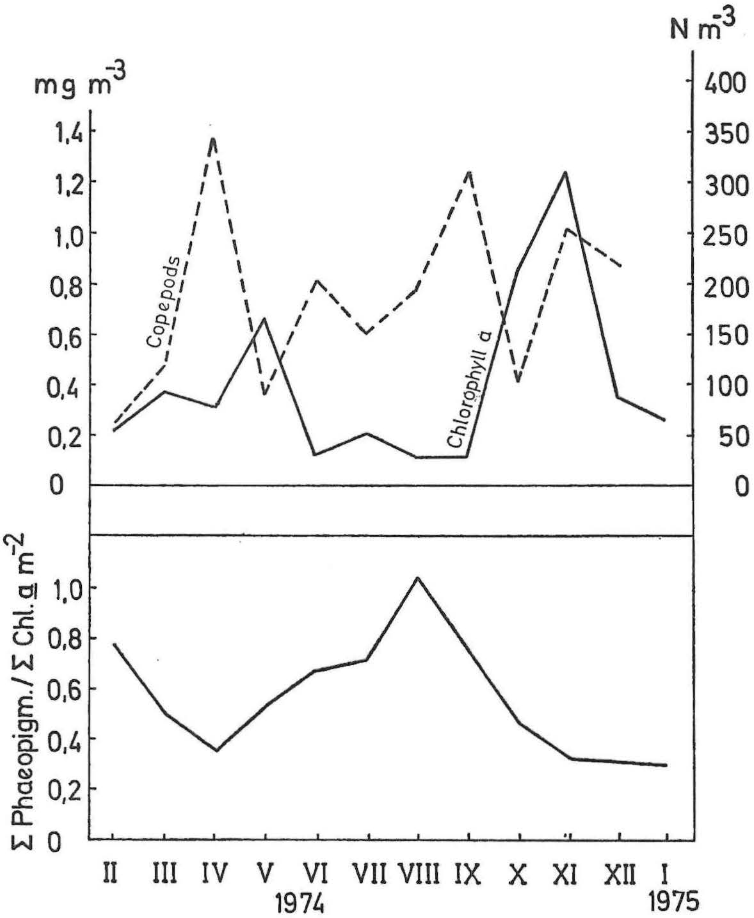

Fig. 18. Seasonal variations in the copepod number (Regner, D., unpublished data), chrorophyll *a* of microplankton (above) and Lorenzen's grazing presure index (below) in the Kaštela Bay.

SUMMARY

Investigations of seasonal fluctuations in the biomass and species composition of phytoplankton from the Kaštela Bay over the February 1974 — January 1975 period showed that all the year round phytoplankton was confined to the surface layer where fluctuations were also most significant.

Several successive phytoplankton blooms were recorded during the year, in the spring, summer, and autumn. Ranges of biomass fluctuations were rather small. The peak of phytoplankton density (about 1 200 000 cells per

liter) occurred during the summer bloom. Maximum chlorophyll *a* concentration (34.30 mg m^{-2}) was recorded in the autumn. The fluctuation patterns of chlorophyll *c* and carotenoids followed that of chlorophyll *a*. Phaeopigment concentrations showed small annual variations. As a rule, their maxima coincided with those of chlorophyll *a*.

The Kaštela Bay phytoplankton community is characterized by the predominance of diatoms in all the seasons. They ranged from 65.5 to 95.8 percent. They ranged from 65.5 to 95.8 percent. Diatom dominance was chiefly due to *Skeletonema costatum*, particularly in the summer.

Chlorophyll *a* and phytoplankton density showed a general similarity with respect to their curve courses during the year. Increase and decrease in the total algal cell counts affected chlorophyll *a* content. Nevertheless, there was no simple relation between chlorophyll *a* concentrations and the number of phytoplankton cells since considerable variations in cell size and their pigment content were observed. Reduction in chlorophyll *a* was observed during the development of spring cells to the summer ones, whereas the cells of the autumn and winter communities were rich in chlorophyll *a*.

It was also established that nannoplankton ($< 50\ \mu$) made a principal contribution to the total biomass, whereas microplankton ($> 50\ \mu$) contribution was important only at certain seasons.

Micro- and nannoplankton phaeopigment contents indicated the selective grazing by zooplankton. Lorenzen's grazing pressure index was poor indicator of zooplankton grazing pressure in the area of investigations with the exception for the summer months.

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SEZONSKE PROMJENE BIOMASE FITOPLANKTONA U OBALNOM SREDNJEM JADRANU

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KRATAK SADRŽAJ

Istraživanja kvalitativnog i kvantitativnog sastava fitoplanktona vršena su u Kaštelanskom zaljevu, u razdoblju od veljače 1974. do siječnja 1975. godine, na stalnoj postaji Instituta za oceanografiju i ribarstvo, Split. Uzorci su sakupljani jedanput mjesečno sa pet standardnih dubina i određivana je količina fotosintetskih pigmenata, gustoća, veličinski i kvalitativni sastav fitoplanktonskih zajednica, te relativni indeks predacije.

Gustoća fitoplanktona pokazala je najviše vrijednosti (oko 1 200 000 stanica na litru) za vrijeme ljetnog cvata fitoplanktona, dok je maksimum koncentracije klorofila *a* (34,30 mg m^{-2}) bio u jesenskom razdoblju. Klorofil *c* i karotinoidi pratili su promjene u koncentraciji klorofila *a* a feopigmenti su kroz cijelo istraživano razdoblje pokazali prilično konstantne vrijednosti.

Fitoplanktonska zajednica Kaštelanskog zaljeva karakterizirana je prevladavanjem dijatomeja u svim sezonama. Njihova procentualna zastupljenost varirala je od 65,5 do 95,8%.

Istraživanja udjela mikroplanktonske ($> 50\ \mu$) i nannoplanktonske ($< 50\ \mu$) veličinske frakcije u ukupnoj koncentraciji klorofila *a* pokazala su da je relativni sezonski doprinos nanoplanktonske komponente u većini slučajeva veći od onog mikroplanktona, s izuzetkom u svibnju, te u listopadu i studenom. Gledajući gustoću fitoplanktonskih zajednica mikroplankton je imao nešto veću važnost jedino u rujnu.

Sadržaj feopigmenata u mikroplanktonu i nanoplanktonu ukazuje na selektivnu pašnju od strane zooplanktona. Lorenzen-ov indeks predacije, međutim, nije u ovom području uvijek bio dobar pokazatelj intenziteta pašnje zooplanktona.

Postoji generalna sličnost u sezonskim varijacijama koncentracije klorofila *a* i gustoće fitoplanktona, ali ne postoji jednostavan odnos između sadržaja klorofila *a* i broja fitoplanktonskih stanica jer su uočene znatne razlike u sadržaju pigmenata u stanicama.

Appendix table 1. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in February 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Melosira sp.	—	—	—	5460	3780
Skeletonema costatum (Grev.) Cl.	30660	30240	42840	25620	10500
Cyclotella sp.	—	1260	3360	—	—
Coscinodiscus sp.	—	—	—	—	420
Lauderia borealis Gran	18480	18900	2940	1680	2520
Dactyliosolen mediterraneus H. Per.	2940	1680	840	—	1680
Leptocylindrus danicus Cl.	3780	2100	420	3780	420
Leptocylindrus adriaticus Schröd.	—	—	840	—	—
Guinardia blavyana Per.	840	1680	—	—	420
Rhizosolenia stolterfothi H. Per.	—	—	—	—	420
Rhizosolenia styliformis Brightw.	—	—	—	420	—
Rhizosolenia hebetata f. semispina (Hen.) Gran	—	—	840	—	420
Rhizosolenia alata f. gracillima (Cl.) Grun.	840	1260	—	—	—
Bacteriastrum delicatulum Cl.	9660	11340	5040	—	—
Bacteriastrum hyalinum var. princeps (Castr.) Ikari	420	—	—	—	—
Chaetoceros atlanticus Cl.	1260	2100	840	—	—
Chaetoceros danicus Cl.	6720	3360	5460	2100	4620
Chaetoceros peruvianus Brightw.	2940	3780	2520	1680	—
Chaetoceros compressus Laud.	1680	1260	1680	1680	840
Chaetoceros didymus Ehr.	15540	21000	1260	—	—
Chaetoceros affinis Laud.	5040	2520	2940	2520	420
Chaetoceros laciniosus Schütt	—	—	—	2520	—
Chaetoceros diversus Cl.	—	840	1680	—	—
Chaetoceros messanensis Castr.	—	—	—	1680	840
Chaetoceros vixvisibilis Schill.	840	—	—	—	—
Chaetoceros curvisetus Cl.	49980	44940	11760	12180	8820
Chaetoceros anastomosans Grun.	6300	7140	2520	2520	3780
Chaetoceros spp.	840	—	5460	2100	2100
Cerataulina bergoni Per.	—	2100	1260	420	—
Hemiaulus haucki Grun.	—	—	—	420	—
Pennatae					
Licmophora flabellata (Carm.) Ag.	1680	1260	—	—	—
Diatoma sp.	840	—	—	—	—
Thalassionema nitzschioides Grun.	840	—	—	—	—
Thalassiothrix frauenfeldi Grun.	—	840	840	420	—
Thalassiothrix mediterranea Pavill.	11760	6720	6300	16800	—
Asterionella japonica Cl.	1260	2100	2100	1260	3780
Achnanthes sp.	—	—	—	—	840
Navicula sp.	—	—	—	2520	—
Diploneis sp.	—	840	420	—	—
Pleurosigma elongatum W. Sm.	—	—	840	420	420
Nitzschia closterium (Ehr.) W. Sm.	1260	1260	1260	840	1680
Nitzschia seriata Cl.	48300	42840	38640	27720	8820
Nitzschia tenuirostris Mer.	—	—	—	840	1260
Pennatae indet.	2520	1680	6300	1680	4620
COCCOLITHINEAE	39380	35740	60480	53480	31520
SILICOFLAGELLATAE	840	840	—	—	—
DINOFLAGELLATAE	31500	28690	47880	33600	25620
»MICROFLAGELLATAE«	4800	3850	7140	1680	2520

Appendix table 2. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in March 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Melosira sp.	4200	—	—	—	—
Skeletonema costatum (Grev.) Cl.	31500	33180	6300	840	—
Cyclotella sp.	—	—	—	840	—
Dactyliosolen mediterraneus H. Per.	—	2100	1680	1680	420
Leptocylindrus danicus Schröd.	2520	5040	5040	3780	4620
Guinardia blavyana Per.	1680	420	—	—	—
Rhizosolenia delicatula Cl.	2100	—	—	—	420
Rhizosolenia stolterfothi H. Per.	—	—	—	—	2940
Rhizosolenia styliformis Brightw.	—	—	—	—	840
Rhizosolenia styliformis var. longispina Hust.	—	—	—	840	—
Rhizosolenia calcar avis Schult.	—	—	—	420	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	—	—	420	420	1680
Bacteriastrum delicatulum Cl.	2520	—	1680	1680	1680
Chaetoceros atlanticus Cl.	9240	420	—	—	—
Chaetoceros danicus Cl.	840	2940	840	—	—
Chaetoceros peruvianus Brightw.	1260	4200	420	—	—
Chaetoceros lorenzianus Grun.	18060	840	840	1680	—
Chaetoceros compressus Laud.	14700	44100	5880	5460	2100
Chaetoceros affinis Laud.	2520	—	60480	8820	—
Chaetoceros laciniosus Schütt	10920	—	47040	33180	2100
Chaetoceros diversus Cl.	1680	7980	840	—	1680
Chaetoceros pseudocrinitus Ostf.	1260	—	—	—	—
Chaetoceros curvisetus Cl.	41160	118860	56700	67620	47040
Chaetoceros anastomosans Grun.	2520	—	—	840	—
Chaetoceros sp.	—	4620	—	—	—
Cerataulina bergoni Per.	840	420	—	1260	840
Hemiaulus haucki Grun.	420	420	—	—	840
Pennatae					
Licmophora sp.	—	—	—	—	840
Thalassionema nitzschioides Grun.	5040	7980	6300	12600	12180
Thalassiothrix frauenfeldi Grun.	420	1680	1260	840	1680
Thalassiothrix mediterranea Pavill.	8400	—	3780	6720	420
Asterionella japonica Cl.	—	5040	—	—	—
Diploneis sp.	—	—	420	—	2100
Pleurosigma sp.	—	—	420	840	—
Amphora sp.	—	840	—	—	—
Nitzschia closterium (Ehr.) W. Sm.	420	4200	1260	2940	4620
Nitzschia seriata Cl.	27300	1680	29400	14700	420
Nitzschia tenuirostris Mer.	—	420	—	—	—
COCCOLITHINEAE	46200	21000	25620	62160	26880
SILICOFLAGELLATAE	—	—	—	—	420
DINOFLAGELLATAE	31920	10080	16800	22680	18480
»MICROFLAGELLATAE«	21000	1260	4200	7560	3360

Appendix table 3. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in April 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	7140	12180	10080	2940	9660
Thalassiosira sp.	2100	2520	—	—	—
Coscinodiscus sp.	—	—	420	—	420
Dactyliosolen mediterraneus H. Per.	7560	14280	7980	6720	2100
Leptocylindrus danicus Cl.	46200	52920	30660	14280	28140
Leptocylindrus adriaticus Schröd.	15960	23100	21840	5460	—
Rhizosolenia delicatula Cl.	16800	16380	7980	3360	—
Rhizosolenia stolterfothi H. Per.	2940	2520	—	420	—
Rhizosolenia styliformis var. longispina Hust.	—	—	840	—	—
Rhizosolenia calcar avis Schult.	—	—	—	1260	840
Rhizosolenia alata f. gracillima (Cl.) Grun.	4200	5460	3360	840	1260
Bacteriastrum delicatulum Cl.	—	—	—	840	840
Chaetoceros danicus Cl.	—	2520	3780	1260	1680
Chaetoceros rostratus Laud.	—	—	2100	840	—
Chaetoceros peruvianus Brightw.	9660	7140	10080	840	—
Chaetoceros compressus Laud.	4620	5880	4200	2100	—
Chaetoceros affinis Laud.	—	—	—	—	4200
Chaetoceros diversus Cl.	3360	3360	840	6300	—
Chaetoceros vixvisibilis Schill.	3780	7140	7560	8820	24360
Chaetoceros curvisetus Cl.	19740	20580	38220	39480	36960
Chaetoceros anastomosans Grun.	14700	21840	40320	27720	24780
Chaetoceros sp.	—	—	3360	—	—
Cerataulina bergoni Per.	3360	3780	1260	840	1680
Hemiaulus haucki Grun.	9240	7980	2100	2520	6720
Pennatae					
Thalassionema nitzcschioides Grun.	6720	5880	—	2100	—
Thalassiothrix frauenfeldi Grun.	9660	6300	1260	1680	6300
Thalassiothrix mediterranea Pavill.	6300	7560	5880	5040	3780
Asterionella japonica Cl.	6300	4200	5040	3360	17220
Pleurosigma elongatum W. Sm.	—	—	—	—	840
Nitzschia closterium (Ehr.) W. Sm.	1260	1680	1260	1260	—
Nitzschia seriata Cl.	225960	257880	113400	94500	102900
Pennatae indet.	2940	2100	1260	7560	840
COCCOLITHINEAE	91980	109620	87780	53340	75600
DINOFLAGELLATAE	34440	52080	51240	18484	46620
»MICROFLAGELLATAE«	7560	7560	5880	3360	3780

Appendix table 4. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in May 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	17220	12600	8400	4200	—
Thalassiosira sp.	—	—	—	—	1680
Cyclotella sp.	—	2520	—	2520	—
Dactyliosolen mediterraneus H. Per.	6300	5040	6720	3360	2940
Leptocylindrus danicus Cl.	401100	524160	199080	99120	33600
Leptocylindrus adriaticus Schröd.	174300	84000	117600	61320	11340
Rhizosolenia delicatula Cl.	11760	8400	20160	15120	7140
Rhizosolenia stolterfothi H. Per.	420	4200	—	1680	—
Rhizosolenia styliformis var. longispina Hust.	3360	1680	2520	840	—
Rhizosolenia calcar avis Schult.	420	2520	—	1680	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	7980	7560	840	840	—
Bacteriastrum delicatulum Cl.	9660	8400	840	4200	—
Chaetoceros danicus Cl.	4620	5040	840	—	2520
Chaetoceros peruvianus Brightw.	4620	12600	1680	840	—
Chaetoceros compressus Laud.	15540	10920	4200	—	—
Chaetoceros didymus Ehr.	2940	5880	—	—	—
Chaetoceros affinis Laud.	166320	42000	50400	25200	9240
Chaetoceros diversus Cl.	8820	9240	17640	—	—
Chaetoceros vixvisibilis Schill.	9240	4200	3360	9240	2520
Chaetoceros curvisetus Cl.	38220	30240	10920	6720	—
Chaetoceros anastomasans Grun.	12180	20160	5040	1680	1260
Chaetoceros spp.	2100	5880	3360	1680	—
Eucampia cornuta (Cl.) Grun.	840	1680	—	1680	2520
Cerataulina bergoni Per.	2520	1680	840	6720	—
Hemiaulus haucki Grun.	48300	43680	14280	9240	7140
Pennatae					
Licmophora sp.	420	—	—	—	—
Thalassionema nitzschioides Grun.	10500	5880	—	—	—
Thalassiothrix frauenfeldi Grun.	27300	44520	22680	4200	3360
Asterionella japonica Cl.	3780	8400	2520	—	—
Cocconeis sp.	840	—	—	—	—
Diploneis sp.	1260	4200	—	840	—
Pleurosigma sp.	—	—	—	—	1260
Cymbella sp.	—	—	—	1680	—
Nitzschia closterium (Ehr.) W. Sm.	420	—	—	—	—
Nitzschia seriata Cl.	422940	674520	406560	110040	16800
Nitzschia tenuirostris Mer.	—	1680	840	1680	840
Pennatae indet.	2940	—	7560	2520	840
COCCOLITHINEAE	105840	125160	40320	21840	17220
DINOFLAGELLATAE	93660	102060	28560	18480	5080
»MICROFLAGELLATAE«	28140	36120	10920	5040	2520

Appendix table 5. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in June 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Melosira sulcata (Ehr.) Kütz.	—	—	—	1680	—
Skeletonema costatum (Grev.) Cl.	916440	180600	185640	89040	12600
Lauderia borealis Gran	1680	1680	—	—	—
Dactyliosolen mediterraneus H. Per.	5880	1680	—	—	—
Leptocylindrus danicus Cl.	134400	59640	35280	21000	6720
Leptocylindrus adriaticus Schröd.	1230600	304080	322560	57120	16800
Rhizosolenia delicatula Cl.	5880	1680	840	4200	840
Rhizosolenia styliformis Brightw.	1680	—	1680	—	—
Rhizosolenia alata Brightw.	—	—	840	—	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	10080	4200	3360	5880	2520
Bacteriastrum delicatulum Cl.	—	—	—	—	1680
Chaetoceros tetrastichon Cl.	—	—	1680	—	—
Chaetoceros danicus Cl.	4200	1680	840	1680	840
Chaetoceros peruvianus Brightw.	6720	2520	1680	—	840
Chaetoceros didyms var. protuberans (Laud.) Gran et Yendo	3360	—	840	—	—
Chaetoceros affinis Laud.	16800	5880	1680	—	—
Chaetoceros diversus Cl.	10920	6720	5880	—	—
Chaetoceros vixvisibilis Schill.	4200	—	—	—	—
Chaetoceros curvisetus Cl.	25200	12600	6720	1680	1680
Chaetoceros spp.	2520	—	7560	2520	4200
Eucampia cornuta (Cl.) Grun.	5040	2520	1680	—	—
Cerataulina bergoni Per.	84840	27720	—	—	—
Hemiaulus haucki Grun.	6720	3360	—	—	1680
Pennatae					
Fragillaria sp.	—	—	—	1680	840
Thalassionema nitzschioides Grun.	—	—	—	1680	—
Thalassiothrix frauenfeldi Grun.	5040	1680	840	—	—
Asterionella japonica Cl.	—	840	840	—	—
Navicula sp.	—	—	—	2520	1680
Diploneis sp.	—	—	—	—	840
Nitzschia closterium (Ehr.) W. Sm.	—	—	840	—	—
Nitzschia seriata Cl.	304920	77280	63840	45360	13440
Nitzschia tenuirostris Mer.	—	—	—	—	1680
Pennatae indet.	5040	2520	8400	840	5040
COCCOLITHINEAE	217560	50400	48720	81480	47040
DINOFLAGELLATAE	146160	42840	41160	36120	31920
»MICROFLAGELLATAE«	73080	21840	21000	21840	10920

Appendix table 6. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in July 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	2716560	614880	79800	7560	1260
Coscinodiscus sp.	840	—	—	420	420
Leptocylindrus danicus Cl.	160440	42840	52920	22680	21840
Leptocylindrus adriaticus Schröd.	635880	166320	142800	5040	7560
Guinardia blavyana Per.	4200	1680	840	—	—
Rhizosolenia delicatula Cl.	12600	9240	4200	3780	840
Rhizosolenia styliformis var. longispina Hust.	1680	—	840	420	—
Rhizosolenia hebetata f. semispina (Hen.) Gran	15960	6720	2520	840	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	11760	3360	8400	2940	3780
Bacteriastrum hyalinum Laud.	—	—	—	840	1260
Chaetoceros danicus Cl.	29400	10920	1680	840	1260
Chaetoceros peruvianus Brightw.	10080	4200	840	1680	420
Chaetoceros compressus Laud.	—	—	—	—	1260
Chaetoceros didymus Ehr.	5880	1680	—	420	—
Chaetoceros affinis Laud.	117600	48720	19320	10080	2940
Chaetoceros laciniosus Schütt	48720	21000	—	—	—
Chaetoceros wighami Brightw.	9240	4200	—	2100	—
Chaetoceros curvisetus Cl.	143640	68880	15120	—	—
Chaetoceros simplex var. calcitrans Pauls.	10920	5040	1680	—	—
Chaetoceros spp.	62160	13440	25200	5040	5880
Eucampia cornuta (Cl.) Grun.	37800	13440	9240	840	—
Cerataulina bergoni Per.	75600	16800	15120	5040	2520
Hemiaulus haucki Grun.	840	840	1680	1680	840
Pennatae					
Licmophora sp.	—	—	840	—	—
Thalassiothrix frauenfeldi Grun.	—	—	1680	1260	840
Achnanthes sp.	840	—	—	—	—
Nitzschia closterium (Ehr.) W. Sm.	840	—	—	—	—
Nitzschia seriata Cl.	124320	54600	35280	7980	2100
Pennatae indet.	840	5880	7560	13440	11340
COCCOLITHINEAE	54600	41160	32760	15540	11760
SILICOFLAGELLATAE	—	—	—	—	840
DINOFLAGELLATAE	46200	23520	19320	9240	10500
»MICROFLAGELLATAE«	29400	15120	10020	2520	2940

Appendix table 7. Speciels composition and density of phytoplankton (cells/l) of the Kaštela Bay in August 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	1227240	320460	21840	2100	—
Coscinodiscus sp.	—	—	420	—	420
Schroederella delicatula (Per.) Pavill.	1680	—	—	—	—
Leptocylindrus danicus Cl.	37800	21420	13020	3360	1680
Leptocylindrus adriaticus Schröd.	61320	128100	10080	12600	3780
Guinardia blavyana Per.	1680	840	420	840	420
Rhizosolenia bergoni H. Per.	840	—	—	—	—
Rhizosolenia delicatula Cl.	1680	420	4200	840	7140
Rhizosolenia stolterfothi H. Per.	4200	8820	3360	—	1260
Rhizosolenia imbricata Brightw.	—	—	—	—	1260
Rhizosolenia setigera Brightw.	—	420	—	—	—
Rhizosolenia hebetata f. semispina (Hen.) Gran	—	—	1680	420	840
Rhizosolenia calcar avis Schult.	—	—	—	420	—
Rhizosolenia alata Brightw.	—	—	420	—	420
Rhizosolenia alata f. gracillima (Cl.) Grun.	14280	6300	7140	4200	9240
Bacteriastrum delicatulum Cl.	—	—	7560	420	—
Chaetoceros densus Cl.	—	—	1260	—	—
Chaetoceros danicus Cl.	840	2100	3780	840	—
Chaetoceros peruvianus Brightw.	4200	2940	840	420	420
Chaetoceros affinis Laud.	34440	23520	3360	—	—
Chaetoceros laciniosus Schütt	—	28560	—	—	—
Chaetoceros subsecundus (Grun.) Hust.	—	—	—	—	1680
Chaetoceros wighami Brightw.	—	42840	12180	—	—
Chaetoceros curvisetus Cl.	11760	24360	4620	—	—
Chaetoceros anastomosans Grun.	23520	10080	5040	1260	—
Chaetoceros spp.	—	7560	5460	3360	8820
Eucampia cornuta (Cl.) Grun.	12600	3360	1680	—	—
Cerataulina bergoni Per.	—	—	—	420	420
Hemiaulus haucki Grun.	5040	4200	1680	1680	5040
Pennatae					
Thalassiothrix frauenfeldi Grun.	840	1260	2940	420	—
Bacillaria paradoxa Gmel.	4200	—	—	—	—
Nitzschia closterium (Ehr.) W. Sm.	840	1260	1260	2100	3780
Nitzschia seriata Cl.	17640	5880	19320	11340	8820
Pennatae indet.	4200	3360	2100	7980	840
COCCOLITHINEAE	70560	48300	22680	19740	26040
SILICOFLAGELLATAE	—	—	—	420	420
DINOFLAGELLATAE	41160	24780	18480	15120	13860
»MICROFLAGELLATAE«	18900	17220	17220	11760	7560

Appendix table 8. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in September 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	680400	1024800	464520	273840	292320
Leptocylindrus danicus Cl.	22680	18480	22680	16800	4200
Leptocylindrus adriaticus Schröd.	47040	68880	36960	28560	25200
Guinardia blavyana Per.	840	—	840	—	—
Rhizosolenia delicatula Cl.	2520	840	1680	1680	—
Rhizosolenia stolterfothi H. Per.	1680	—	840	—	—
Rhizosolenia hebetata f. semispina (Hen.) Gran	5880	10920	3360	—	840
Rhizosolenia alata Brightw.	—	—	840	840	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	840	840	1680	3360	—
Bacteriastrum delicatulum Cl.	2520	—	—	1680	—
Chaetoceros dadayi Pavill.	—	—	—	1680	—
Chaetoceros rostratus Laud.	—	—	2520	—	—
Chaetoceros peruvianus Brightw.	1680	3360	840	—	—
Chaetoceros affinis Laud.	6720	—	7560	—	—
Chaetoceros wighami Brightw.	14280	—	—	—	—
Chaetoceros curvisetus Cl.	5040	20160	6720	12600	—
Chaetoceros simplex var. calcitrans Pauls.	—	—	—	840	—
Chaetoceros sp.	1680	—	—	—	840
Eucampia cornuta (Cl.) Grun.	840	1680	—	—	—
Cerataulina bergoni Per.	—	—	840	—	1680
Hemiaulus haucki Grun.	—	—	—	—	840
Pennatae					
Thalassionema nitzschioides Grun.	1680	2520	840	2520	840
Cymbella sp.	—	—	—	—	840
Nitzschia closterium (Ehr.) W. Sm.	840	3360	2520	1680	—
Nitzschia seriata Cl.	18480	35280	11760	15120	15960
Pennatae indet.	—	840	—	2520	3360
COCCOLITHINEAE	8400	13440	13440	15120	15960
DINOFLAGELLATAE	5880	11760	10920	11760	6720
»MICROFLAGELLATAE«	8400	2520	6720	8400	5040

Appendix table 9. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in October 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	31080	—	—	1680	2940
Cyclotella sp.	30240	840	10920	2520	—
Coscinodiscus sp.	—	—	—	840	—
Dactyliosolen mediterraneus H. Per.	10920	2520	1680	—	—
Leptocylindrus danicus Cl.	48720	20160	7560	2100	—
Leptocylindrus adriaticus Schröd.	202440	36120	11760	—	—
Guinardia blavyana Per.	7560	—	—	—	—
Rhizosolenia delicatula Cl.	840	—	—	—	—
Rhizosolenia stolterfothi H. Per.	15120	2520	5040	—	1260
Rhizosolenia hebetata f. semispina (Hen.) Gran	13440	—	6720	—	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	7560	—	2520	—	—
Bacteriastrum delicatulum Cl.	5040	—	3360	—	—
Chaetoceros danicus Cl.	45360	5880	—	—	—
Chaetoceros peruvianus Brightw.	5040	840	—	—	—
Chaetoceros lorenzianus Grun.	26880	—	—	—	—
Chaetoceros lauderi Ralfs	83360	23520	13440	—	—
Chaetoceros didymus Ehr.	36120	—	10920	—	—
Chaetoceros affinis Laud.	47040	4200	2520	10080	5460
Chaetoceros diversus Cl.	2520	—	—	—	—
Chaetoceros pseudocrinitus Ostf.	17640	—	—	—	—
Chaetoceros curvisetus Cl.	68880	7560	9240	8400	6300
Chaetoceros socialis Laud.	25200	—	—	—	—
Chaetoceros simplex var. calcitrans Pauls.	11760	—	5040	—	—
Chaetoceros spp.	4200	—	—	—	—
Eucampia zoodiacus Ehr.	1680	—	—	—	—
Eucampia cornuta (Cl.) Grun.	56280	6720	—	2100	—
Cerataulina bergoni Per.	118440	16800	3360	—	2100
Hemiaulus haucki Grun.	5040	1680	—	—	—
Pennatae					
Thalassionema nitzschioides Grun.	77280	15960	6720	—	—
Thalassiothrix frauenfeldi Grun.	5040	—	—	2100	2100
Thalassiothrix mediterranea Pavill.	840	—	—	—	—
Achnanthes sp.	—	—	—	3360	—
Diploneis interrupta (Kütz.) Cl.	—	—	—	—	840
Diploneis sp.	—	840	—	—	—
Pleurosigma nicobaricum Grun.	—	—	—	1260	—
Cymbella sp.	—	840	—	—	—
Nitzschia closterium (Ehr.) W. Sm.	10920	10920	6720	2520	2100
Nitzschia seriata Cl.	193200	36960	43680	—	—
Pennatae indet.	1680	—	—	2520	3780
COCCOLITHINEAE	15120	10080	5880	6720	5040
SILICOFLAGELLATAE	—	840	840	840	840
DINOFLAGELLATAE	11760	8400	5040	4200	840
»MICROFLAGELLATAE«	5880	—	1680	2520	—

Appendix table 10. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in November 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	6720	10920	—	—	—
Cyclotella sp.	2520	4200	6300	—	2520
Dactyliosolen mediterraneus H. Per.	1680	—	—	—	—
Leptocylindrus danicus Cl.	2520	5880	—	1260	—
Leptocylindrus adriaticus Schröd.	135240	63000	11340	25200	3780
Rhizosolenia delicatula Cl.	4200	1680	—	—	—
Rhizosolenia stolterfothi H. Per.	4200	1680	3780	—	—
Rhizosolenia hebetata f. semispina (Hen.) Gran	3360	5040	—	—	—
Rhizosolenia alata Brightw.	1680	—	—	—	—
Bacteriastrum delicatulum Cl.	840	—	1260	—	—
Chaetoceros atlanticus Cl.	4200	—	—	—	—
Chaetoceros densus Cl.	—	13440	—	—	—
Chaetoceros danicus Cl.	16800	14280	3780	—	—
Chaetoceros rostratus Laud.	34440	—	—	—	—
Chaetoceros peruvianus Brightw.	18480	10920	2520	7560	3780
Chaetoceros lorenzianus Grun.	—	—	11340	15120	—
Chaetoceros lauderi Ralfs	72240	—	—	—	—
Chaetoceros affinis Laud.	90720	33600	6300	—	—
Chaetoceros affinis var. circinalis (Meun.) Hust.	8400	—	—	—	—
Chaetoceros laciniosus Schütt	—	71400	32760	37800	—
Chaetoceros diversus Cl.	4200	—	3780	—	—
Chaetoceros messanensis Castr.	43680	14280	—	—	—
Chaetoceros curvisetus Cl.	435120	187320	51660	25200	10080
Chaetoceros simplex var. calcitrans Pauls.	2520	2520	—	—	—
Eucampia cornuta (Cl.) Grun.	2520	7560	3780	11340	—
Cerataulina bergoni Per.	277200	111720	26460	23940	—
Hemiaulus haucki Grun.	5880	9240	—	—	—
Pennatae					
Thalassionema nitzschioides Grun.	8400	14280	12600	15120	15120
Thalassiothrix mediterranea Pavill.	2520	1680	5040	—	—
Asterionella japonica Cl.	—	840	—	—	—
Navicula sp.	—	—	—	1260	2520
Diploneis bombus Ehr.	—	—	—	—	7560
Pleurosigma nicobaricum Grun.	—	—	—	—	2520
Nitzschia closterium (Ehr.) W. Sm.	10920	10920	—	10080	7560
Nitzschia seriata Cl.	231000	90720	26460	32760	—
Pennatae indet.	3360	840	3780	—	—
COCCOLITHINEAE	33600	14280	31080	11340	6300
SILICOFLAGELLATAE	840	—	840	—	—
DINOFLAGELLATAE	21840	5040	4200	3780	2520
»MICROFLAGELLATAE«	8400	840	5040	—	—

Appendix table 11. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in December 1974.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	2520	—	—	—	—
Cyclotella sp.	1680	2520	2520	—	—
Coscinodiscus sp.	—	—	—	—	840
Dactyliosolen mediterraneus H. Per.	6720	5880	5040	—	—
Leptocylindrus danicus Cl.	16800	4200	21000	8400	—
Leptocylindrus adriaticus Schröd.	25200	26040	30240	9240	—
Guinardia blavyana Per.	840	—	—	—	—
Rhizosolenia delicatula Cl.	—	—	—	2520	—
Rhizosolenia stolterfothi H. Per.	3360	1680	6720	5880	—
Rhizosolenia hebetata f. semispina (Hen.) Gran	840	3360	840	—	—
Rhizosolenia alata Brightw.	840	—	—	—	—
Rhizosolenia alata f. gracillima (Cl.) Grun.	—	1680	840	—	—
Bacteriastrum delicatulum Cl.	1680	840	840	—	—
Chaetoceros danicus Cl.	12600	21840	11760	3360	—
Chaetoceros rostratus Laud.	1680	—	9240	—	—
Chaetoceros peruvianus Brightw.	2520	—	—	—	—
Chaetoceros lorenzianus Grun.	—	5880	5880	—	—
Chaetoceros didymus var. protuberans (Laud.) Gran et Yendo	—	3360	—	—	—
Chaetoceros affinis Laud.	37800	21840	7560	5040	1680
Chaetoceros diversus Cl.	—	1680	—	—	—
Chaetoceros curvisetus Cl.	16800	12600	15960	50400	2520
Chaetoceros sp.	1680	2520	2520	—	—
Eucampia cornuta (Cl.) Grun.	3360	3360	1680	—	—
Cerataulina bergoni Per.	42000	42000	25200	85680	840
Hemiaulus haucki Grun.	4200	5880	3360	2520	—
Pennatae					
Licmophora sp.	840	1680	—	—	—
Thalassionema nitzschioides Grun.	14280	840	—	11760	—
Thalassiothrix frauenfeldi Grun.	—	—	—	—	840
Thalassiothrix mediterranea Pavill.	840	840	840	—	—
Asterionella japonica Cl.	1680	840	840	14280	2520
Cocconeis scutellum Ehr.	—	—	—	—	840
Navicula sp.	—	—	—	840	—
Diploneis interrupta (Kütz.) Cl.	—	—	—	—	840
Pleurosigma nicobaricum Grun.	—	—	—	1680	—
Nitzschia closterium (Ehr.) W. Sm.	1680	5880	4200	4200	1680
Nitzschia seriata Cl.	158760	94920	147840	117600	37800
Pennatae indet.	—	—	840	—	—
COCCOLITHINEAE	31920	35280	34440	50400	25200
SILICOFLAGELLATAE	—	840	840	840	1680
DINOFLAGELLATAE	16800	15120	13440	10080	5880
»MICROFLAGELLATAE«	19320	12600	10920	1680	1680

Appendix table 12. Species composition and density of phytoplankton (cells/l) of the Kaštela Bay in January 1975.

Species	0 m	5 m	10 m	20 m	35 m
DIATOMEAE					
Centricae					
Skeletonema costatum (Grev.) Cl.	22680	13440	58800	8400	5040
Thalassiosira sp.	—	—	—	5880	—
Cyclotella sp.	3360	—	—	—	—
Lauderia borealis Gran	5880	840	16800	840	—
Dactyliosolen mediterraneus H. Per.	1680	1680	5040	—	—
Leptocylindrus danicus Cl.	1680	8400	7560	—	—
Leptocylindrus adriaticus Schröd.	75600	36120	151200	3360	2520
Rhizosolenia delicatula Cl.	2520	3360	4200	—	840
Rhizosolenia stolterfothi H. Per.	840	840	2520	—	840
Rhizosolenia styliformis Brightw.	—	2520	5880	—	—
Rhizosolenia styliformis var. longispina Hust.	1680	—	—	—	—
Rhizosolenia calcar avis Schult.	840	—	840	—	—
Rhizosolenia alata Brightw.	840	840	840	840	840
Rhizosolenia alata f. gracillima (Cl.) Grun.	6720	6720	10080	840	840
Bacteriastrum delicatulum Cl.	4200	—	—	—	—
Chaetoceros danicus Cl.	840	—	3360	—	—
Chaetoceros peruvianus Brightw.	—	2520	840	—	—
Chaetoceros lorenzianus Grun.	—	—	1680	—	—
Chaetoceros compressus Laud.	—	15960	35280	5040	—
Chaetoceros affinis Laud.	—	2520	19320	—	2520
Chaetoceros affinis var. circinalis (Meun.) Hust.	1680	5880	—	—	—
Chaetoceros laciniosus Schütt	4200	—	—	—	—
Chaetoceros diversus Cl.	840	2520	1680	1680	2520
Chaetoceros curvisetus Cl.	11760	5880	16800	10080	840
Chaetoceros pseudocurvisetus Mang.	—	—	—	15120	—
Chaetoceros simplex var. calcitrans Pauls.	—	—	840	—	—
Eucampia cornuta (Cl.) Grun.	—	—	3360	—	—
Cerataulina bergoni Per.	4200	2520	8400	3360	840
Hemiaulus haucki Grun.	9240	—	2520	840	840
Pennatae					
Thalassiothrix mediterranea Pavill.	2520	840	840	840	—
Thalassiothrix frauenfeldi Grun.	—	—	2520	—	—
Thalassiothrix mediterranea Pavill.	2520	840	840	840	—
Asterionella japonica Cl.	—	840	7560	17640	7560
Navicula sp.	—	—	2520	—	—
Pleurosigma nicobaricum Grun.	—	—	840	1680	840
Nitzschia closterium (Ehr.) W. Sm.	840	3360	8400	13440	3360
Nitzschia seriata Cl.	113400	120960	168000	38640	47880
Nitzschia tenuirostris Mer.	—	—	1680	—	—
Pennatae indet.	—	—	1680	2520	—
COCCOLITHINEAE	32760	21840	26040	24360	21000
SILICOFLAGELLATAE	840	—	840	—	—
DINOFLAGRLLATAE	25200	19320	17640	10920	11760
»MICROFLAGELLATAE«	7560	12600	5880	2520	840