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Phytoplankton communities in upwelling areas. The example of NW Africa *

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INTRODUCTION

Many tables reporting the composition of phytoplankton in different marine areas have been published. Their value is not only taxonomic and biogeographical. Presence and abundance of organisms of different species reflects the results of historical and dynamical processes, in which a great number of factors and interactions are involved. Lists of plankton contain much information, but more often than not we are unable to decode it. Any information has a price, and no wonder that we are reluctant to invest much effort in training and employing taxonomists, if we cannot properly place plankton composition at the end of a coherent and intelligible chain of events.

Compared with the phytoplankton of oceanic and «sinking» areas, the phytoplankton of upwelling areas is distinctive. There is more plankton and there are more diatoms in it. But the same can be said of other fertile areas that are not properly upwelling areas. Not only the presence of definite species —often qualified as indicators— is relevant, but also the general pattern of distribution or of organization of communities in space. In the areas of California, Perú, South and North West Africa we may have four replicates of an essentially similar upwelling, allowing the introduction of a comparative method of plankton analysis. Events transitory and peripheral to the upwelling like formation of domes, eddies, «El Niño» and red water, are found with different degree of development in different areas.

Many species have been reported from the four main upwelling areas, as well as from other fertile regions, with or whithout true upwelling. It seems that there are many species extraregional or almost cosmopolitan in distribution, frequent in seasonally fluctuating or in chemostat-like environments. They can be considered as oportunists, fugitive species or *r*-selected species. Although many of the species appear to have a large geographical distribution, a considerable amount of subspeciation or even of speciation is not excluded. *Skeletonema* and *Thalassiosira* are represented by many races of different physiological capacities, and a considerable amount of speciation in other groups (*Nitzschia*, for instance) has been covered by sloppy taxonomic work. In common dinoflagellates, as in *Ceratium furca*, or in species of *Gonyaulax*, there exists local populations that can be separed biometrically, or chemically (toxicity, for instance).

In several groups *(Oxytoxum, Peridinium)* painstacking work —not easy to be carried on as a part of routine counting— can reveal the existence of well characterizable species inside the old poorly defined entities, but its value is difficult to understand in the absence of any knowledge about individual variation in cultured clones.

Other formidable difficulties block the way to a comparative study of plankton composition in upwelling areas. Phytoplankton collected with a net may be useful for biogeographical purposes —the species retained by the net, that are the largest,

* Texto de una comunicación presentada al Simposio sobre sistemas de afloramiento, en Kiel, julio 1974.

are usually the species of restricted geographical distribution—, but it does not reflect the actual composition of communities. Data on centrifuged or sedimented samples are more scarce, very unequal in quality, and must disregard the smallest organisms. Although proper fixation allows to count small organisms that in numbers are at least one order of dimension over the counts of net plankton, nevertheless a great number of the smallest items explode or aggregate and become uncensable. BERNHARD, RAMPI and ZATTERA (1967) refer to small plankton as «non-Utermöhl plankton», stressing that it cannot be counted properly with the current use of Utermöhl's or inverted microscope. Its density and composition can be ascertained, although with difficulty, making use of dilution cultures, but rarely this has been applied to routine analysis of natural environments (THRONDSEN, 1969, 1970). This is a serious roadblock. Perhaps the application of scanning electron microscope to the analysis of plankton retained on filters might help, taking advantage that many of the small things have scales or otherwise identifiable structures. As they now stand, the available data are full of uncertainties regarding the identification of the species, and the fraction of actual plankton really counted depends on kind of plankton, fixation, elapsed time and disposition of the observer and, in any case, is inferior to the amount of plankton present in water. Things should not be overdramatized, however, since the position of the planktonologist is not much worse than that of the terrestrial ecologists, which identify, count and track butterflies or birds, but tend to overlook ants and mites.

In number and activity the small size phytoplankton is really important. In percentage of total productivity (^{14}C-fixation) the plankton passing through a mesh of 35 μm represents 50-97 % (ANDERSON, 1965; HOLMES and ANDERSON, 1963), through 65 μm, 65-96 % (TEIXEIRA *et al.*, 1963, 1967, 1968), through 90 μm, 76-99 % (SAIJO and TAKESUE, 1965), and through 110 μm, 95-97 % (SAIJO, 1964; MALONE, 1971).

With usual procedures it is almost impossible to tell apart and cense properly the smallest components of phytoplankton. This undercuts any attempt to estimate properly affinity between samples, diversity, or made principal component analysis of total distributions, because only a small proportion of the cells have been identified (and very often wrongly), and persistence in the effort produces only a number of sketches of small things distributed in a number of tentative and very subjective taxa. I am convinced that one of the most urgent needs in marine biology is to develop some standard procedure for phytoplankton study, combining perhaps dilution cultures and scanning electron microscope.

All these difficulties made almost hopeless my attempt to compare plankton lists from the four main upwelling regions. Net samples are not representative of the whole plankton, and too few samples have been counted at the Utermöhl's microscope in the different areas, and moreover, the numbers reported are not comparable, as discussed before. Thus I have concentrated on the area of NW Africa, hoping that extant information on the other areas will reveal some comparable pattern. If an upwelling area could be conceived as an organized whole, then the different areas, or the same area in different seasons can be compared making use of projection and deformation, that is, assuming a certain uniform dynamic structure. The average organization or structure of an upwelling region should be projected or reflected on the sediment, where it can be studied. I believe that another urgent need in marine biology is the careful comparison of the pattern of sedimentation below the four main upwelling areas. It is curious that interest in it so far has centered on the recognition of past events (HAYS and PERUZZA, 1972; PARKIN and SHACKLETON, 1973). In connection with this it can be remembered in what concerns the upwelling area in NW Africa that there exists a Tertiary «fossil upwelling area» in form of phosphate beds in adjacent land, in a way that reveals a maximum of (old) upwelling close to what is now Cabo Bojador.

The distribution of communities is a reflection of the dynamics of the ecosystem. Any approach to a community description is based on some personal beliefs about the function of the system. Primary production depends obviously from light, temperature, nutrients and oligoelements. In the upwelling areas it seems to me inoperative to develop very detailed models of dependence, since primary production is defined practically by the auxiliary energy made available, very much like crop yield is related to the input of auxiliary energy (machines, irrigation, fertilizer) in agriculture. Perhaps the best estimate of primary production in the oceans is to relate it to energy degraded in each area (STROKINA, 1963, 1967). Ecological cycles in water slow down productivity to a minimum, by the simple fact that movement downwards of biogenic elements is more probable in particulate form than dissolved in water. It is easy to understand how the level of primary production depends on the available extra energy (waves, turbulence, tides, currents, upwelling), but it is more difficult to explain the funnelling or concentration of energy in particular spots, and how the movement of water breaks down in cells. This is a problem in hydrodynamics, and progress in this area is essential to understand the pattern of distribution of phytoplankton, that can only be conceived as the result of local selection on a large pool of available species (MARGALEF, 1975b). This conception is more akin to the version used by different Russian workers (VINOGRADOV *et al.*, 1973, etc.) of the mathematical models of plankton ecosystems, than to the openings in use among most Western workers. Essentially, phytoplankton dynamics in upwelling areas are much controlled by forcing functions that cannot be internalized in dealing with local systems. This is relevant to the understanding of community composition and distribution.

MATERIALS

The data that I have used as a core for this paper come from two cruises of the research vessel «Cornide de Saavedra» in the region of NW Africa. One cruise (Sahara II) was made in later summer (August, September, 1971) and the second (Atlor II) in spring (March, 1973). Data on pigments, primary production and global counts of phytoplankton have been published elsewhere (ESTRADA, 1974; MARGALEF, 1972, 1973, 1975a). In the Sahara II cruise, samples were obtained in 31 stations and 13 depths (0, 5, 10, 20, 30, 50, 75, 100, 150 200, 300, 400 and 500 m). During the Atlor II cruise, samples were secured in 27 stations, and only those of 8 depths have been so far studied (0, 10, 20, 30, 40, 50, 75 and 100 m). The present paper refers only to the patterns of distribution in a scale of tens to hundreds miles. Many samples collected in the surface between stations are not considered in this paper.

Samples of 100 ml, fixed with iodide, were examined using combined sedimentation chambers and an inverted microscope. Total cells in a surface representing 3 ml of the original sample were counted at high magnification, and the whole sample was observed rapidly at lower magnification.

The difficulties and unreliabilities associated with such kind of work have been stressed already. Although the total number of identified species exceeds 300, the largest percentage of cells present could never be identified under the optical microscope. Being obtained by the same person, the numbers retain maybe some comparative value, and may be related as well with the results of previous work in the Mediterranean (MARGALEF, 1966) and Caribbean (MARGALEF, 1965).

Even if identifiability is assumed, many names that have been adopted refer rather to larger groups, collective species or ill-defined species, than to entities appropriate for taxonomic work. *Nitzschia «seriata»* and *Nitzschia «delicatissima»* refer, respectively, to groups of species, and more valuable results could be obtained with a careful study of the material. Under the name *N. «seriata»* there is certainly much *N. fraudulenta* or perhaps *N. subfraudulenta* (HASLE, 1972, 1974). There is also much confusion in *Thalassiosira*, where almost no names have been used. Not as an excuse, it should be remembered that confounded species belong to the same life-forms and may show similar ecological behaviour. The tendency of the *Nitzschiae* of the *«seriata»* group to develop in deeper levels that those of the *«delicatissima»* group, is observed in different areas (Mediterranean, NW Africa) and presumably with separate species. *Nitz-*

schia «closterium» includes many straight forms *(recta, longissima)* in our area. Names as *Oxytoxum variabile* and *Gyrodinium fusiforme*, among others, cannot be taken too seriously. Even *Amphidinium acutum* and *Oxytoxum variabile* may be often the same thing, although placed far away in the classification. A common flagellate has been referred to a form noted by HASLE (1960, p. 41, fig. 36). It should be added that I have included not only primary producers, but also heterotrophic or phagotrophic forms, such as *Gyrodinium spirale*, many *Peridinium* and *Noctiluca scintillans* and related forms. A detailed lists of the names of all identified forms has been published (MARGALEF, 1973, 1975a).

In this paper I have attempted to compress the information recorded in the original lists, in order to allow a synoptic view. The procedure has been as follows. Comparisons between all pairs of neighboring stations have been established, on the basis of the lists of phytoplankton composition, and making use of rank correlation. The results are admittedly very rough, because of the frequently different numbers of items in both compared lists. As plankton density is higher in the photic zone or close to the surface, affinities or differences among the superior layers have been led to overrule affinities and differences manifested in deeper layers, that anyways were much less reliable due to the small number of counted cells and the extremely high statistical error, associated with the small counts. The procedure has led to draw a number of boundaries, represented as shaded bands in figs. 1 and 2, that divide the whole region in a number of areas, to which reference will be made through the use of code letters. Most of the major discontinuities encountered in plankton distribution have some hydrographic support, as can be gathered from the consideration of the several maps of distribution of physical and chemical variables in the area that have been published by different authors.

Data have been pooled over each area, computing simple arithmetic averages for each level. The use of geometric means would have been more appropriate to the usual properties of marine distributions, but inside each area variance is lower than between areas and perhaps may allow such simplificative procedure. Moreover a sensible averaging should have been based on the representative volume of water associated with each sample. Such niceties would have been out of proportion with the statistical errors in counting and the poor identification of most of the cells. The present data, as they stand, represent only a first approximation to the problem.

Anyway, arithmetic averages of species densities in each area are presented in the tables 1 to 12, that form the bulkiest part of this paper. The drastic averaging that has been conducted has, perhaps, created some monsters. As a result of the averaging procedure, moreover, one species may appear having a low density over a large area, being in fact absent or very scarce over most of it and infiltrating in peripheric positions from neighboring areas where the species may be common (*Oscillatoria*, for instance).

Not all hitherto considered species have

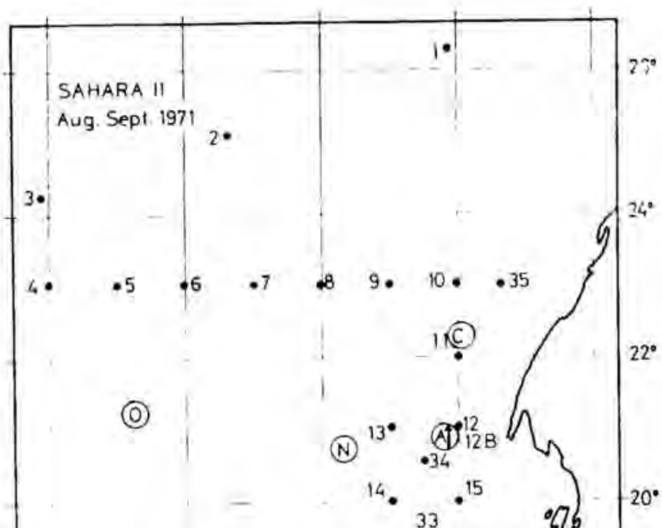

FIG. 1. — Cruise SAHARA II. Dots and numbers refer to stations. Shaded bands are the boundaries between areas. Encircled letters are used through this paper as a reference to the different areas.

been taken further: some are not common, the distribution of others seems erratic, and some groups pool together too many different forms and are confusing. A selection of species and groups whose distribution may be significant have been used in the preparation of figures 5 to 14. In them, numbers of the respective species, or groups, taken from tables 1 to 12 have been plotted at the corresponding intersections of depth and area, and lines of equal density have been drawn freely. Only such lines have been retained in figs. 5 to 14. The densities selected for such lines are a matter of convenience and are not the same for the different species. I wanted just to emphasize the patterns of distribution.

It has been found necessary to represent areas defined on a bidimensional surface (figs. 1 and 2) over one single dimension, and the adopted solution perhaps is not bad after all, but has required to represent twice the area N in the survey of late summer. The geographical position and the extension in different seasons of areas assumed to be

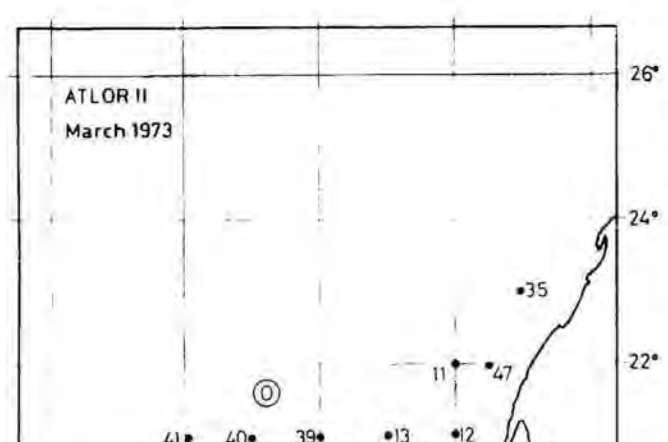

FIG. 2. — Cruise ATLOR II. Dots and numbers refer to stations. Shaded bands represent the boundaries between areas. Encircled letters are used through this paper as a way to refer to the different areas.

comparable, and hence designated by the same letters (O, N, etc.), is not the same. Along time, size, shape and position of what can be considered as an equivalent piece of the ecosystem, shifts continuously.

In the fig. 15 some of the patterns that can be found in figs. 5 to 14 have been superimposed. More complete representations can be produced by the reader using other species, or the information supplied in the tables. The selection of species to be included in fig. 15 has been done having in mind the wish to emphasize the seasonal changes in the concentric structure of upwelling regions, generated by fluctuations in a localized input of energy.

Figs. 3 and 4 present averaged thermic profiles for each of the areas, as well as vertical distribution in cells and plant pigments. Primary production is also included.

The use of numbers averaged over a rather large area gives the impression that, in the NW Africa upwelling, concentration of cells is never really high. In fact, samples collected in some stations produced much larger counts (MARGALEF, 1973, 1975a). In the tables 1 to 12, presence of species at a density lower than one cell per 100 ml has been recorded by a +.

During the cruise Atlor II a Coulter Counter has been in constant operation (MARGALEF, 1974). The numbers produced by this piece of equipment may be very important if treated as an independent variable, but a high number of small detritic particules may produce significant lacks of correlation between plankton and Coulter counts; relations change from place to place. Nevertheless valable general conclusions about general pattern of phytoplankton composition, kinds of life-form presents, and so on, can be derived from the counts (MARGALEF, 1974 and locs. cits.; PARSONS, 1969). Acceptable correlations can be found between phytoplankton numbers and counts in channels that sense cells over 8 or 10 microns across. ESTRADA and VALLESPINÓS (1975) have considered some of these aspects, and there is hope that the main types of phytoplankton communities, as presented in this paper, can be suitably recognized using the information provided by a Coulter Counter.

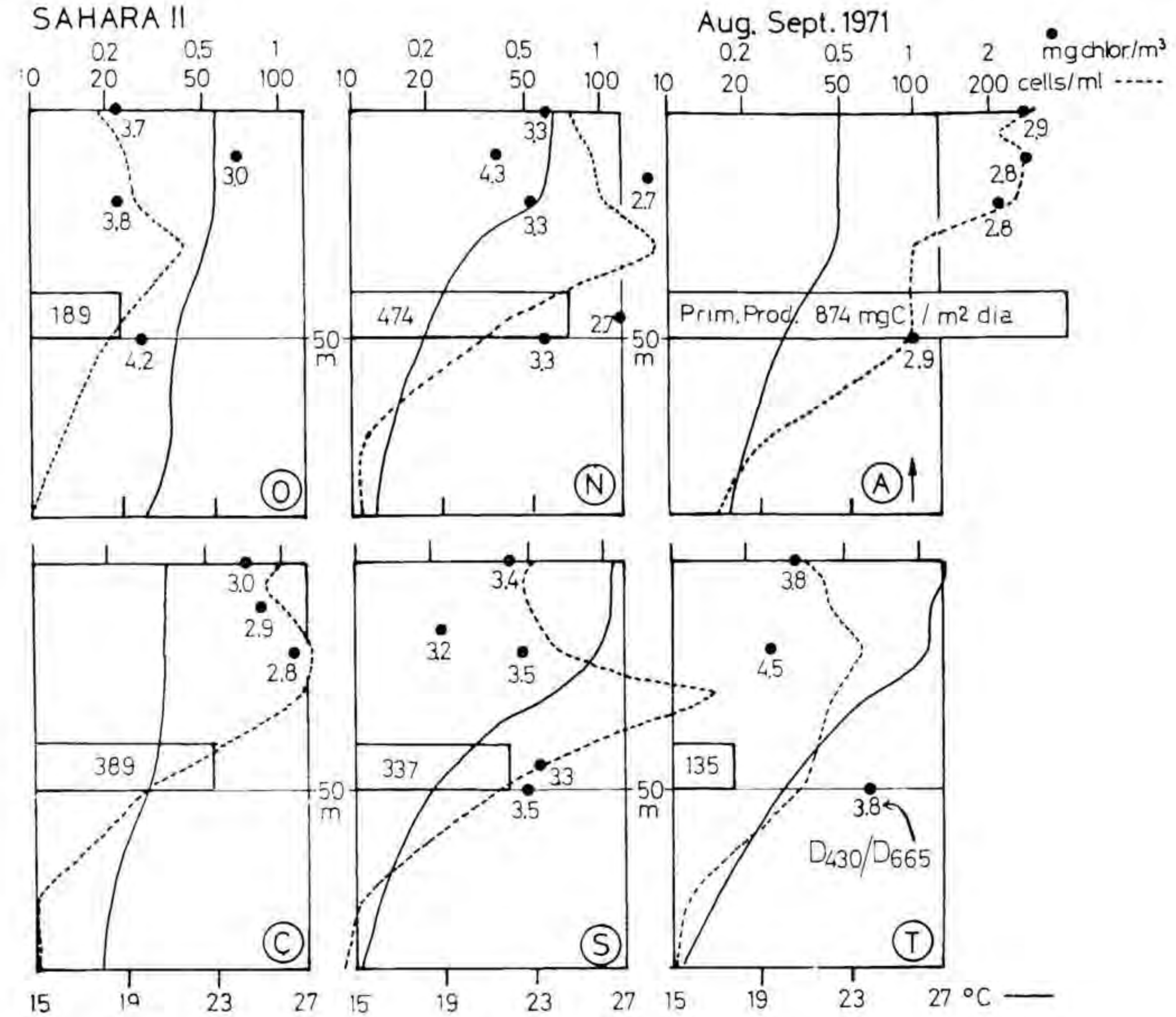

FIG. 3. — Cruise SAHARA II. Vertical distribution of some parameters, expressed as arithmetic means, averaged for each area (O, N, A, C, S, T, see fig. 1). Temperature, arithmetic scale, down; number of cells and chlorophyll a, logarithmic scale, up. Chlorophyll concentration in represented by the spots, and the figures close to them refer to the pigment index $D_{430}$and for one day, is represented by the central bars, $/D_{665}$. Primary production computed from 0 to 50 m,in arithmetic scale, and in terms of mg C assimilated per m^2.

RESULTS

Tables 1 to 12 and figures 5 to 14 confirm, in a very sketchy way, a number of facts about the distribution of phytoplankton in the upwelling regions that were well known, but some times forgotten. Most species may be found almost everywhere and even in the upwelling spots there is much mixing and dinoflagellate populations are not at lower density than in more stable and apparently «better» conditions for them. But such populations appear in such places completely dominated by the species that pass as typical of the upwelling. Species closer to the core of upwelling appear often covered by mucilage (*Thalassiosira*, in this case *partheneia* and others; *Phaeocystis; Chaetoceros* with small cells covered by secretions, like *socialis* and *radians*). Presence of mucilage is the result of a particularly abundant excretion of organic assimilates; it may have some buoyancy effect, but certainly it brakes the absorption of nutrients by the cell. Thus a certain cycle can be assumed, in which the mucilage is later dissolved or used by bacteria, the cells become loose, and start to grow again,

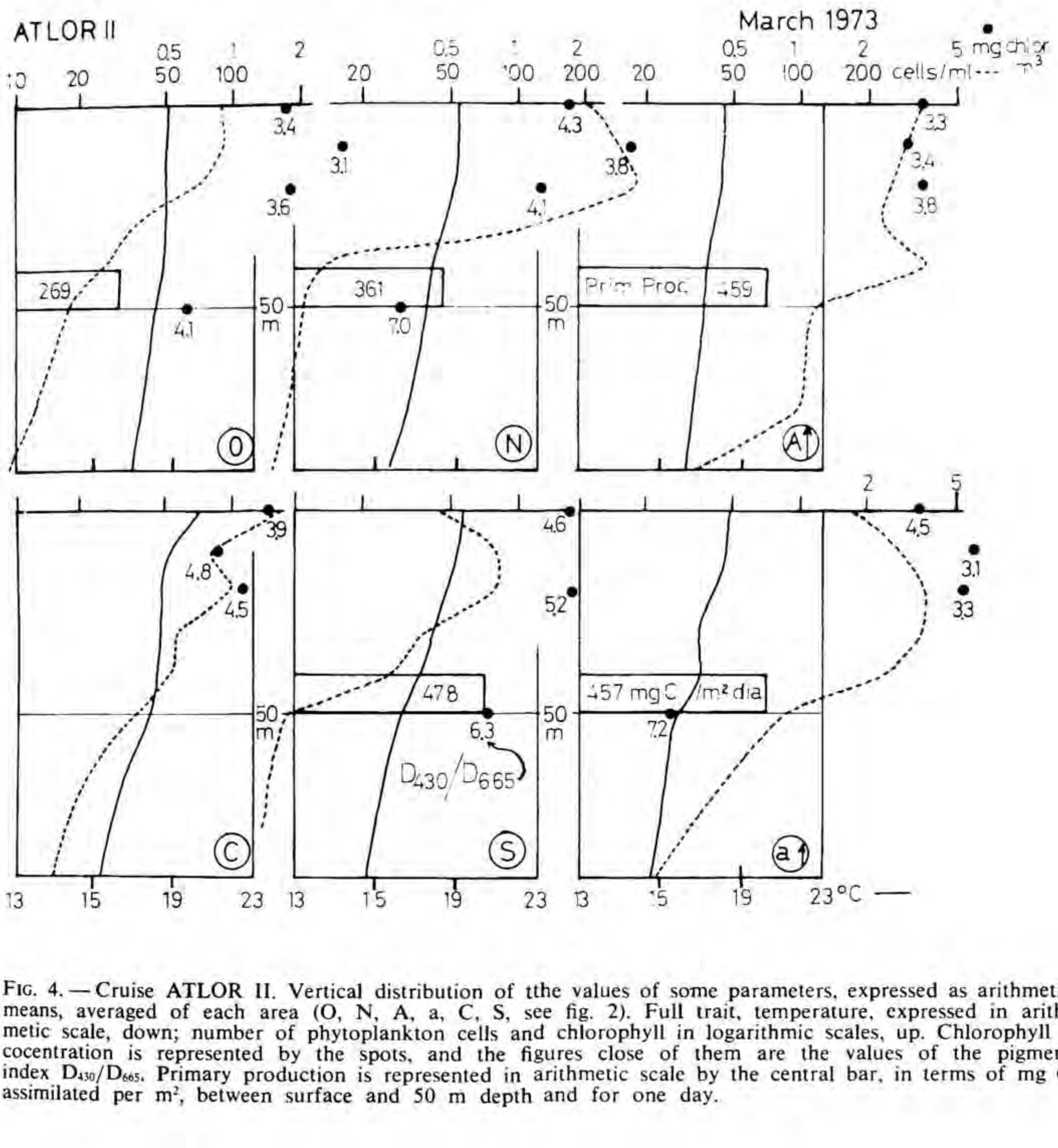

FIG. 4. — Cruise ATLOR II. Vertical distribution of tthe values of some parameters, expressed as arithmetic means, averaged of each area (O, N, A, a, C, S, see fig. 2). Full trait, temperature, expressed in arithmetic scale, down; number of phytoplankton cells and chlorophyll in logarithmic scales, up. Chlorophyll a cocentration is represented by the spots, and the figures close of them are the values of the pigment index D_{430}/D_{665}. Primary production is represented in arithmetic scale by the central bar, in terms of mg C assimilated per m², between surface and 50 m depth and for one day.

perhaps after having travelled over a certain space, in an open or along a closer trajectory. In the freshwater diatom *Gomphonema olivaceum*, developing in running water, there is a definite seasonal pattern in mucilage production: In early spring there is an abundant jellylike mass that envelops cells and colonies; later on, as assimilation drops, the secretion shrinks down to the form of small, but more ressilient, threads. Perhaps some sort of analogous cycle will be discovered in the development of the *Thalassiosira* species, in which secretions come in form of thin threads, or as jelly-like coverings. Anyway, mucilage producing *Thalassiosira*, *Phaeocystis* (and *Ruttnera*), and *Chaetoceros* have been reported from large and small (MARGALEF, 1965) upwelling areas, in the Norwegian sea (PAASCHE, 1960), and in other situations of fertilization and flow. In NW Africa (fig. 5) the distribution of *Thalassiosira* and *Phaeocystis* appear related to the place and intensity of upwelling, and cells of *Thalassiosira* devoid of mucilage (the same species?) become more frequent than secretion-covered cells as we more in a centrifugal direction.

I have been unable to observe «empty»

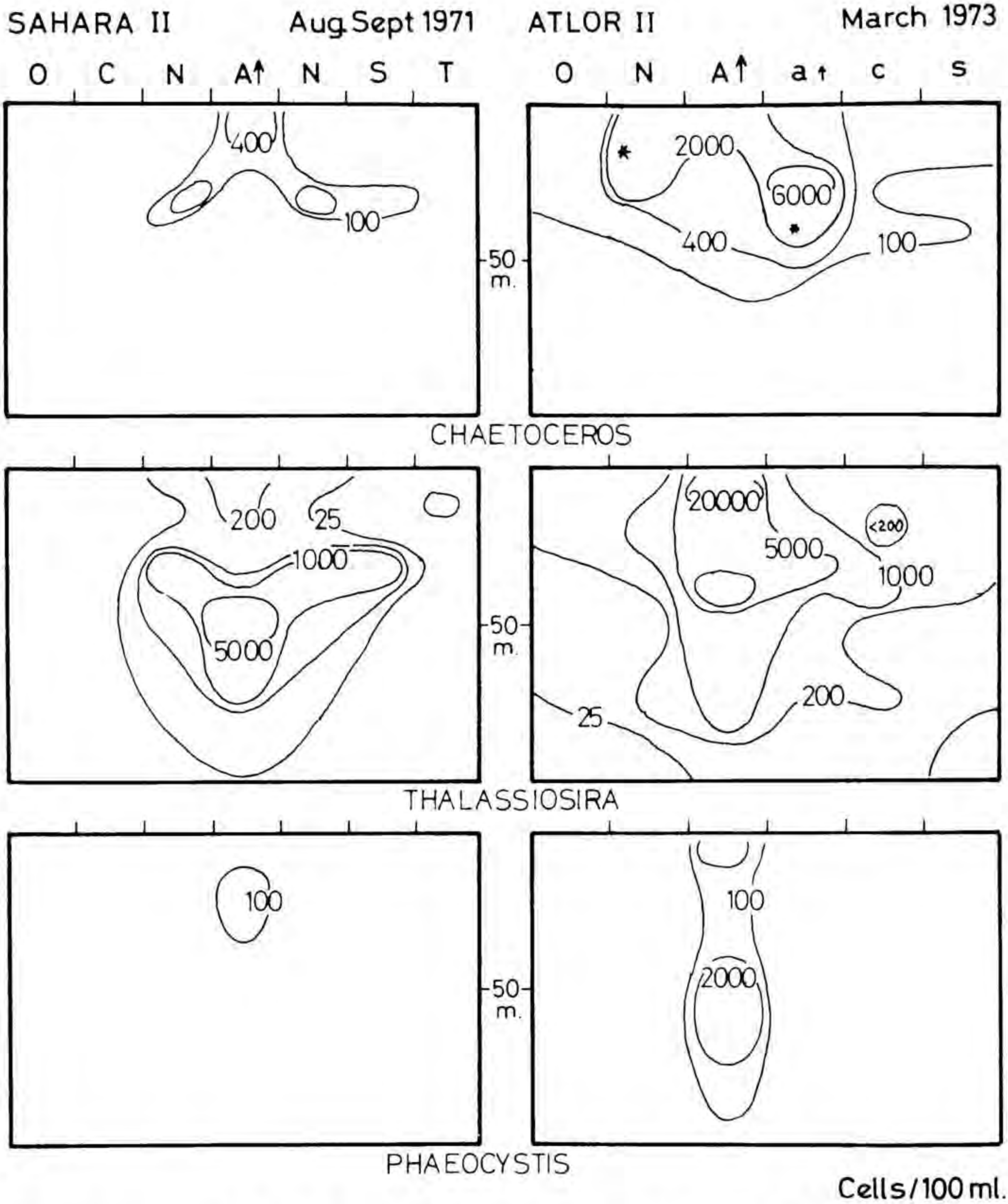

FIG. 5. — Each figure from this to number 14 gives the distribution of three species, or larger taxonomic groups, according to deep (vertical dimension) and to "areas", as defined in figs. 1 and 2 and reported at the top of the figure (horizontal dimension). Values from tables 1-2 have been plotted on the original graphs, but in the present simplified form only lines of equal density, freely drawn, habe been retained. The plankton composition in the two seasons (spring and late summer) are compared through all this series of diagrams. The present figure refers to the three organisms most common in and around the upwelling spots.

parcels of recently upwelled water, and tend to believe that they do not exist, and that upwelling cannot be visualized as the ascension of water rich in nutrients and devoid

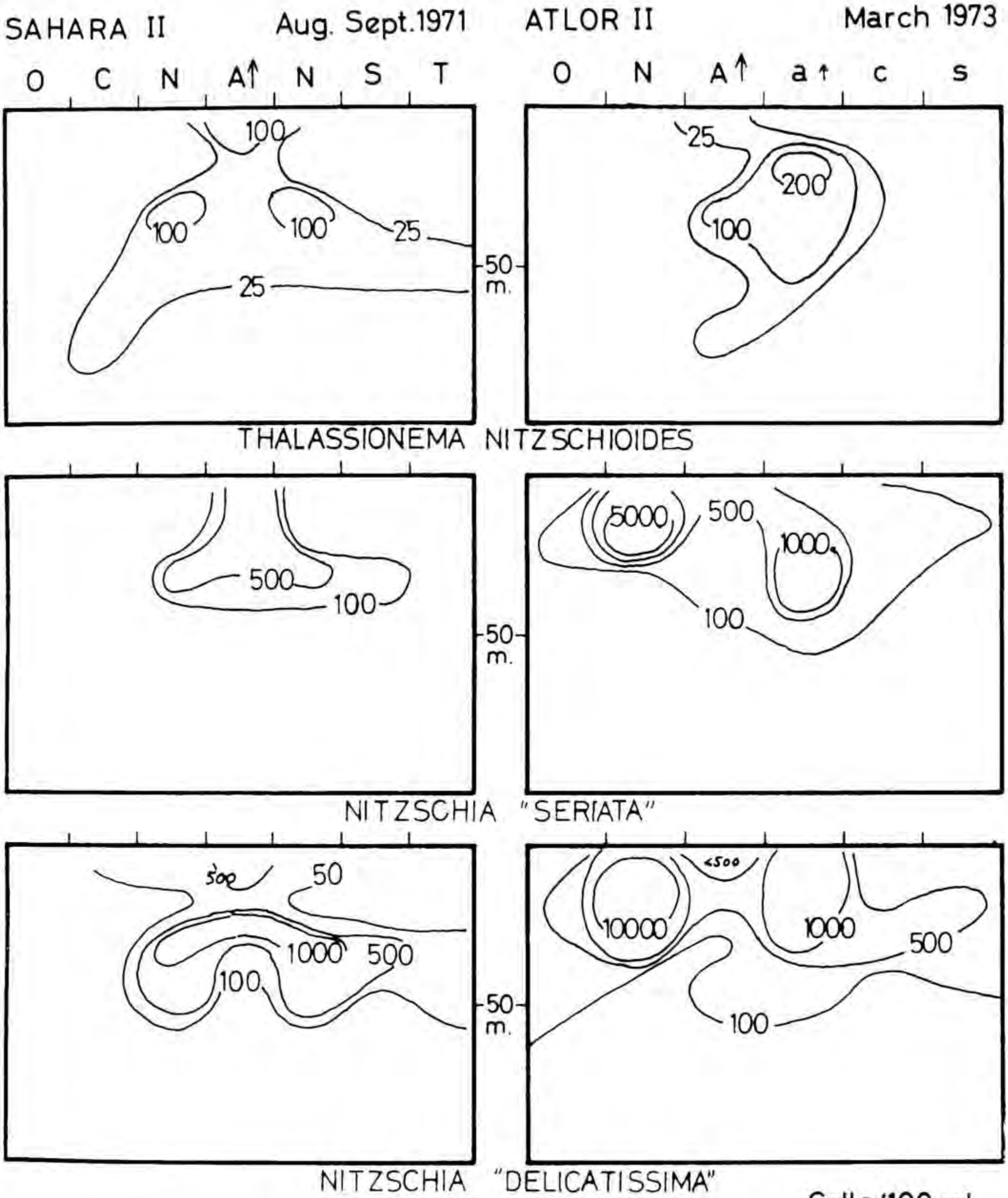

FIG. 6. — Refer to figure 5. In the present diagram are data on three diatoms common in and around the upwelling.

or organisms, but rather as a complex system of accelerated recycling —chemical and mechanical— driven by a moderate inflow of deep water that, even before arriving to the euphotic zone, is well mixed and breaks down in a number of circulation cells, through local differences in momentum arising from many causes.

Around the core species, that may consist of small cells envelopped in mucilage, the most typical populations involve diatoms of rather large individual cell size. *Nitzschia*,

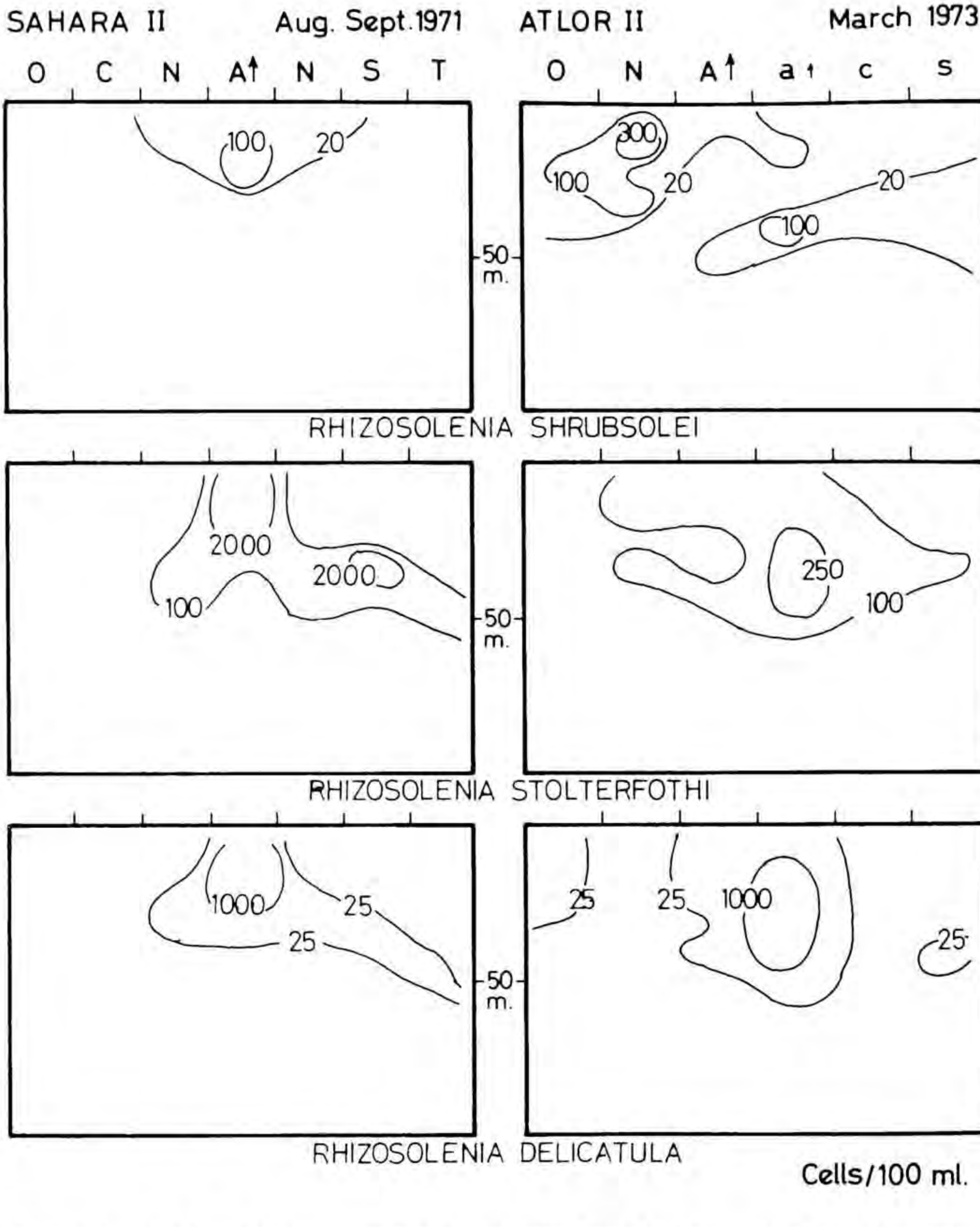

FIG. 7. — Refer to fig. 5. Three species of the genus *Rhizosolenia* that accumulate after a short time in upwelled water.

Chaetoceros, *Rhizosolenia*, and the like, are common (figs. 5 to 8). These are the diatoms most frequently reported in the fertile areas of all the oceans. In conditions of low intensity of upwelling, populations of such species may overlap the center of fertility. It looks as if speed of water, nutrient concentration, and use and penetration of light were decisive in the establishment of a definite layered distribution (fig. 15, below). I suspect that the example of NW Africa may be typical, in the sense that an intensi-

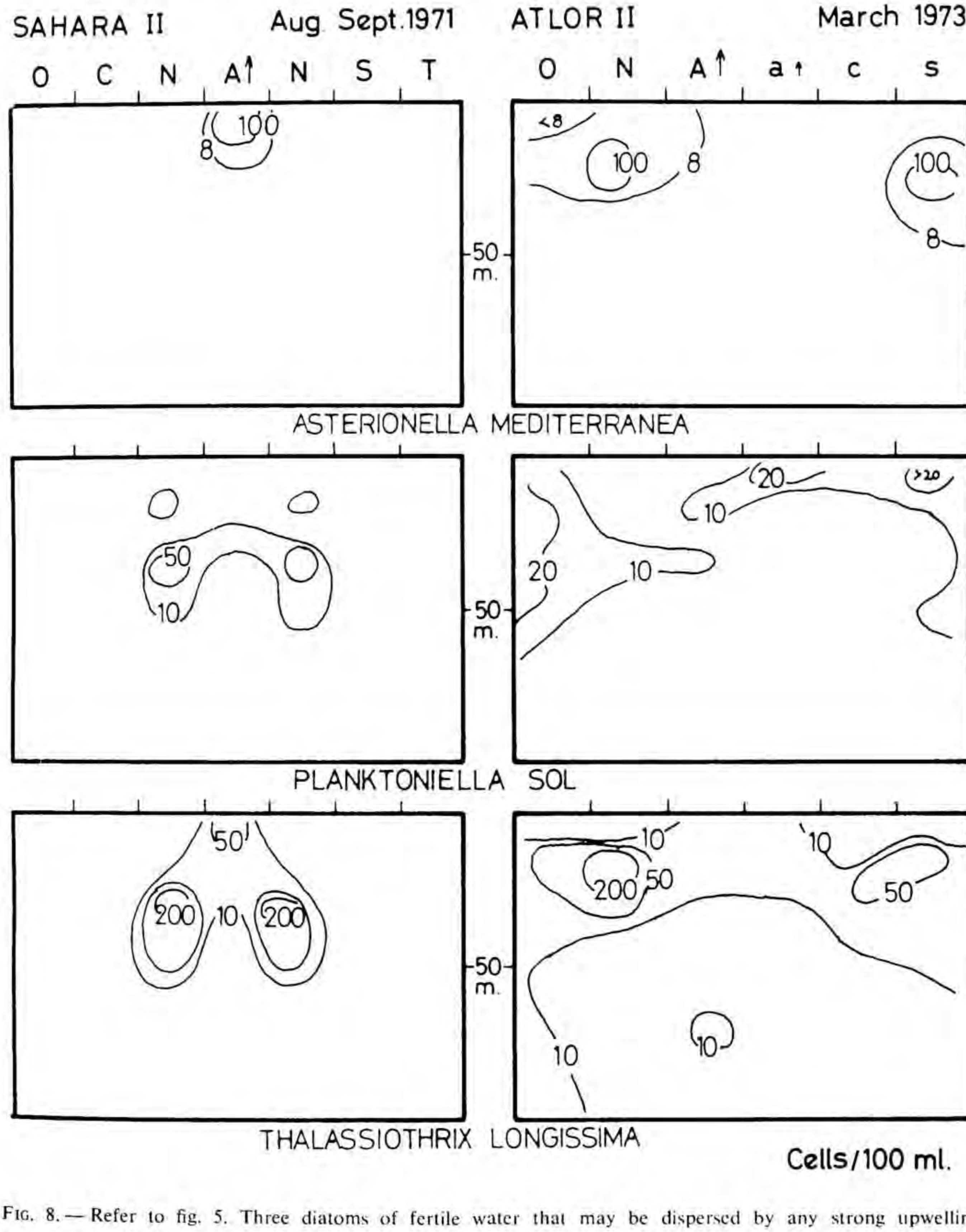

FIG. 8. — Refer to fig. 5. Three diatoms of fertile water that may be dispersed by any strong upwelling

fication of upwelling (spring, top of same fig. 15) blows the whole structure apart, and the populations of large diatoms come to adopt a peripheric or concentric position in relation with the center of maximum nutrients outflow. Consideration of several of the figures provides excellent illustration of this. Many species of large diatoms grow plentifully around the upwelling areas, but some others almost vanish if the upwelling is too strong (figures 8 and 9). These last species, in a certain way, can be considered

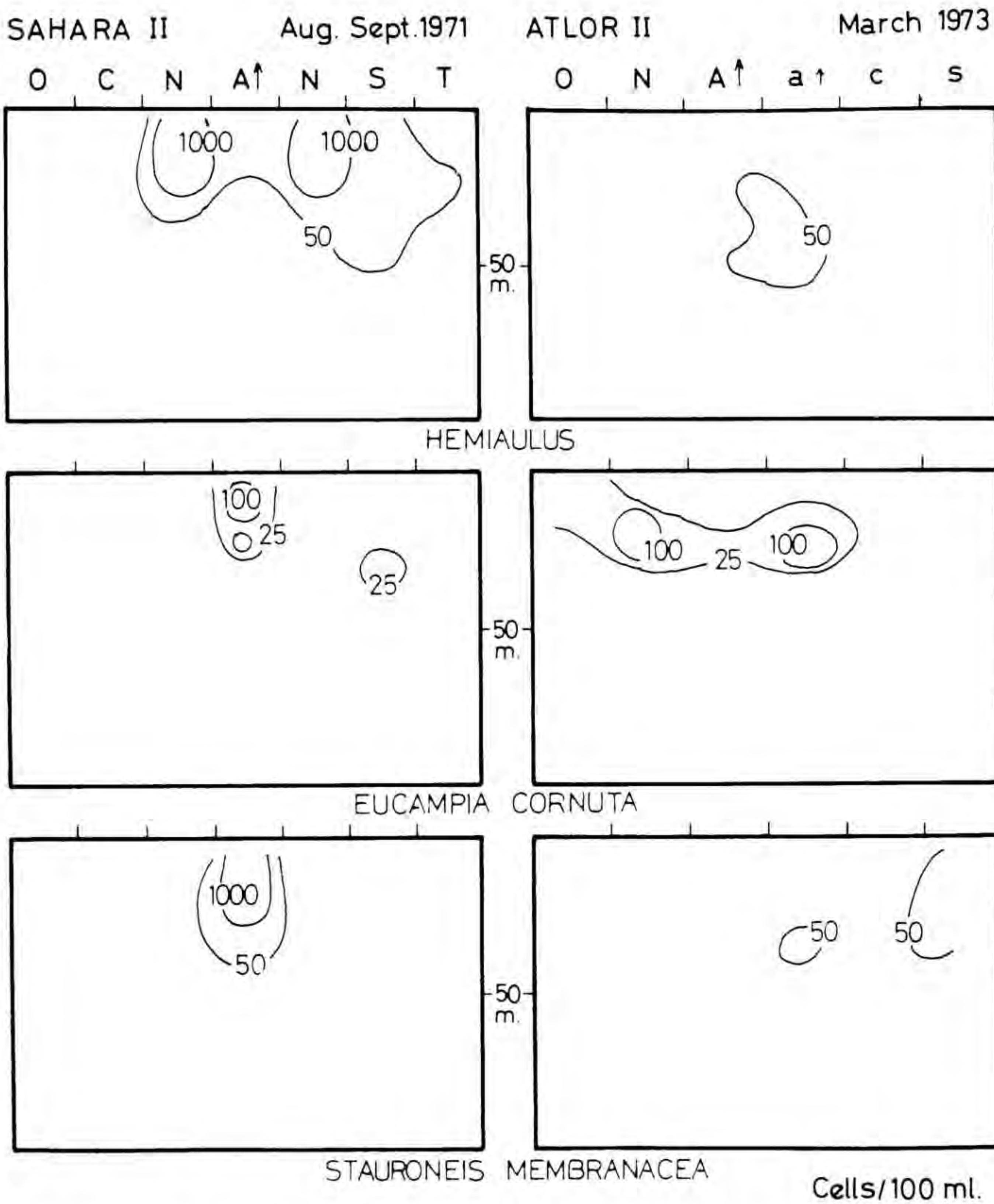

FIG. 9. — Refer to figs. 5 and 8. Other three diatoms of relatively fertile water that are surely dispersed by strong upwelling.

as ecologically intermediate between the diatoms of fertile spots and most of the dinoflagellates. Dinoflagellates may develop in rather large numbers around the places of moderate upwelling, but in the seasons of stronger flow, populations disperse perhaps too fast, or else have too many powerful competitors in the turbulent water, and dense populations do not materialize (fig. 11). Distribution of coccoliths may be in part affected by similar circumstances (fig. 14).

It cannot be forgotten that there were

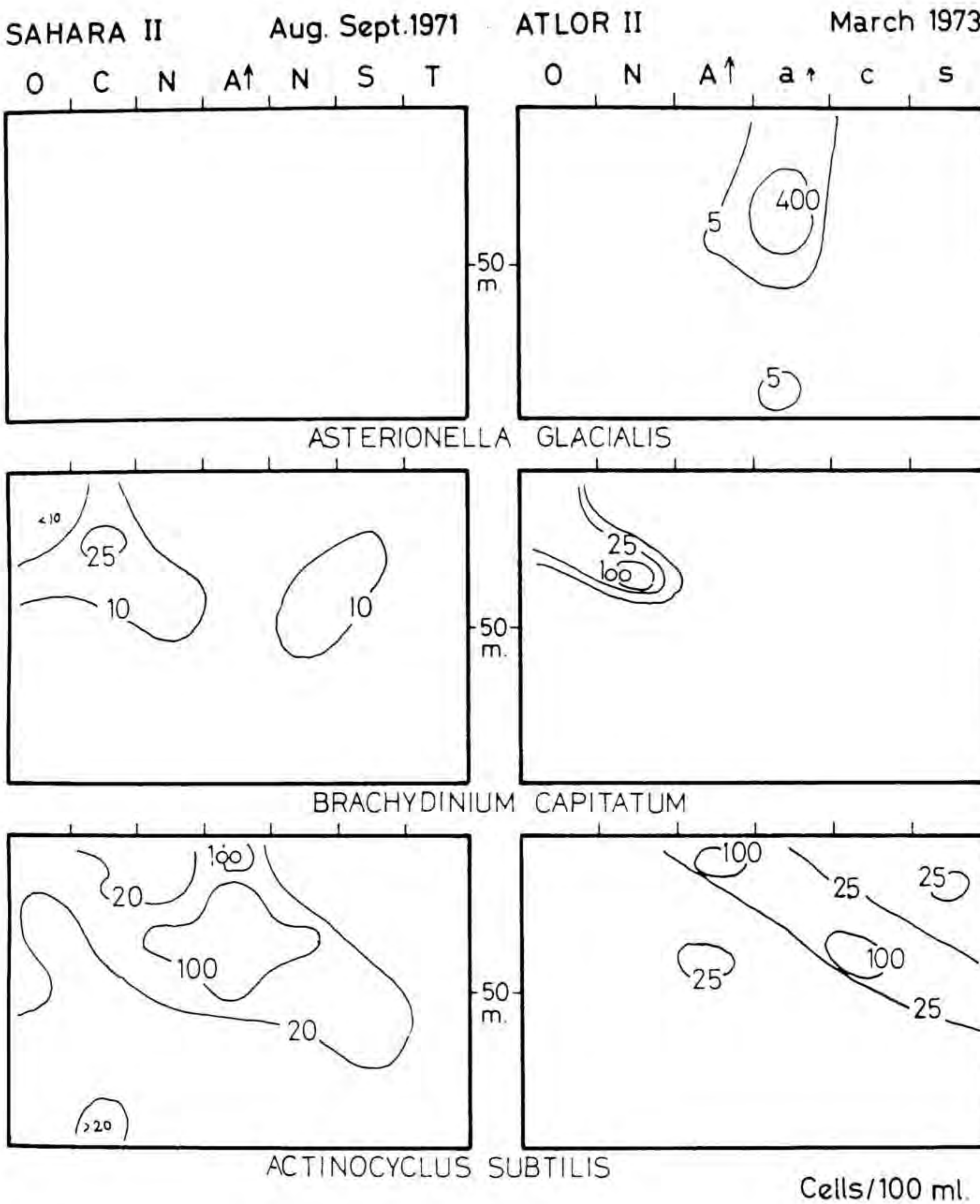

FIG. 10. — Refer to figure 5. *Asterionella glacialis* (=*japonica*) is a diatom common in most fertile and upwelling systems, and in NW Africa developed only in mass in the Southern seasonal upwelling. *Brachydinium* (dinoflagellate) and *Actinocyclus*, come from North, increase numbers in the upwelling area, but are dispersed by strong upwelling.

important ecological differences, in temperature, etc., between both compared surveys, and this may explain notable differences in the distribution of diatoms like *Hemiaulus*, *Asterionella glacialis* or *Amphora hyalina* (figs. 9, 10, 12). Thermic conditions were, in fact, quite different (figs. 3 and 4). But, on the whole, I am under the impression

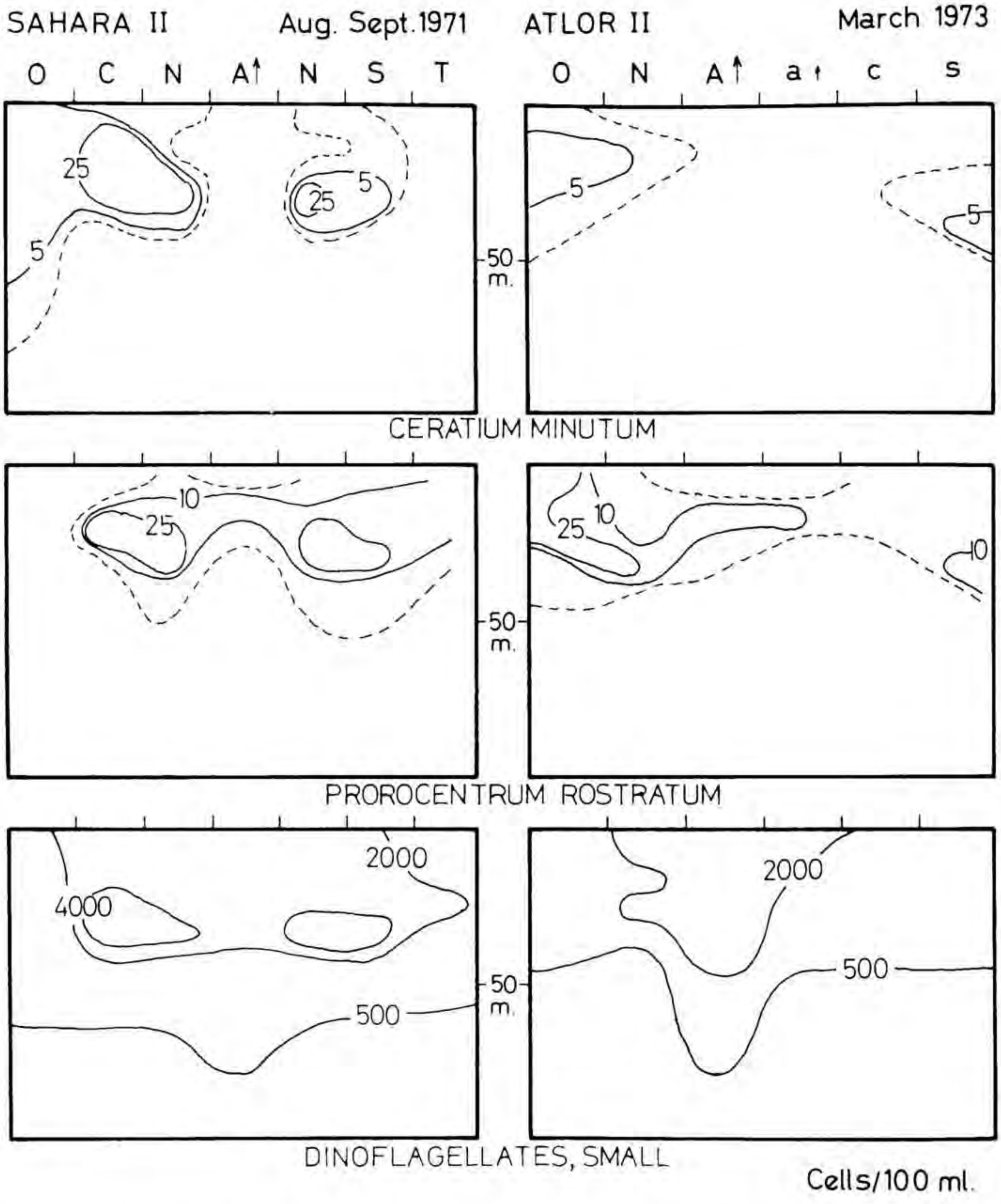

FIG. 11. — Refer to fig. 5. Dinoflagellates increase numbers in the fertile waters around a moderate upwelling, but never attain high density under a strong flow.

that mechanical factors, and the associated inflow of nutrients, are determining the whole pattern of distribution. This I want to stress, because in previous papers I have tended to emphasize interaction among species and the internal organization of the pelagic ecosystem.

There are many interesting hints; all of them cannot be followed now. In the distribution of related species, dynamic

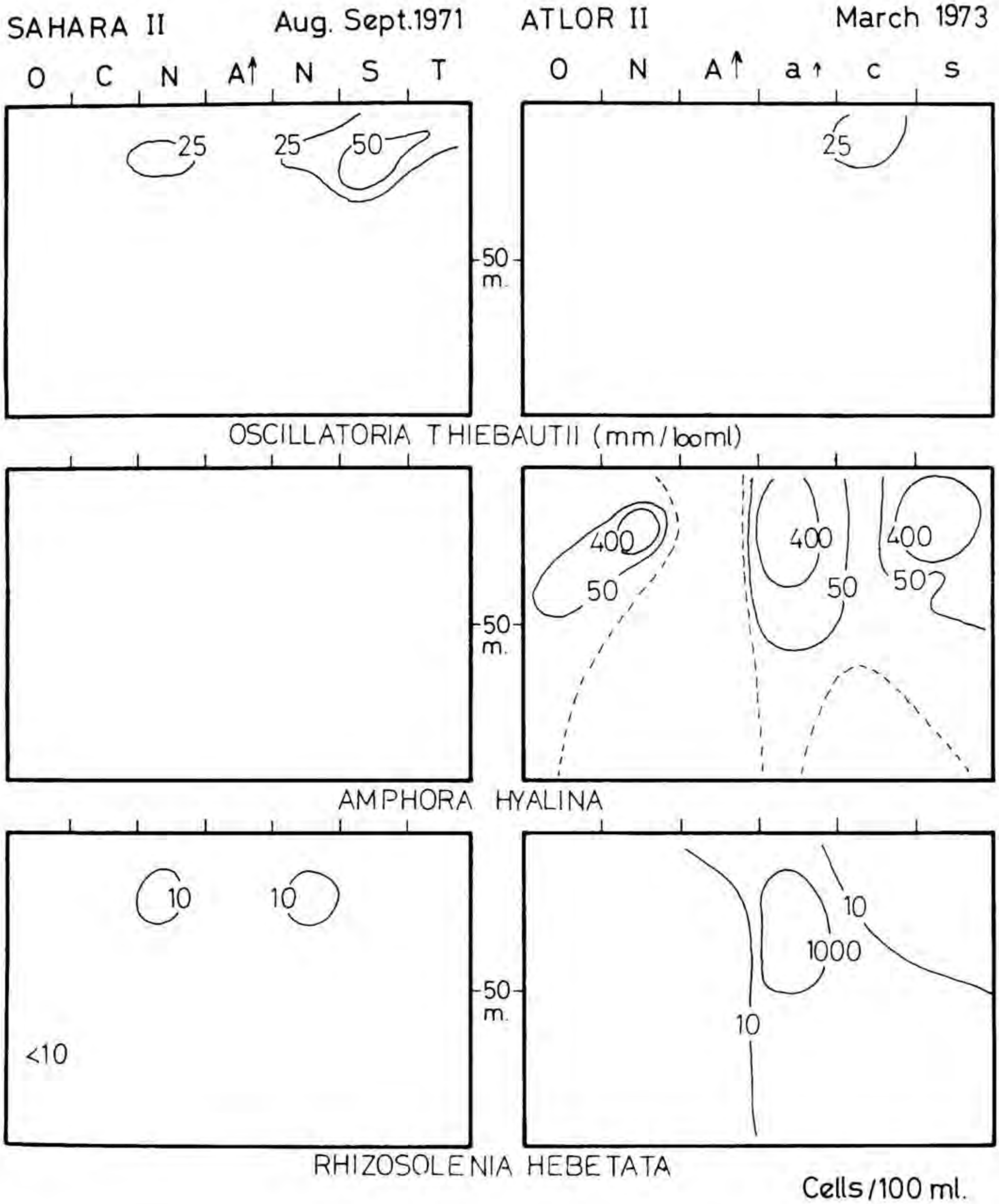

FIG. 12. — Refer to fig. 5. *Oscillatoria* comes from South, with warm surface water. Its distribution retracts around actual upwelling. *Amphora hyalina* and *Rhizosolenia hebetata* behave as well as if of Southern origin. Interrupted line is the limit of presence.

processes along a plume of rapid production can overrule the usual issue of selection and competition in more stable conditions. *Nitzschia «seriata»* in an ascending system (fig. 15, below) comes after *Nitzschia «delicatissima»* because it grows slower at high concentrations of nutrients, but in the outfall around the upwelling, maximum development of *N. «seriata»* is usually found at deeper levels than those in which *N. «deli-*

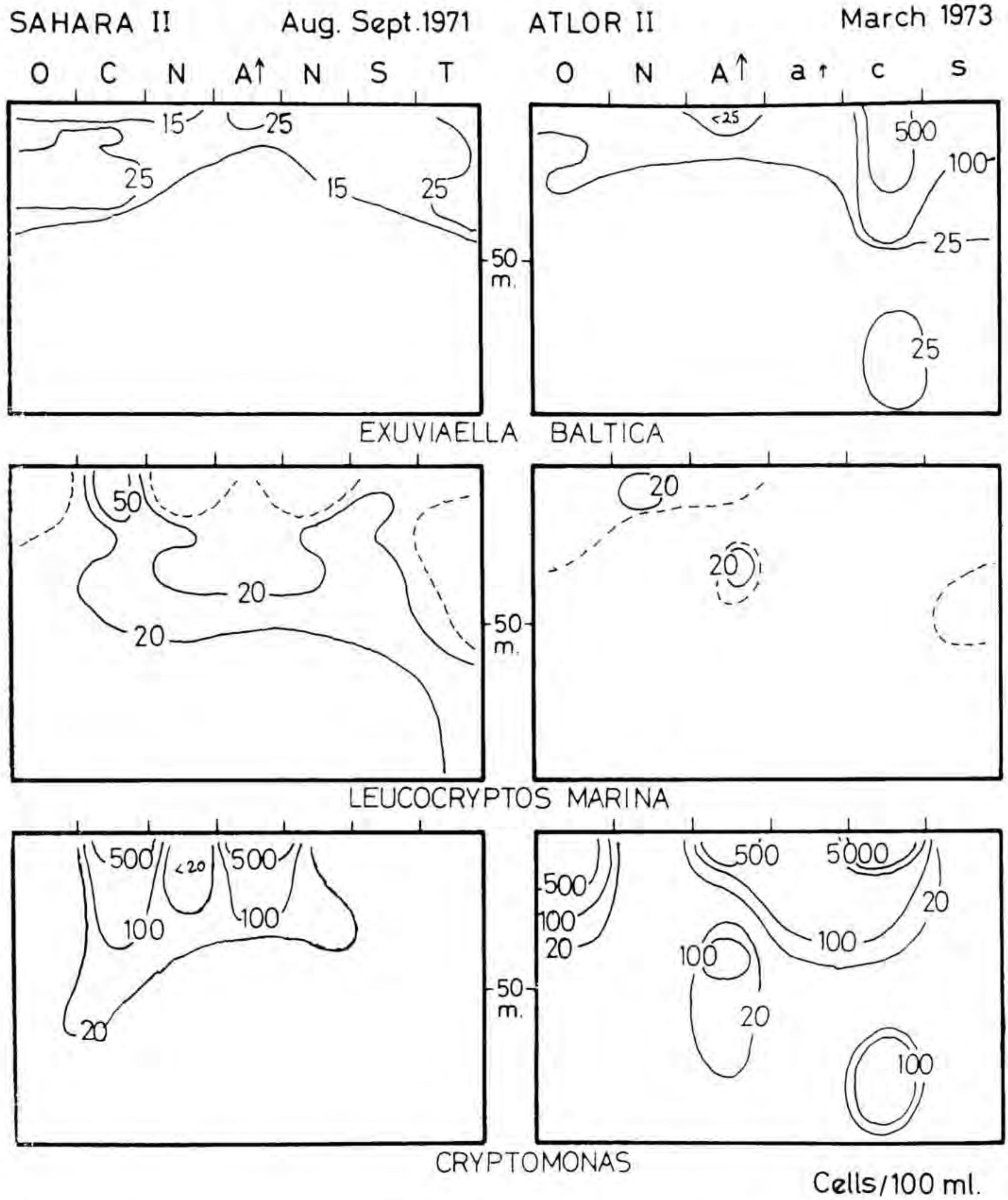

FIG. 13. — Refer to fig. 5. Cryptomonads, photosynthetic or heterotrophic *(Leucocryptos)* and their common dinoflagellate associate *Exuviaella*. The interrupted line means the limit of presence.

catissima» is dominant (this happens also in the Mediterranean and elsewhere).

The whole sequence of populations as they develop around the core of maximum movement of water represent an ecological succession. Expansion and contraction of the whole pattern according to the seasons is consistent with this interpretation. In the Norwegian Sea, North Sea, Long Island Sound and many other places (SMAYDA, 1966, etc.) successions have been reported that fit to the same sketch, with *Thalas-*

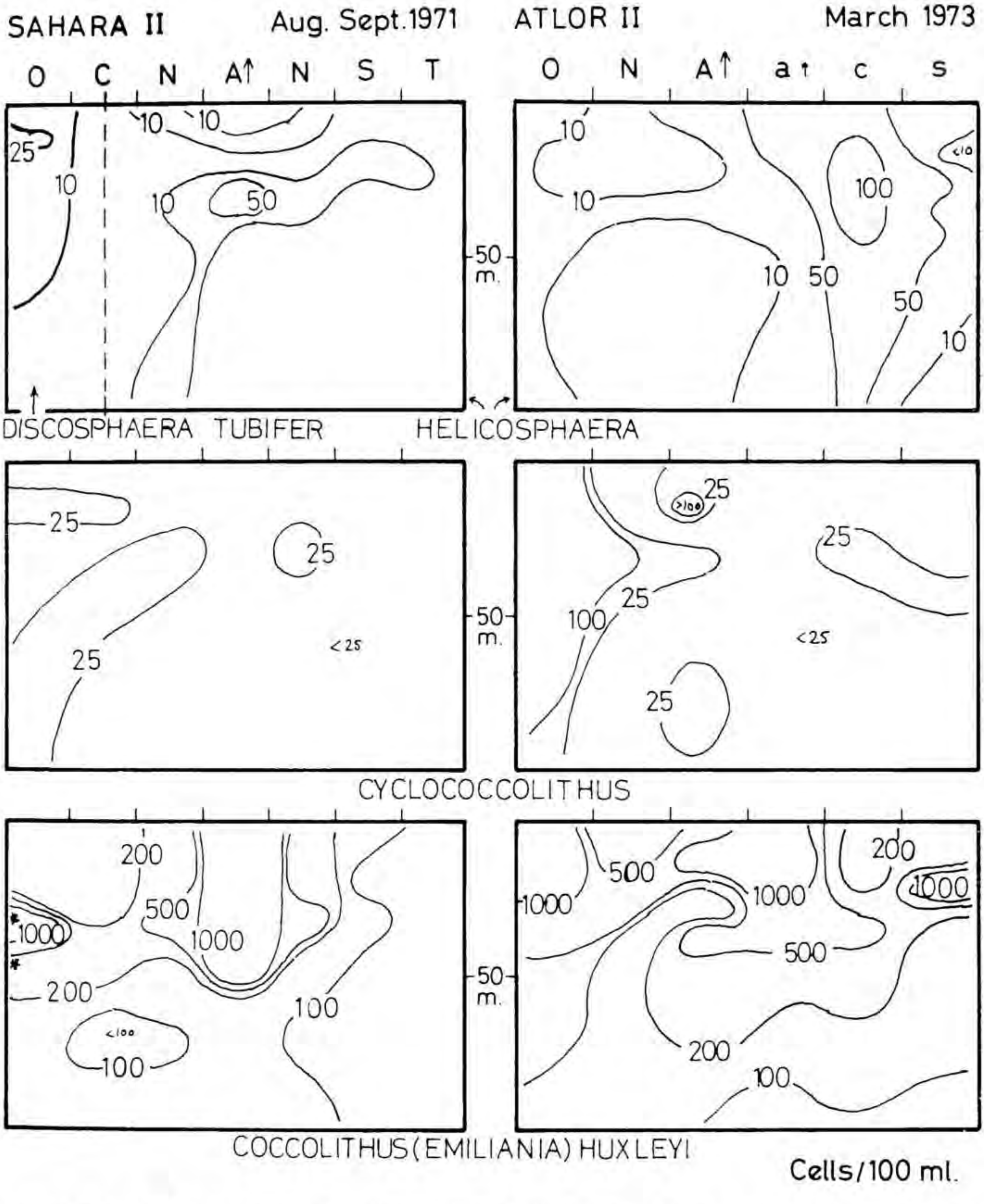

FIG. 14. — Refer to fig. 5. Coccoliths. *Discosphaera tubifer* was common only in Northern water in late summer. *Coccolithus huxleyi* is common in and around upwelling, and perhaps more common North than South. Asterisks means places where extremely dense local concentrations have been observed.

siosira, *Skeletonema* and other diatoms, sometimes *Phaeocystis*, in the first place, going over to larger diatoms with an increasing proportion of coccoliths, and finally to dinoflagellates. In a study of the plankton of the Ría de Vigo, in NW Spain (MARGALEF, 1958) I divided the succession in three stages, and each of them was characterized, among others, by following species: 1) *Skeletonema*, *Leptocylindrus*, small *Chaetoceros*, *Thalassiosira*, etc. 2) *Thalassiosira rotula*, *Lauderia*, *Eucampia*, *Bacteriastrum*, larger *Chaetoceros*, *Rhizosolenia*, *Thalassionema*, *Nitzschia* «*seriata*». 3) *Dinophysis*, *Peridinium*, *Gonyaulax*, *Prorocentrum*, *Ceratium* and other dinoflagellates. Coccoliths were never plentiful in the Rías. This sequence fits quite well to the spatial distribution observed in Africa (compare figures 5, 6 and 11), and the suggestion arises of evaluating distances in terms of time. But probably this would be impossible or misleading, because there is an important sinking of the phytoplankton around the upwelling spots, to the level of the thermocline, where there is much rolling, fertilization of small packets of water, and spreading, favoured by high horizontal diffusion coefficients at the level of the pycnoclines, making a much more complicated, if extremely interesting, image. The spreading of large diatoms at a level of 30-40 m can be gathered from the tables and figures. In species that can be easily recognized as dead cells, like *Actinocyclus subtilis*, movements can be tracked much further, as has been signaled previously (MARGALEF, 1973). In my model of succession based on the observations in Vigo I assumed that in the first stage small cells are common, and the rationale behind was that a large ratio surface:volume, as found in small cells, should be conductive to a rapid multiplication in numbers. But a large relative surface may be as well important in cells living in very dilute milieus. SEMINA (1972; SEMINA and TARKHOVA, 1972) has given consideration to the average diameter of cells in phytoplankton populations, and one of her findings is that dimensions are more diversified —that is, including also larger cells— in tropical and stable areas, and this may be a consequence of the larger diversity of such sort of communities, but also that diameter is related to upwelling movement of water. This may distort my image of succession as starting with small cells, but seems to be true in the area of upwelling of NW Africa, where the routine analysis using a Coulter Counter (MARGALEF, 1974) has revealed a larger proportion of not so small cells in the areas of upwelling. In fact, there is plenty of diatoms of relatively large size, although many of the most characteristic elements of the core of upwelling are still of small cells, like *Phaeocystis*, some *Thalassiosira* and *Chaetoceros*, although envelopped in an abundant secretion.

It would be dangerous to oversimplify the pattern of distribution of plankton. Certainly, many similarities will be discovered with published surveys about South Africa, or about the coasts of Perú (BLASCO, 1971; GUILLÉN *et al.*, 1971). But nevertheless important differences exist, even over short distances. The spring survey is interesting because it allows to compare the composition of communities in the persistent upwelling area of the North (A, Cabo Blanco) with the seasonal upwelling areas of Cap Timiris further South (a), as can be gathered from tables 9 and 10. *Rhizosolenia hebetata semispina*, *Amphora hyalina*, *Asterionella glacialis* and a relatively secondary position of small-celled *Thalassiosira* appear as differential for the Southern area, against the permanent one. Some chemical or nutritional difference has to be suspected, and this is confirmed by the diverging composition of blooms in fertile waters in other areas. Areas that receive important runow from land (Orinoco, Black Sea) may develop masses of *Exuviaella*, *Cyclotella*, *Coscinodiscus* and other genera, and it seems that this is not only a matter of an increased stability of water.

Upwelling areas are large, and have space for a considerable diversification. Red water may appear in patches of stabilized and still fertile upwelled water, specially close to the shore. Patches with cryptomonads (and sometimes *Mesodinium*) appear in Africa and have been separed as an area «C» (tables 2 and 11). But, on the whole, it seems that there is no reason to consider that the most important upwelling spots are characterized otherwise that by diatoms. Diatoms are the most characteristic organisms of the upwelling areas, as well as gramineae are characteristic of temperate grasslands.

The horizontal expansion of populations following a depth, usually in association with thermoclines, may be seen in figs. 3 and 4. Primary production is maximal in the center of upwelling (areas A, a), but it is important also in the peripheric areas with large diatoms (areas N, S). In figs. 3 and 4, the double representation of populations, in cells, and in chlorophyll *a*, allows a comment about the average chlorophyll content of the cells found in different areas. It is risky to extrapolate, since there is always much detritic chlorophyll. The scales have been choosen in the way that the dots expressing the amount of chlorophyll fall on the lines expressing the number of cells for the case in which 1 cell contains 10 pg of chlorophyll *a* (one million cells contains 10 micrograms). This is rather high, and mostly reported values fall between 1 and 10. Incomplete counting of cells and detritic chlorophyll may be the causes. As for *Oscillatoria*, according to MARUMO and ASOKA (1974), 1 mm of trichom per 100 ml corresponds to 0.002 mg chlorophyll *a* per cubic meter. According to the data from figs. 3 and 4, chlorophyll content per cell in spring may be on the average higher than in summer, but the evidence is rather tenuous. I have kept computing the pigment ratio D_{430}/D_{665} (D being the optical densities of plankton extracts at the stated wavelenghts) with conflicting results. In the present case (figs. 3 and 4, summarized in fig. 15) results are not too bad. The value of the index increases centrifugally around the core of the upwelling, and this may be adscribed to loss of activity, senescence and diversification of phytoplankton populations, as well as to the increasing proportion of detritic chlorophyll and pigments of the faeces of the animals. Admittedly this is not a «clean» index, but might be an indicator useful in surveys.

DISCUSSION

The procedure used in this paper is reminiscent of oldfashioned plant ecology. In present times it is more common to use some form of multivariate analysis, principal component analysis and extraction of clusters or of recurrent groups of species. Such methods behave well when number of samples is small and the number of species taken in consideration is artificially limited, implying a form of personal selection. Otherwise, number of clusters is very high, and number of principal components necessary to explain a reasonable amount of the variance may turn to be unmanageable (MARGALEF and GONZÁLEZ BERNÁLDEZ, 1969). High correlations among species may appear as an artifact resulting from low frequencies. Sampling procedures may influence strongly the outcoming associations. This may be inoportune in situations as the present one, where a structure made of different parts wants to be visualized, and it happens that some area is represented by many more samples than other areas.

ESTRADA (1975) has prepared a principal component analysis of phytoplankton of this same area of NW Africa, collected at the same time, but at different stations during the Atlor II survey. The three first components account for the 48.4 % of the total variance (only 20 species were included in the analysis). The first component expresses a contrast North-South: *Brachydinium capitatum*, *Prorocentrum rostratum*, *Ceratium kofoidii* and *Planktoniella sol* show high positive loadings, and *Amphora hyalina* the highest negative values. The second component seems associated with coastal fertility, several diatoms *(Rhizosolenia)*, *Exuviaella* and coccolithophorids show important positive loadings. The third component singles out *Thalassiosira partheneia* and some *Chaetoceros* and can be associated with the upwelling center. There is a support for the results presented in this paper, and the way is open for a more sophisticated analysis of the dependence of groups of species on particular combinations of environmental factors.

BLASCO (1971) has studied the correlations among the distribution of a set of 103 species in the Peruvian upwelling areas. Three groups come out. First group includes diatoms frequent in the upwelling area; second group includes most of dinoflagellates and some diatoms that proliferate around the fertile spots, and the third group includes a small number of coastal and benthic diatoms, distributed in the shallower areas.

Some interesting analogies, and sometimes real affinities, can be discovered with the different groups of recurrent species, with common ecological significance, that have been proposed as the results of dif-

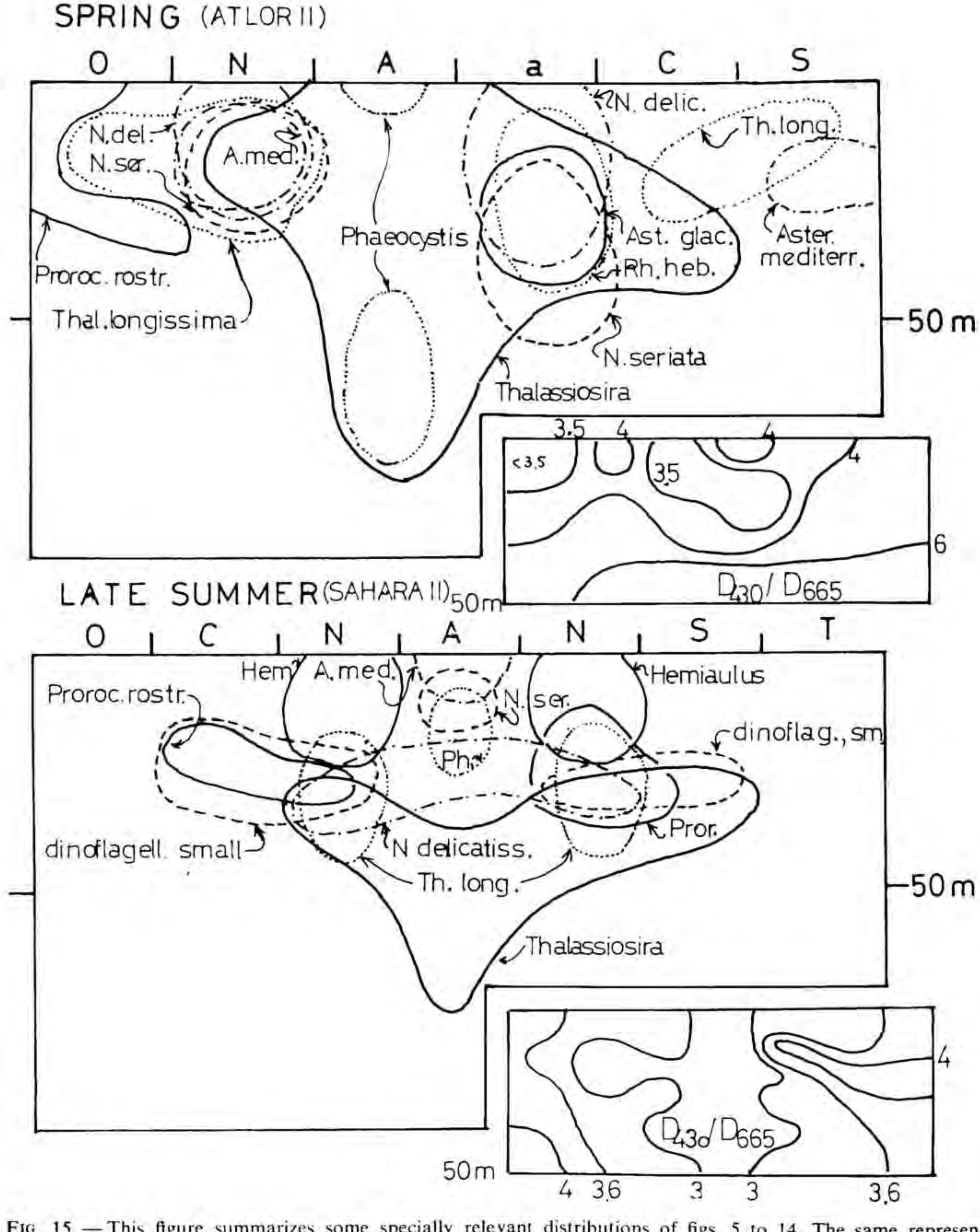

FIG. 15. — This figure summarizes some specially relevant distributions of figs. 5 to 14. The same representation (depth in vertical scale; areas in the horizontal dimension) has been used and only the cores of maximal density for the different species selected have been entered. Actual densities can be read in figures 5 to 14. In the smaller insets, distribution of the averaged pigment ratios (from figs. 3 and 4) over the same sections.

ferent studies in warm Atlantic waters (DANDONNEAU, 1971, 1973; RAT'KOVA and KOKAN, 1974), in the Pacific (VENRICK, 1971), in the Indian Ocean (THORRINGTON-SMITH, 1971), in the Mediterranean (MARGALEF, 1966) and in the Caribbean (MARGA-

LEF and GONZÁLEZ BERNÁLDEZ, 1969). But the usefulness of such correspondences provides no deeper insight than a general comparison between floristic lists. In particular, many of the clusters or groups of secondary importance look often very artificial, as if they were the result of vagaries of samples and species selection and of statistical errors. At least it is difficult to make ecological sense of them. But it seems advisable to carry on a similar analysis with all the data that have served to prepare tables 1 to 12, in special if this can led to a more careful consideration of physical and chemical environmental factors that were measured in the collection points. Probably the adopted methods will be supplemented or corrected by topological considerations of proximity, avoiding an indiscriminate comparison of all the samples independent of their position, as if they were, so to speak, drawn from a bag, as is done in the usual statistical procedures. It is important that one whole ecological structure —such as an upwelling region— could be considered and described in terms of a deformation of another, but preserving the same structural (spatial) relations among the different areas or the different elements. In other words, an upwelling system has to be recognized as a dynamic system generated by the decay of a point like input of energy, and not as a mosaic of taxonomic rags.

From present evidence we expect distributions to be really complicated. In the analysis of transects (MARGALEF, in press) always a «mountain range» pattern is found: small scale fluctuations develop around a trend that shows large scale fluctuations, and so on. Probably this is true also in deep water and over the three dimensions: I mean that around a core of upwelled water there may be small discontinuous —separated— blobs of the same water, that, on their turn, give off small parcels of water all around. And this is not a static pattern, but a dynamic one linked to the process of decaying movement associated with systems of eddies. Diffusion and flow in the oceans always results in discontinuities, at least in discontinuities at the level of plankton populations. It can be understood easily that patchiness as observed from the surface may be difficult to explain, if processes going on in deeper water, and if the results of their interference with the interface air/water, are not carefully considered.

The physical organization of the environment can be reinforced and amplified by chemical processes. There are many circulation cells in the upwelling areas, in which part of the elements are recycled, with sensible losses, for instance, phosphate can be precipitated, oxygen exhausted and not replaced, and nitrogen passed partially from inorganic compounds to molecular form. In my opinion, analysis of concentration of certain elements (metals, etc.) in the different gyres and eddies of an upwelling region could give useful indications on these processes (HEAD, 1971; RILEY and TAYLOR, 1972). If the structures have a certain degree of persistence, it may be expected that they are reflected in the composition of sediment. It is common knowledge that inorganic phosphate is precipitated below every important upwelling region.

The local composition of communities results from a loose and dynamic adaptation of a large stock of available species to local conditions. As it happens that the seemingly most important environmental factors, viz., turbulence and nutrients, are usually associated, it results a sort of lineal range of adaptation that runs between species able to use high nutrient concentration and to support losses due to high turbulence and dispersability (*r*-strategists) and the opposite kind of species, adapted to use diluted nutrients and to low turbulence, and able to move around by themselves (*K*-strategists). The best example of the last ones are the large dinoflagellates of flattened cells and complex morphology. Such main axis of classification of planktonic life-forms comes out in the classification of actual communities, as one important principal component, or is expressed as the opposition between the main clusters of species. These ideas that have been developped in part and will be developped further elsewhere are presented in a very sketchy form in MARGALEF (1975 b). Nevertheless, actual situations are never so straightforward. In particular situations, low turbulence can be exceptionally associated with high nutrient concentration, generating «red water». There is a large spectrum of possibilities in the utilization of natural turbulence: Large chain-like diatoms can move anchored in relatively large eddies, and their absorption of nutrients can be enhanced by smaller eddies around the particular cells. Organisms with an important excretion of mucilaginous organic matter can put themselves out of competition. Diversification of possible strategies in phytoplankton is larger than usually assumed, even when the many possibilities associated with the absorption of nutrients are taken into account (GRENNEY and al., 1973). Moreover, turbulence has the peculiar property of not only serving as a selective agent for a particular set species, but by itself is a cause of continuous mixing of potentially segregated populations. I suspect that plankton development in nature never laggs as a consequence of the absence of adapted species or of their diaspores. There is no paradox of the plankton, but we are often excessively myopic in the perception of the many possibilities of spatial and temporal organization. Perhaps more effort should go in the study of small scale processes and small scale organization. They can provide a key to a better understanding of the larger systems.

RESUMEN

COMUNIDADES FITOPLANCTÓNICAS EN ÁREAS DE AFLORAMIENTO. EL EJEMPLO DEL NW DE ÁFRICA. Las áreas de afloramiento del Norte y Sur de África, California y Perú nos presentan por cuadruplicado un fenómeno que es sustancialmente el mismo. El estudio comparado de dichas regiones puede resultar extraordinariamente útil, y un aspecto del mismo es la descripción de las respectivas comunidades. La presencia y la distribución de las distintas especies refleja la heterogeneidad de cada región de afloramiento. Pero los datos que se poseen son pocos y su comparación es difícil. Debería revalorizarse el estudio de la taxonomía y distribución del fitoplancton.

La dependencia de la producción primaria se ha estudiado en relación con la intensidad de la luz y la concentración del nutrimento, pero, en realidad, el factor más importante que define el valor local de la producción primaria es la energía externa que se degrada en cada área marina. El estudio del afloramiento es, sustancialmente, el estudio de las manifestaciones hidrodinámicas y biológicas de una intensa disponibilidad local de energía. Consideraciones físicas nos permiten comprender cómo el flujo del agua se descompone en un gran número de células de circulación, de diferente tamaño, produciendo un motivo de heterogeneidad horizontal que se superpone al flujo promediado del líquido. Las formas biológicas del fitoplancton se pueden interpretar como adaptaciones a determinadas constelaciones de factores de selección, tales como la turbulencia del agua y el aporte de nutrimento, que se repiten una y otra vez, aunque con notable heterogeneidad local y muchas fluctuaciones. Las distribuciones de flujo, turbulencia, nutrimento, luz y presión de consumo por parte de los animales, seleccionan alternativamente unas u otras especies, según los lugares, y la inestabilidad del medio permite una considerable mezcla en todos los límites.

Se analizó un gran número de muestras de fitoplancton recolectado en el sistema de afloramiento del NW de África y regiones próximas, en agosto y septiembre de 1971 (crucero SAHARA II) y en marzo de 1973 (crucero ATLOR II). Comparando las muestras de estaciones vecinas se ha podido dividir la región estudiada (figuras 1 y 2) en cierto número de subregiones más homogéneas, designadas por letras en aquellas figuras y en las tablas. Los límites entre unas y otras subregiones coinciden, frecuentemente, con diferencias notables en las características del agua. Aunque el contorno y las características de las subáreas varían según la estación del año, como se deduce de las figuras, persiste, sin embargo, cierto motivo topográfico común, y aquellas diferencias, hasta cierto punto, se pueden interpretar como deformaciones, contracciones o expansiones de un motivo generalizado de distribución. De esta forma se encuentran semejanzas también con otras regiones de afloramiento, semejanzas que incluyen ciertos fenómenos muy fugaces. Nunca se encuentran volúmenes de agua con muy poco plancton, es decir, no hay en superficie masas de agua recién aflorada, sino que el afloramiento, en realidad, pone en circulación torbellinos de todos los tamaños, en los que inyecta cierta proporción de agua fértil de origen profundo. Por supuesto, jamás faltan células de fitoplancton para dar origen a poblaciones. Hay especies cosmopolitas que son comunes a distintas áreas de afloramiento; otras especies parecen de representación más local. Se ha promediado la composición vertical del fitoplancton para cada subregión, obteniendo las cifras reunidas en las tablas. De esta forma se consigue una visión simplificada y esquemática del conjunto de la distribución, que puede facilitar su interpretación en términos de la adaptación de las respectivas poblaciones a las condiciones locales. La figura 15 resume y superpone algunas de las distribuciones que parecen más significativas, de entre las que se recogen en las figuras 5 a 14.

En el área de afloramiento del NW de África,

los puntos donde la velocidad ascendente del agua y su divergencia en superficie son más intensos, albergan poblaciones formadas principalmente por diatomeas, con las células cubiertas por una abundante secreción orgánica visible. Alrededor de estos focos se encuentra una abundante población, más diversificada, en la que siguen predominando diatomeas. Más hacia fuera, se reconocen comunidades ricas en cocolitoforales, a los que se mezclan pequeñas dinoflageladas y flageladas. Algunas manchas, más o menos discontinuas, en toda la zona periférica, pueden mostrar características peculiares, por ejemplo, dominancia local de criptomonadales o de organismos que colorean visiblemente el agua, sean dinoflageladas o ciliados. Esta estructura o motivo de distribución, formado por áreas más o menos concéntricas, pasa paulatinamente al plancton oceánico, de densidad mucho más baja, pero no necesariamente con menos especies, en el que predominan organismos móviles, cuyo tamaño varía entre amplios límites. Dentro de un régimen de densidad baja y uniforme, la composición de este plancton de alta mar puede variar considerablemente entre estaciones, incluso vecinas.

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TABLES

TABLE 1. — Cruise SAHARA II, Aug. Sept. 1971. Averages of 10 stations (numbers 1, 3, 4, 5, 6, 7, 8, 9, 10, 11). Area *O* («offshore»).

Cells per 100 ml at depth, m	0	5	10	20	30	50	75	100	150	200	300	400	500
Dinoflagellates, small	752	984	1048	1112	1861	736	459	213	176	64	62	29	29
Flagellates, small	659	742	821	956	1213	696	523	317	268	145	132	99	91
Coccolithus huxleyi	119	152	143	151	1613*	264**	167	135	143	122	139	73	106
Syracosphaera sp. pl.	26	30	58	26	33	20	2o	13	25	7	18	14	7
Cyclococcolithus sp.	13	33	66	13	16	26	33	27	17	13	33	29	18
Gyrodinium fusiforme	43	24	26	21	33	1o	1o	3	+	o	o	o	o
Peridinium cf. trochoideum	3o	2o	18	23	6o	1o	3	o	o	o	o	o	o
Discosphaera tubifer	1o	27	7	3	13	13	3	o	o	o	o	o	o
Exuviaella baltica	6	23	15	39	26	13	o	o	o	+	7	4	4
Clyptrosphaera sp.	1o	o	7	3	o	17	3	6	o	o	18	22	o
Thalassiosira sp. pl., small	i6	12	16	3	8	1o	3	3	o	8	4	o	o
Prorocentrum ovale + obtusidens	3	7	11	1o	6o	13	3	1o	o	o	2	o	o
Ceratium minutum (+ kofoidii)	17	7	12	3	1o	7	3	o	o	o	o	o	o
Oxytoxum mediterraneum	3	7	7	3	16	3	7	o	o	o	o	o	o
Oxytoxum variabile	o	2o	4	16	43	1o	o	o	o	o	o	o	o
Actinocyclus subtilis	42	25	18	15	11	44	5	6	15	1	1	o	o
Flagellate, Hasle, 196o	3	3	3	16	13	7	1o	o	o	o	o	o	o
Climacodium frauenfeldianum	7	1o	4	1	1o	+	+	o	o	o	o	o	o
Brachydinium capitatum	1	7	+	+	12	o	o	o	o	o	o	o	o
Leucocryptos marina	o	o	o	1o	13	3	1o	o	o	o	o	o	o
Nitzschia "delicatissima"	3	7	o	3	7	7	+	7	4	3	o	o	o
Prorocentrum micans + gracile	1	7	4	3	7	3	3	+	o	o	o	o	o
Mesoporos perforata	3	13	o	3	o	o	o	o	o	o	o	o	o
Nitzschia "closterium"	o	o	11	o	o	7	o	3	o	o	o	+	o
Navicula sp. pl.	o	+	o	17	o	1o	7	o	7	3	o	o	+
Dictyocha fibula	o	o	3	1o	o	3	o	o	3	o	o	o	o
Rhizosolenia delicatula	o	o	o	13	o	3	o	o	o	o	o	o	o
Cladopyxis brachiolata	o	6	1o	o	o	3	o	o	o	o	o	o	o
Ceratium fusus	7	1	+	o	o	1	3	2	4	4	o	o	o
Coccolithus pelagicus	o	o	o	o	3	1o	13	o	7	3	o	o	o

* 11613 including "bloom" stations
** 49264 including "bloom" stations

Other species, with lower abundances and frequencies: Abedinium dasypus, Acanthoica sp., Amphidoma cf. nucula, cells like Ankistrodesmus, Amphisolenia globifera, Amphisolenia pl. sp., Blepharocysta splendormaris, Ceratium azoricum, C. contrarium, C. declinatum, C. extensum, C. furca, C. pentagonum, C. trichoceros, C. tripos, Ceratocorys horrida, Chaetoceros decipiens, Ch. sp., Corethron criophilum, Cochlodinium brandti, Coscinodiscus radiatus, Coscinodiscus sp., Cyclotella sp., Ceratium massiliense, Dinophysis parvula, D. uracantha, D. sp., Diplopsalis minor, Erythropsis sp., Eutreptiella sp., Exuviaella compressa, E. vaginula, Glenodinium sp., Gonyaulax fragilis, G. polygramma, G. sp., Gyrodinium spirale, Halosphaera viridis, Helicosphaera sp., Hemiaulus sp., Heteraulacus polyedricus, Histioneis hyalina, Lauderia sp., Nitzschia «seriata», N. sp., Minuscula bipes, Oscillatoria thiebautii, Ornithocercus sp., Oxytoxum curvatum, O. constrictum, O. scolopax, Peridinium brochi, P. crassipes, P. mite, P. divergens, P. oblongum, P. oviforme, P. globulus, Planktoniella sol, Podolampas palmipes, P. spinifer, Polykrikos schwartzi, Pronoctiluca spinifera, Prorocentrum rostratum, Pyramimonas sp., Pyrocystis sp., Pyrophacus steinii, Richelia intracellularis, Rhizosolenia alata, Rh. calcaravis, Rh. hebetata, Rh. shrubsolei, Rh. stolterfothii, Skeletonema costatum, Stauroneis membranacea, Tetraselmis sp., Thalassionema nitzschioides, Thalassiothrix longissima, Tropidoneis sp.

TABLE 2. — Cruise SAHARA II, Aug. Sept. 1971. One station (number 11). Area *C* («cryptomonads»).

Cells per 100 ml at depth, m	0	5	10	20	30	50	75	100	150	200	300	400	500
Flagellates, small	3565	468o	52oo	535o	581o	1o25	433	366	4oo	133	3oo	3oo	2oo
Dinoflagellates, small	379o	271o	357o	6ooo	7125	1715	466	366	165	66	66	133	6o
Cryptomonas cf. pseudobaltica	8oo	1oo	333	433	4oo	33	o	o	o	o	o	o	o
Prorocentrum ovatum + obtusidens	366	133	366	466	56o	o	o	o	o	o	o	o	o
Coccolithus huxleyi	133	1oo	1oo	1oo	133	2oo	66	15o	o	33	13o	13o	35
Gyrodinium fusiforme	2oo	35	33	66	13o	18	2	o	o	o	o	o	o
Oxytoxum cf. longiceps	o	66	66	2oo	166	o	o	o	o	o	o	o	o
Navicula wawrikae	1oo	66	66	1oo	133	3	o	o	o	o	o	o	o
Actinocyclus subtilis(incl.dead cells)	2	33	4	33	52	17	6	66	3o	33	o	6o	1
Cyclococcolithus sp.	o	33	33	o	33	65	17	o	6o	o	o	o	o
Peridinium cf. trochoideum	66	133	166	133	3oo	o	o	o	o	o	o	o	o
Coccolithus pelagicus	66	o	o	o	66	33	37	6o	o	o	o	o	o
Solenicola setigera	o	o	o	o	25o	55	o	o	o	o	o	o	o
Thalassionema nitzschioides	o	o	33	o	12	15	33	o	o	o	o	o	o
Prorocentrum micans	o	1	4	4	33	2	o	o	o	o	o	o	o
Oxytoxum mediterraneum	1oo	+	o	1oo	33	o	o	o	o	o	o	o	o
Brachydinium capitatum	18	o	o	33	o	o	o	o	o	o	o	o	o
Amphidoma cf. nucula (=G. rouchi)	66	1	o	1oo	33	o	o	o	o	o	o	o	o
Nitzschia "delicatissima"	1oo	o	o	33	33	15	o	o	o	o	o	o	o
Ceratium minutum (+ kofoidii)	1	66	33	33	65	o	o	o	o	o	o	o	o
Nitzschia "closterium"	o	66	13o	o	o	o	o	o	o	o	o	o	o
Exuviaella baltica	o	33	o	33	66	o	o	o	o	o	o	o	o
Navicula sp. pl.	o	33	o	33	66	33	33	33	o	o	o	o	o
Ceratium furca	o	33	1	2	3	1	o	o	o	o	o	o	o
Cochlodinium brandti	1	66	1	33	o	o	o	o	o	o	o	o	o
Ceratium fusus	2	2	4	3	1	1	o	o	o	o	o	o	o
Leucocryptos marina	2oo	65	65	o	6o	5o	33	o	o	o	o	o	o
Chaetoceros sp.	66	o	o	o	o	o	o	1	o	o	o	o	o
Pronoctiluca spinifera	o	1	o	o	16	1o	o	o	o	o	o	o	o
Rhizosolenia shrubsolei	o	o	1	+	33	o	o	o	o	o	o	o	o
Tetraselmis sp.	o	o	o	66	o	o	33	o	o	o	o	o	o
Thalassiosira sp.	o	o	o	33	o	33	o	o	o	o	o	o	o
Pyramimonas sp.	o	o	o	15o	o	o	o	o	o	o	o	o	o
Eutreptiella sp.	o	o	+	33	o	o	o	o	o	o	o	o	o
Prorocentrum rostratum	o	o	o	33	o	o	o	o	o	o	o	o	o
Syracosphaera sp.	o	o	o	o	33	o	o	o	o	o	o	o	o
Nitzschia "seriata"	o	o	o	o	33	o	o	o	o	o	o	o	o

Other species, less abundant: Actinoptychus senarius, Amphisolenia laticincta, Asteromphalus arachne, Coscinodiscus radiatus, C. sp., Dinophysis parvula, D. pugiunculus, Dactyliosolen mediterraneus, Dictyocha fibula, Diplopsalis asymmetrica, D. minor, Gyrodinium spirale, Lauderia borealis?, Oxytoxum scolopax, O. sp., Peridinium brochi, P. sp., Pleurosigma sp., Podolampas spinifer, Stauroneis membranacea, Tropidoneis sp.

TABLE 3. — Cruise SAHARA II. Aug. Sept. 1971. — Averages of 6 stations (numbers 13. 14. 15. 21. 33. 35). — Area *N* («Northern»).

Cells per 100 ml at depth, m	0	5	10	20	30	50	75	100	150	200	300	400	500
Flagellates, small	2154	3043	3736	3854	4339	992	547	424	340	218	152	165	110
Dinoflagellates, small	2185	2559	2984	3380	4116	953	350	386	138	196	138	176	77
Hemiaulus indicus (* local)	2233	1369	1540	1243	60	0	0	0	0	0	0	0	0
Coccolithus huxleyi	222	192	240	286	532	129	77	133	115	52	33	22	11
Thalassiosira sp. pl.	27	33	20	47	3088	249	22	5	0	6	0	0	0
Nitzschia "seriata"	16	44	38	5	597	10	0	+	0	0	0	0	0
Nitzschia "delicatissima"	88	115	60	264	1300	548	8	0	0	0	0	0	0
Nitzschia "closterium"	66	22	16	71	531	47	0	0	0	+	0	0	0
Chaetoceros sp. pl.	6	+	0	1	447	60	0	0	0	0	5	0	0
Rhizosolenia stolterfothii	7	+	6	6	154	99	11	6	5	0	0	0	0
Thalassionema nitzschioides	22	11	0	22	172	27	16	11	0	0	0	0	0
Navicula sp. (wawrikae, etc.)	11	27	44	+	58	208	+	+	6	0	+	+	0
Prorocentrum ovale + obtusidens	0	6	16	155	88	0	0	0	0	0	0	0	0
Oscillatoria thiebautii (mm trichom)	15.1	69.0	40.8	13.0	1.1	0	0.8	0	0	0	0	0	0
Thalassiothrix longissima	0	0	0	0	236	80	0	0	0	0	0	0	0
Solenicola setigera	0	165	0	16	0	32	4	0	8	0	0	0	0
Actinocyclus subtilis (incl.dead cells)	8	12	3	41	107	73	17	8	8	12	+	1	+
Gyrodinium fusiforme	44	27	27	38	66	12	6	6	+	0	0	0	5
Cyclococcolithus sp.	22	6	11	33	43	0	11	5	22	11	16	0	6
Rhizosolenia shrubsolei	22	1	22	7	30	12	+	+	0	0	0	0	0
Calyptrosphaera sp.	33	55	44	83	86	19	25	44	16	19	16	0	6
Peridinium cf. trochoideum	27	39	60	44	45	5	6	0	0	0	0	0	0
Rhizosolenia delicatula	0	+	0	27	83	0	0	0	0	0	0	0	0
Prorocentrum rostratum	6	6	16	28	30	5	0	0	0	0	0	0	0
Helicosphaera sp.	16	5	5	0	14	0	11	16	11	5	0	0	11
Leucocryptos marina	6	5	11	6	5	20	6	5	5	5	0	5	0
Rhizosolenia hebetata	0	1	16	16	1	0	0	0	0	0	0	0	0
Exuviaella baltica	0	21	22	16	8	0	0	0	0	+	0	0	0
Eucampia cornuta	0	11	0	0	11	5	0	0	0	0	0	0	0
Oxytoxum variabile	16	16	11	14	14	5	0	0	0	5	0	5	0
Leptocylindrus danicus	55	5	6	0	44	11	0	0	0	0	0	0	0
Planktoniella sol	+	11	0	0	58	11	+	6	0	0	0	0	0
Prorocentrum micans	+	1	11	4	22	0	+	0	0	0	0	0	0
Mesoporus perforatus	0	0	27	22	2	0	0	0	0	0	0	0	0
Oxytoxum mediterraneum	11	5	0	11	19	3	0	0	0	0	0	0	0
Richelia intracellularis (colonies)	0	1	66	16	0	0	0	0	0	0	0	0	0
Nitzschia sp.	22	11	11	26	24	5	5	0	0	0	0	0	0
Flagellate Hasle, 1960	0	0	0	11	21	13	5	5	0	5	5	0	0
Coccolithus pelagicus	+	0	0	6	11	+	+	5	11	11	0	0	5
Tropidoneis sp.	0	0	0	22	11	+	+	0	0	0	0	0	0
Brachydinium capitatum	0	+	0	5	11	16	0	0	0	0	0	0	0
Climacodium frauenfeldianum	0	11	11	+	0	0	0	0	0	0	0	0	0
Dictyocha fibula	0	0	11	0	24	2	0	0	0	0	0	0	0
Erythropsis sp.	0	0	0	11	3	0	0	0	0	0	0	0	0
Lauderia annulcta	0	0	0	0	72	6	0	0	0	0	0	0	0
Ceratium minutum (+ kofoidi)	+	0	0	1	27	6	0	0	0	0	0	0	0
cells like Ankistrodesmus	1	+	0	11	50	0	0	0	0	0	0	0	0
Glenodinium sp.	22	9	0	16	0	0	0	0	0	0	0	0	0
Skeletonema costatum	0	0	9	55	16	0	0	0	0	0	0	0	0
Ceratium fusus	1	1	11	1	3	+	+	0	0	0	0	0	0
Dactyliosolen mediterraneus	0	11	0	5	0	11	1	0	+	0	0	0	0
Cryptomonas pseudobaltica	0	0	0	0	24	0	0	0	0	0	0	0	0
Rhizosolenia fragilissima	0	5	0	0	22	0	0	0	0	0	0	0	0
Pronoctiluca spinifera	11	11	11	0	0	0	+	0	0	0	0	0	0
Chaetocerus peruvianus	0	0	0	0	50	0	0	0	0	0	0	0	0
Pseudoeunotia doliolus	22	0	5	0	0	0	0	0	0	0	0	0	0
Gephyrocapsa sp.	0	0	0	11	0	0	0	0	0	0	+	6	0
Schroederella delicatula	0	0	44	11	0	0	0	0	0	0	0	0	0
Bacteriastrum sp.	0	0	0	0	15	0	0	0	0	0	0	0	0
Asterionella mediterranea	0	0	0	0	11	0	0	0	0	0	0	0	0
Gyrodinium spirale	+	+	+	11	+	+	0	0	0	0	0	0	0
Chaetoceros brevis	0	0	0	0	55	0	0	0	0	0	0	0	0
Chaetoceros atlanticus skeleton	0	0	0	0	77	60	0	0	0	0	0	0	0

Other species (lower abundances and frequencies): Amphidoma cf. nucula (Gonyaulax rouchi). Asteromphalus arachne, Blepharocysta splendormaris. Ceratium buceros. C. contrarium. C. extensum. C. falcatiforme, C. furca, C. macroceros. C. pentagonum. C. strictum. C. trichoceros. C. tripos. Chaetoceros coarctatus, Ch. danicus, Ch. decipiens. Ch. densus. Cladopyxis sp.. Cochlodinium brandti. Corethron criophilum, Coscinodiscus sp., Dinophysis doryphorum. D. rotundata. Diplopsalis asymmetrica, Ditylum brightwelli, Eucampia zoodiacus, Exuviaella compressa. Exuviaella sp.. Guinardia flaccida, Heterodinium sp.. Kofoidinium velelloides. Minuscula bipes. Navicula pennata. Oxytoxum scolopax, Peridinium depressum. P. divergens. P. globulus. P. oblongum. P. pentagonum. P. steinii. Peridinium sp., pl., Podolampas elegans, P. palmipes. P. spinifer. Oxytoxum curvatum. Pterosperma, sp., Pyrocystis sp., Pyrophacus steinii. Rhizosolenia alata. Rh. cylindrus. Rh. robusta. Stephanopyxis palmeriana, Streptotheca tamesis.

TABLE 4. — Cruise SAHARA II, Aug. Sept. 1971. — Averages of 3 stations (12, 12B, 34). Area *A* («upwelling»).

Cells per 100 ml at depth, m	0	5	10	20	30	50	75	100	150	200	300	400	500
Flagellates, small	11391	7942	8863	98o4	4o69	1954	81o	397	695	242	176	133	166
Dinoflagellates, small	3722	2310	3436	3177	2o12	1747	7o6	342	474	118	132	33	66
Thalassiosira sp. pl.	233	178	2o1	111	66	9688	1333	77	o	o	11	1	o
Rhizosolenia stolterfothii	2764	291	3218	2518	95	44	11	o	11	11	o	o	o
Coccolithus huxleyi	3476	2985	353o	3427	1563	1o69	122	132	99	88	77	83	33
Rhizosolenia delicatula	1255	1651	212o	1754	88	22	o	o	o	o	o	o	o
Nitzschia "delicatissima"	722	544	188	1188	121	22	1	o	o	11	o	o	o
Nitzschia "seriata"	598	721	899	631	154	22	o	o	o	o	o	o	o
Stauroneis membranacea	113o	216o	1664	1185	782	3	o	o	o	o	o	o	o
Chaetoceros brevis	966	5oo	433	22	35	33	o	o	o	o	o	o	o
Chaetoceros affinis	133	+	+	11	o	1	o	o	o	o	o	o	o
Chaetoceros curvisetus	o	15o	o	o	o	o	o	o	o	o	o	o	o
Chaetoceros didymus	o	11	137	o	o	o	o	o	o	o	o	o	o
Chaetoceros sp. pl.	555	165	255	77	44	o	o	o	o	o	o	o	o
Cryptomonas sp.	678	232	77	122	o	o	o	o	o	o	o	o	o
Phaeocystis sp.	o	o	533	352	88	o	o	o	o	o	o	o	o
Rhizosolenia fragilissima	5oo	255	299	465	11	o	o	o	o	o	o	o	o
Actinocyclus subtilis	148	72	188	188	125	21o	1o	5	8	11	13	2	2
Navicula cf. wawrikae	89	55	77	55	1oo	88	66	11	33	33	11	o	o
Nitzschia "closterium"	122	67	188	199	66	22	11	11	o	o	o	o	o
Thalassionema nitzschioides	122	121	33	55	11	33	22	22	11	22	o	o	16
Leptocylindrus danicus	187	111	388	144	o	o	o	o	o	o	o	o	o
Lauderia annulata (+ sp.?)	2oo	77	155	22	22	11	o	o	o	o	o	o	o
Rhizosolenia shrubsolei	45	69	178	11o	5	o	o	o	o	o	o	o	o
Eucampia cornuta	66	133	33	1oo	+	o	o	o	o	o	o	o	o
Streptotheca tamesis	33	o	3	166	+	11	+	o	o	o	o	o	o
Rhizosolenia sp.	o	1oo	1oo	2oo	22	o	o	o	o	o	o	o	o
Thalassiothrix longissima	68	+	44	44	11	o	o	o	o	o	o	o	o
Guinardia flaccida	77	4o	14	8	12	o	+	+	o	o	o	o	o
Asterionella mediterranea	1oo	33	o	o	o	o	o	o	o	o	o	o	o
Bacteriastrum sp.	o	o	22	3	2	o	o	o	o	o	o	o	o
Ditylum brightwelli	o	o	o	o	o	11	11	o	+	o	o	o	o
Gyrodinium fusiforme	1	11o	55	111	33	1oo	1	11	22	o	o	o	o
Coccolithus pelagicus	o	66	11	45	22	66	o	o	12	22	o	o	16
Rhizosolenia alata	24	25	24	23	o	o	o	o	o	o	o	o	o
Exuviaella baltica	39	11	11	1o	11	1o	o	o	o	o	o	o	o
Prorocentrum ovale	1o	11	66	1o	11	o	o	o	o	o	o	o	o
Peridinium cf. trochoideum	77	144	11	o	o	o	o	8	o	o	o	o	o
Oxytoxum variabile	22	44	+	55	22	11	1o	o	o	o	o	o	o
Helicosphaera sp.	o	22	o	77	55	o	o	o	o	o	o	o	o
Ceratium furca	o	1	3	22	2	2	1	1	o	o	o	o	o
Prorocentrum micans	34	4	1	34	11	o	o	o	o	o	o	o	o
Prorocentrum rostratum	o	11	1o	7	o	o	o	o	o	o	o	o	o
Diplopsalis asymmetrica	1	13	1	1	+	1	o	o	o	o	o	o	o
Gyrodinium spirale	+	o	1	+	11	2	11	2	o	o	o	o	o
Climacodium frauenfeldianum	2	o	34	1	o	o	o	o	o	o	o	o	o
Coscinodiscus sp.	11	34	1	1o	1	+	1	o	o	o	o	o	o
Cyclococcolithus sp.	o	22	11	o	o	o	22	o	o	o	11	33	o
Leucocryptos marina	o	o	o	22	+	44	11	o	o	o	o	o	o
Hemiaulus sp. pl.	33	11o	111	44	o	o	o	o	o	o	o	o	o
cells like Ankistrodesmus	88	11	22	13	o	o	o	o	o	o	o	o	o
Thalassiothrix frauenfeldii	o	o	66	o	o	o	o	o	o	o	o	o	o
Pseudoeunotia doliolus	o	o	66	o	o	o	o	o	o	o	o	o	o
Gephyrocapsa sp.	o	o	o	o	o	o	o	66	o	o	o	o	o
Syracosphaera sp.	o	o	o	o	o	o	o	o	o	11	22	o	o
Planktoniella sol	o	o	o	11	+	o	o	o	o	o	o	o	o

Other species, with lower abundances and frequencies: Asteromphalus arachne, Biddulphia alternans, B. mobiliensis, Brachydinium capitatum, Ceratium azoricum, C. buceros, C. contortum, C. contrarium, C. falcatum, C. fusus, C. horridum, C. macroceros, C. massiliense, C. minutum, C. trichoceros, C. tripos, C. vultur, Ceratocorys armata, Cochlodinium brandti, Chaetoceros densus, Ch. danicus, Ch. coarctatus, Ch. peruvianus, Ch. rostratus, Coscinodiscus radiatus, Dictyocha fibula, Dinophysis rotundata, D. sacculus, Ebria sp., Eutreptiella sp., Exuviaella compressa, Gonyaulax polygramma, G. spinifera, Heteraulacus polyedricus, Kofoidinium velelloides, Mesoporos adriatica, Navicula pennata, Noctiluca scintillans, Oscillatoria thiebautii, Oxytoxum mediterraneum, O. scolopax, Peridinium crassipes, P. depressum, P. diabolus, P. oceanicum, P. pellucidum, P. pentagonum, P. steinii, Podolampas bipes, P. palmipes, Polykrikos schwartzii, Pleurosigma sp., Porosira sp., Pronoctiluca sp., Oxytoxum curvatum, Pyrocystis sp., Rhizosolenia acuminata, Rh. calcaravis, Rh. bergoni, Rh. cylindrus, Rh. firma, Rh. robusta, Tropidoneis sp.

TABLE 5. — Cruise SAHARA II, Aug. Sept. 1971. — Averages of 7 stations (numbers 17, 18, 19, 20, 30, 31, 32). Area *S* («Southern»).

Cells per 100 ml at depth, m	0	5	10	20	30	50	75	100	150	200	300	400	500
Flagellates, small	1746	2oo7	169o	2oo1	827o	1671	57o	339	421	264	343	3o8	352
Dinoflagellates, small	2o64	21o1	2239	281o	6383	1481	357	2o7	146	192	86	92	41
Rhizosolenia stolterfothi	42	9	28	5	3472	56	2	+	+	o	o	o	o
Thalassiosira sp. pl.	o	o	9	o	2596	9	+	+	+	14	o	o	8
Solenicola setigera	213	+	127	+	292	61	o	o	o	o	o	o	o
Nitzschia "delicatissima"	5	14	37	22	715	60	19	5	o	9	o	o	o
Hemiaulus sp. pl.	188	274	297	292	66	66	o	o	o	o	o	o	o
Oscillatoria thiebautii (mm trichom)	44.1	38.9	59.5	59.3	7.3	11.9	3.7	o.2	o.2	o	o	o	o
Nitzschia "seriata"	o	o	o	o	237	19	14	o	9	o	o	o	o
Coccolithus huxleyi	116	51	33	66	113	18	3o	28	61	19	13	59	8
Nitzschia "closterium"	42	1o4	37	11	142	51	2	o	o	o	o	o	o
Gyrodinium fusiforme	19	33	33	11	219	14	9	5	1o	o	o	o	o
Oxytoxum variabile	14	28	37	27	137	19	5	o	o	o	o	o	o
Leucocryptos marina	14	28	23	5	38	23	5	o	9	5	o	6	o
Actinocyclus subtilis(incl.dead cells)	+	+	+	1	6	43	20	14	36	2o	2	9	+
Rhizosolenia fragilissima	5	5	37	5	23	28	o	o	o	o	o	o	o
Prorocentrum micans	11	6	1o	23	16	1o	1	+	o	o	o	o	o
cells like Ankistrodesmus	7	1	5	5	47	7	o	o	o	o	o	o	o
Navicula sp. pl., small	5	18	19	33	14	19	2	14	+	5	o	6	o
Chaetoceros sp. pl.	5	9	9	5	119	59	o	o	o	5	o	o	o
Prorocentrum ovale + obtusidens	o	14	o	99	38	23	o	o	o	o	o	o	o
Syracosphaera sp.	5	9	5	44	61	28	6	o	9	o	o	o	25
cells (blue greens or yeasts)	9	5	o	16	o	9	56	42	23	9	13	13	o
Dactyliosolen mediterraneus	23	+	9	+	38	o	o	o	o	o	o	o	o
Peridinium cf. trochoideum	14	14	9	11	14	5	5	o	o	o	o	o	o
Rhizosolenia alata	+	o	14	1	24	19	2	o	o	o	o	o	o
Exuviaella baltica	33	18	9	22	8o	9	o	o	o	5	o	o	o
Leptocylindrus danicus	23	5	28	o	o	5	o	o	o	o	o	o	o
Flagellate Hasle, 196o	5	o	5	5	33	5	o	o	o	o	o	o	o
Coccolithus pelagicus	14?	o	9	o	5	o	5	o	o	9	18	26	8
Thalassionema nitzschioides	o	o	+	o	9	28	5	o	o	o	o	o	o
Oxytoxum cf. mediterraneum	9	9	9	5	33	19	o	o	o	o	o	o	o
Ceratium fusus	5	6	3	3	17	2	o	o	o	o	o	o	o
Rhizosolenia delicatula	5	23	9	o	38	o	o	o	o	o	o	o	o
Prorocentrum rostratum	5	18	5	11	24	5	o	o	o	o	o	o	o
Dictyocha fibula	o	o	o	o	35	+	o	o	o	o	o	o	c
Cochlodinium brandti	o	5	9	2	15	+	+	o	o	o	o	o	o
Eucampia cornuta	o	o	o	o	49	7	o	o	o	o	o	o	o
Helicosphaera sp.	o	5	o	11	5	o	o	5	5	5	6	o	o
Amphidoma cf. nucula	o	o	o	+	89	o	+	o	o	o	o	o	o
Oxytoxum curvatum	o	o	o	o	14	9	o	o	o	o	o	o	o
Brachydinium capitatum	o	o	1	11	18	5	o	o	o	o	o	o	o
Glenodinium sp.	o	18	47	+	9	o	o	o	o	o	o	o	o
Calyptrosphaera sp.	14	5	14	5	9	9	o	5	5	o	o	o	o
Lauderia annulata ?	o	o	o	o	23	1	o	o	o	o	o	o	o
Mesoporus perforatus	5	o	5	6	5	28	o	o	o	o	o	o	o
Podolampas palmipes	+	+	1	2	+	+	o	o	o	o	o	o	o
Rhizosolenia calcaravis	o	o	o	11	5	+	o	o	o	o	o	o	o
Nitzschia sp.	9	5	14	11	14	9	o	o	o	o	o	o	o
Gyrodinium spirale	o	o	5	5	14	+	o	o	o	o	o	o	o
Chaetoceros affinis	o	o	o	o	+	19	+	o	o	o	o	o	o
Ceratium minutum (+kofoidii)	o	5	+	+	5	1	o	o	o	o	o	o	o
Cyclococcolithus sp.	o	o	o	o	o	9	5	o	9	o	6	o	8
Ceratium tripos	+	5	1	o	+	1	o	o	o	o	o	o	o
Ceratium trichoceros	+	+	+	+	o	+	o	o	o	o	o	o	o
Blepharocysta splendormaris	o	o	5	11	o	o	o	o	o	o	o	o	o

Other species, with lower abundances and frequencies: Amphidinium sp., Amphisolenia sp., Bacteriastrum sp., Cerataulina pelagica, Ceratium azoricum, C. buceros, C. contrarium, C. extensum, C. furca, C. gibberum, C. macroceros, C. massiliense. C. pentagonum, C. ranipes, C. strictum, Ceratocorys armata, Chaetoceros curvisetus, Ch. lorenzianus, Ch. peruvianus, Climacodium frauenfeldianum, Corethron criophilum, Coscinodiscus radiatus, Coscinodiscus sp., Cryptomonas pseudobaltica, Cyclotella sp., Dinophysis mitra, D. parvula, D. rotundata, Diplopsalis asymmetrica, Erythropsis sp., Eutreptiella sp., Exuviaella compressa, Gonyaulax digitale, G. spinifera, Guinardia flaccida, Gymnodinium sp. (large), Halosphaera sp., Heteraulacus polyedricus, Kofoidinium velelloides, Oxytoxum scolopax, Peridinium brochi, P. depressum, P. globulus, P. leonis, P. oblongum, P. oceanicum, P. oviforme, Planktoniella sol, Pleurosigma sp., Podolampas reticulata, P. spinifer, Pronoctiluca spinifera, Pseudoeunotia doliolus, Pyrocystis sp., Richelia intracellularis, Rhizosolenia bergoni, Rh. hebetata, Rh. robusta, Rh. shrubsolei, Stauroneis membranacea, Triposolenia bicornis, Tropidoneis sp.

TABLE 6. — Cruise SAHARA II, Aug. Sept. 1971. Averages of 3 stations (numbers 27, 28, 29). Area *T* («tropic»).

Cells per 100 ml at depth, m	0	5	10	20	30	50	75	100	150	200	300	400	500
Dinoflagellates, small	1371	1826	1793	2486	1837	845	319	187	176	165	276	148	44
Flagellates, small	1195	1356	1386	2112	165o	9o2	629	539	33o	353	32o	264	132
Rhizosolenia fragilissima	77	77	187	88	22	22	22	o	o	o	o	o	o
Nitzschia "delicatissima"	o	o	22	22	275	341	o	33	o	o	o	o	o
Oscillatoria thiebautii(mm trichom)	25.o	84.o	19.o	o	o.3	7.6	o	o	o	o	o	o	o
Solenicola setigera	11	o	27	165	o	o	o	o	o	o	o	o	o
Syracosphaera sp.	o	o	22	242	55	o	o	o	o	o	o	o	o
Coccolithus huxleyi	22	22	88	66	22	66	55	22	33	11	66	16	11
Rhizosolenia stolterfothii	11	o	o	o	11	154	1	o	o	o	o	o	o
Oxytoxum variabile	22	33	44	22	88	22	o	o	o	o	o	o	o
Prorocentrum ovale + dentatum +obtus.	o	o	11	187	44	11	o	o	o	o	o	o	o
Thalassiosira sp. pl.	11	44	+	o	23	22	o	o	o	o	o	o	1o
Nitzschia sp.	55	11	55	+	11	o	o	o	o	o	o	o	o
Prorocentrum micans	o	11	1	o	22	+	o	11	11	o	o	o	o
Ceratium fusus.	+	22	1	3	12	o	o	o	o	o	o	o	o
Cyclococcolithus sp.	o	o	11	o	22	o	o	o	22	11	33	o	o
Calyptrosphaera sp.	o	33	22	o	22	11	o	o	11	o	o	o	o
Gephyrocapsa sp.	o	22	o	o	o	o	o	o	o	o	11	16	22
Cochlodinium brandti	+	o	o	+	11	11	o	11	o	o	o	o	o
Exuviaella baltica	22	22	11	11	22	o	o	o	o	o	o	o	o
Prorocentrum rostratum	11	11	o	12	1	o	o	o	o	o	o	o	o
Peridinium cf. trochoideum	o	22	11	22	o	o	o	o	o	o	o	o	o
Helicosphaera sp.	o	o	22	o	o	1o	o	o	11	o	o	o	o
Gyrodinium fusiforme	11	11	33	33	1o	+	22	o	+	o	o	o	o
Navicula sp.	33	33	22	33	o	o	o	o	o	o	o	o	o
Hemiaulus sp.	o	35	11	65	o	o	o	o	o	o	o	o	o
Chaetoceros lorenzianus	o	22	o	o	o	44	o	o	o	o	o	o	o
Chaetoceros sp.	55	o	o	o	35	o	o	o	o	o	o	o	o
Nitzschia "seriata"	o	44	o	o	44	44	o	o	o	o	o	o	o
cells. like Ankistrodesmus	33	33	33	11	o	o	o	o	o	o	o	o	o
Leptocylindrus danicus	55	33	33	o	o	11	o	o	o	o	o	o	o
Rhizosolenia calcaravis	2	44	+	+	o	o	o	o	o	o	o	o	o
Oxytoxum mediterraneum	o	o	11	35	4o	o	o	o	o	o	o	o	o
Leucocryptos marina	11	o	o	o	11	o	22	21	o	11	o	o	o
Actinocyclus subtilis(incl.dead cells)	o	o	o	+	o	2	+	o	2	4	+	16	1
Dactyliosolen mediterraneus	11	o	2	11	o	1o	o	o	o	o	o	o	o
Nitzschia "closterium"	o	22	o	o	1o	o	o	o	o	o	o	o	o
Thalassionema nitzschioides	o	o	o	o	o	45	o	o	o	o	o	o	o
Rhizosolenia delicatula	o	o	o	o	o	32	o	o	o	o	o	o	o
Bacteriastrum sp.	o	1o	o	o	o	4	o	o	o	o	o	o	o
cells (bluegreens or yeasts)	o	44	11	66	33	o	o	33	33	11	55	115	33

Other species, with lower abundances and frequencies: Ceratium contrarium, C. furca, C. macroceros, C. macroceros gallicum, C. minutum, C. pentagonum, C. strictum, C. trichoceros, C. tripos, Cerataulina pelagica, Chaetoceros diversus, Ch. atlanticus skeleton, Ch. peruvianus, Climacodium frauenfeldianum, Cyclotella sp., Dictyocha fibula, D. octonaria, Dinophysis doryphorum, D. parvula, D. rotundata, Diplopsalis asymmetrica, Exuviaella compressa, Fragilaria sp., Gonyaulax polyedra, Guinardia flaccida, Gymnodinium splendens, Gyrodinium spirale, Halosphaera sp., Kofoidinium velelloides, Mesoporos perforata, Oxytoxum scolopax, Peridinium brochi, P. crassipes, P. globulus, Peridinium sp. pl., Podolampas palmipes, Pseudoeunotia doliolus, Pseudonoctiluca sp., Pterosperma sp., Pyrophacus steinii, Richelia intracellularis, Rhizosolenia alata, Rh. firma, Rh. hebetata, Schroederella delicatula, Skeletonema costatum, Streptotheca tamesis, Thalassiothrix longissima.

TABLE 7. — Cruise ATLOR II, March 1973. Averages of 8 stations (numbers 31, 35, 39, 40, 41, 42, 43, 47). Area *O* («offshore»).

Cells per 100 ml at depth, m	0	10	20	30	40	50	75	100
Dinoflagellatae, small	1630	1842	1863	1018	663	221	165	94
Flagellates, small	1549	1734	1576	944	58o	396	294	231
Coccolithus huxleyi	1617	1291	1344	648	538	388	286	158
Cryptomonas cf. pseudobaltica	912	708	389	44	5	o	o	o
Nitzschia "delicatissima"	419	721	67o	235	3o1	11o	33	11
Thalassiosira sp. pl., small	453	324	346	152	151	1o3	61	11
Chaetoceros sp. pl., small	299	263	118	12o	o	5	5	o
Cyclococcolithus sp.	195	218	144	137	132	149	135	61
Calyptrosphaera sp.	145	128	45	121	1o4	37	64	66
Nitzschia "seriata"	87	143	240	12	61	5	o	o
Rhizosolenia alata	57	66	1oo	46	125	62	+	6
Rhizosolenia shrubsolei	37	29	1o8	33	33	9	5	+
Gymnodinium rete ?	292	2o1	125	9	o	o	o	o
Peridinium cf. trochoideum	25	71	46	19	19	14	o	5
Rhizosolenia stolterfothii	66	71	42	9	5	o	o	o
Thalassiothrix longissima	8	58	77	9	24	5	14	11
Helicosphaera sp.	25	4	8	12	9	28	9	16
Coccolithus pelagicus	25	o	4	8	14	19	14	o
Exuviaella baltica	49	14	58	12	9	14	o	o
Brachydinium capitatum	48	76	91	+	5	+	o	o
Gyrodinium fusiforme	51	31	33	8	9	1	+	o
Syracosphaera sp. pl.	17	33	32	12	24	14	73	16
Rhizosolenia delicatula	57	37	25	8	5	14	o	o
Amphora hyalina	29	37	17	57	61	28	9	5
Prorocentrum ovale + obtusidens . . .	54	23	17	12	9	9	o	o
Navicula wawrikae ?	64	95	79	16	63	+	9	o
Nitzschia closterium (+ recta) . . .	33	37	12	25	5	9	o	o
Planktoniella sol	17	28	28	13	43	15	1	1
Prorocentrum rostratum	35	22	33	o	5	o	o	o
Rhizosolenia fragilissima	17	13	12	4	o	o	o	o
Asterionella mediterranea	o	33	33	o	5	o	o	o
Schroederella delicatula	25	37	16	o	o	5	o	o
Eucampia cornuta (+ zoodiacus). . . .	75	25	8	o	19	o	o	o
Cochlodinium brandti, and other sp.	4	8	8	8	14	o	2	o
Mesoporos perforatus	16	21	o	5	1	+	o	o
Bacteriastrum sp.	4	12	52	o	o	5	o	o
Actinocyclus subtilis	+	4	1	7	2	2	+	+
Oxytoxum curvatum	17	1	8	5	+	o	o	o
Oxytoxum scolopax	1	1	23	+	+	o	o	o
Tropidoneis sp.	6	1	1	+	5	2	+	o
Diplopsalis asymmetrica	8	1	1	+	1	o	+	o
Hemiaulus sp.	25	+	12	o	o	o	o	o
Ceratium furca	5	11	1	1	1	+	o	o
Ceratium fusus	2	15	7	11	1	+	+	o
Ceratium minutum + kofoidii	1	8	6	+	1	o	o	o
Leucocryptos marina	8	o	12	o	o	o	o	o
Solenicola setigera	o	145	o	o	o	o	o	o
Thalassiosira partheneia	o	1o5	o	o	o	o	o	o
Cerataulina pelagica	4	4	4	o	5	o	o	o
Amphisolenia globifera	4	+	+	+	o	o	o	o
Guinardia flaccida	+	o	+	+	+	o	+	o

Other species, with lower abundances and frequencies: Acanthoica sp., Asteromphalus arachne, Biddulphia alternans, Ceratium azoricum, C. buceros, C. extensum, C. falcatum, C. macroceros gallicum, C. massiliense, C. trichoceros, Chaetoceros danicus, C. decipiens, Ch. peruvianus, Climacodium frauenfeldianum, Coscinodiscus sp., Detonula sp., Dactyliosolen mediterraneus, Dinophysis caudata, D. sacculus, D. tripos, Erythropsis sp., Exuviaella compressa, E. vaginula, Gonyaulax diacantha, G. digitale, G. fragilis, G. monacantha, G. polygramma, G. spinifera, Gymnaster pentasterias, Gymnodinium sp., large, Gyrodinium spirale, Halosphaera sp., Heteraulacus polyedricus, Oscillatoria thiebautii, Oxytoxum constrictum, O. mediterraneum, O. variabile, Peridinium brochi, P. crassipes, P. depressum, P. diabolus, P. globulus, P. inflatum, P. mite, P. oblongum, P. oceanicum, P. oviforme, P. pellucidum, P. steinii, P. sphaericum, Podolampas bipes, P. palmipes, P. spinifer, Pomatodinium sp., Prorocentrum triestinum, Pseudoeunotia doliolus, Pterosperma sp., Pyrocystis sp., Pyrophacus steinii, Thalassiosira rotula, Torodinium robustum.

TABLE 8. — Cruise ATLOR II, March 1973. Averages of 3 stations (numbers 14, 19, 44). Area N («Northern»).

Cells per 100 ml at depth, m	0	10	20	30	40	50	75	100
Nitzschia "delicatissima"	10750	13500	14800	1850	0	66	33	0
Nitzschia "seriata"	2120	5420	6200	65	2	100	0	0
Chaetoceros sp. pl.	2200	1630	3100	286	100	33	33	0
Flagellatae, small	2320	1520	3000	1996	65	600	400	366
Dinoflagellates, small	2510	1330	2100	1630	66	230	100	198
Thalassiosira sp. pl.	430	1060	1300	387	65	100	300	0
Coccolithus huxleyi	465	330	600	819	100	130	66	245
Navicula cf. wawrikae	0	600	1000	942	0	0	0	0
Solenicola setigera	0	0	2500	530	0	0	0	0
Amphora hyalina	5	330	400	33	0	1	0	0
Rhizosolenia fragilissima	0	200	300	153	0	0	0	0
Thalassiothrix longissima	0	335	400	133	0	0	0	0
Chaetoceros socialis	0	800	+	67	0	0	0	0
Asterionella mediterranea	65	132	200	1	0	0	0	0
Rhizosolenia alata	133	200	150	23	0	0	0	0
Rhizosolenia stolterfothii	200	200	+	121	0	0	0	0
Eucampia cornuta (+ zoodiacus)	0	330	100	0	0	0	0	0
Rhizosolenia shrubsolei	133	330	0	109	+	0	0	0
Gyrodinium fusiforme	50	52	150	23	33	0	0	0
Calyptrosphaera sp.	0	0	0	640	0	0	0	0
Cyclococcolithus sp.	0	0	0	177	0	0	0	0
Brachydinium capitatum	1	0	2	156	0	0	0	0
Lauderia annulata	200	132	0	0	0	0	0	0
Coscinodiscus sp.	65	200	+	11	0	0	0	0
Peridinium cf. trochoideum	65	65	0	80	0	0	0	0
Exuviaella baltica	66	65	0	0	0	0	0	0
Diplopsalis asymmetrica	33	1	1	0	0	0	0	0
Planktoniella sol	1	3	0	22	0	0	0	0
Torodinium robustum	0	0	50	22	0	0	0	0
Cerataulina pelagica	0	0	0	22	30	0	0	0
Prorocentrum rostratum	3	1	1	33	0	0	0	0
Ceratium fusus	9	0	0	12	0	0	0	0
Dinophysis tripos	65	2	0	0	0	0	0	0
Leucocryptos marina	66	0	0	0	0	0	0	0
Chaetoceros decipiens	0	0	0	0	100	0	0	0
Guinardia flaccida	0	0	0	44	0	0	0	0
Tropidoneis sp.	0	45	0	0	0	0	0	0
Cochlodinium brandti	0	2	0	22	0	0	0	0
Rhizosolenia cylindrus	25	0	0	0	0	0	0	0
Helicosphaera sp.	0	0	0	22	+	0	0	0
Mesoporos perforata	0	0	0	22	0	0	0	0
Rhizosolenia delicatula	0	0	0	22	0	0	0	0
Exuviaella compressa	3	0	0	11	0	0	0	0
Thalassionema nitzschioides	0	0	0	20	0	0	0	0
Prorocentrum ovale	0	0	0	22	0	0	0	0

Other species, less abundant and less frequent: Acanthoica sp., Achnanthes sp., Actinocyclus subtilis, Actinoptychus heptactis, Asteromphalus arachne, Ceratium azoricum, C. extensum, C. furca, C. lunula, C. massiliense, C. tripos, C. falcatum, C. minutum, Chaetoceros atlanticus, Ch. concavicornis, Ch. coarctatus, Ch. danicus, Ch. lauderi, Ch. peruvianus, Dinophysis parvula, D. rotundata, Gonyaulax spinifera, Gyrodinium spirale, Leptocylindrus danicus, Navicula sp., Nitzschia closterium, Noctiluca scintillans, Oscillatoria thiebautii, Oxytoxum constrictum, O. curvatum, O. scolopax, Peridinium brochi, P. crassipes, P. marielebourae, P. oceanicum, P. pentagonum, P. steinii, Podolampas palmipes, P. spinifer, Pronoctiluca spinifera, Prorocentrum gracile, P. micans, Rhizosolenia acuminata, Rh. hebetata, Stauroneis membranacea, Syracosphaera sp., Thalassiosira rotula.

TABLE 9. — Cruise ATLOR II, March 1973. Averages of 4 stations (numbers 11, 12, 13, 34). Area *A* («main upwelling»).

Cells per 100 ml at depth, m	0	10	20	30	40	50	75	100
Thalassiosira partheneia (+ sp?) . .	22565	12952	188oo	15367	31191	375o	3188	111
Phaeocystis sp.	3400	+	4oo	353	+	2133	5187	12o
Flagellates, small	3122	3oo2	3425	1243	2956	128o	1532	33o
Dinoflagellates, small	3ooo	3876	262o	2276	2833	1696	1o98	233
Chaetoceros sp. pl.*.	2749	135o	5o6	777	47o	233	34	33
Coccolithus huxleyi	865	1291	158	122	849	376	415	1oo
Nitzschia "delicatissima"	165	741	3oo	77	416	111	58	22
Nitzschia "seriata"	666	341	325	166	1o8	33	17	o
Cryptomonas cf. pseudobaltica	55o	5o	+	66	141	66	25	o
Nitzschia "closterium" (+ recta). . .	15o	2oo	15o	241	66	55	33	11
Thalassiosira sp.	1oo	133	25	111	94	144	25	25
Rhizosolenia stolterfothii	15o	15o	25	3	216	11	8	21
Syracosphaera sp.	25o	25o	75	+	217	34	58	o
Rhizosolenia delicatula	66	15o	5o	22	1oo	11	o	o
Thalassionema nitzschioides	57	o	7	167	25	o	25	11
Thalassiothrix longissima	5o	33	17	o	o	o	17	1
Skeletonema costatum	125	+	o	o	75	o	o	o
Gyrodinium fusiforme	75	5o	25	44	33	144	25	11
Cyclococcolithus fragilis + leptoporus	25	183	+	55	17	22	25	33
Actinocyclus subtilis	158	1	1	12	42	+	+	5
Oxytoxum longum	17	66	33	11	o	22	o	o
Oxytoxum variabile	8	8	17	11	75	33	o	o
Lauderia annulata (+ borealis ?). . .	16	25	o	o	5o	66	o	o
Guinardia flaccida	17	25	4o	11	+	1	1	1
Peridinium cf. trochoideum	17	88	8	o	o	1o	o	1o
Nitzschia sp.	33	17	o	o	8	22	33	o
Prorocentrum ovale + obtusidens . . .	35	32	8	o	o	o	o	o
Planktoniella sol	1	17	1	12	+	+	o	o
Hemiaulus sp.	o	o	5o	o	o	1oo	o	o
Schroederella delicatula	o	o	5o	65	o	o	o	o
Coscinodiscus cf. alborani	1	o	1	1	2	11	1	1o
Leucocryptos marina	17	o	o	33	17	o	o	o
Exuviaella baltica	8	5o	o	o	+	o	o	1o
Diplopsalis asymmetrica	+	9	o	34	16	1	o	o
Tropidoneis sp.	+	1o	+	21	17	1	o	o
Ceratium furca	2	51	1	o	+	o	o	o
Ceratium fusus	1o	1	2	1o	1o	1	o	o
Flagellate, Hasle, 196o	o	8	17	22	o	o	o	o
Rhizosolenia shrubsolei	25	o	8	11	1o	33	8	o
Rhizosolenia alata	+	25	o	+	+	o	+	o
Ditylum brightwelli	o	8	+	33	+	+	o	+
Pseudoeunotia doliolus.	8	17	o	+	o	5	+	o
Helicosphaera sp.	12	o	o	33	o	1o	8	o
Streptotheca tamesis	o	o	17	1	1	o	o	o
Stephanopyxis palmeriana	o	1	2	2	o	o	o	o
Asterionella mediterranea	8	8	1	o	+	o	o	o
Eucampia cornuta	o	o	25	+	o	o	o	o
Stauroneis membranacea	16	o	3	o	o	o	o	o
Brachydinium capitatum	8	o	+	+	o	o	o	o
Oxytoxum mediterraneum	17	o	o	1o	o	o	o	o
Calyptrosphaera sp.	+	1o8	o	o	o	o	o	o
Prorocentrum rostratum	o	17	o	+	o	o	o	o
Coccolithus pelagicus	o	33	o	o	o	o	o	o
Cochlodinium sp.	o	o	16	o	o	o	o	o
Rhizosolenia hebetata	25	o	o	o	o	o	o	o
Asterionella glacialis.	o	o	o	o	8	o	o	o

*includes affinis, compressus, curvisetus, decipiens, didymus, among others

Other species, less abundant and less frequent: Asteromphalus heptactis, Bacteriastrum sp., Ceratium azoricum, C. buceros, C. contrarium, C. falcatum, C. minutum, C. tripos, Chaetoceros atlanticus, Ch. densus, Ch. lauderi, Ch. peruvianus, Ch. rostratus, Climacodium frauenfeldianum, Detonula sp., Dinophysis caudata, D. rotundata, D. tripos, Dictyocha fibula, Distephanus speculum, Exuviaella compressa, Eutreptiella sp., Fragilaria sp., Gephyrocapsa sp., Gonyaulax polygramma, Gymnodinium splendens, Gyrodinium spirale, Heteraulacus polyedricus, Leptocylindrus danicus, Navicula sp., N. wawrikae, Oscillatoria thiebautii, Oxytoxum milneri, O. scolopax, O. sp., Peridinium brochi, P. conicum, P. crassipes, P. depressum, P. divergens, P. excentricum, P. globulus, P. oblongum, P. oceanicum, P. pallidum, P. steinii, Podolampas bipes, P. palmipes, P. spinifer, Pseudophalacroma nasutum, Prorocentrum scutellum, Pterosperma sp., Rhizosolenia imbricata, Rh. robusta, Rh. setigera, Torodinium robustum.

TABLE 10. — Cruise ATLOR II, March 1973. Ave
46). Area *a* («seasonal or secondary upwelling»).rages of 6 stations (numbers 15, 16, 17, 29, 45,

Cells per 100 ml at depth, m	0	10	20	30	40	50	75	100
Rhizosolenia hebetata semispina	540	5057	5690	8665	11750	4540	+	67
Thalassiosira sp. pl.	653	1315	3405	7588	872	586	1	60
Flagellatae, small	2536	4585	4022	5018	2240	919	222	284
Nitzschia "delicatissima"	2379	2582	2373	1005	320	367	22	7
Dinoflagellates, small	2116	1965	1906	1442	1252	465	121	126
Coccolithus huxleyi	2207	1545	2490	990	539	393	166	73
Chaetoceros sp. pl. *	413	1962	7424	3882	2910	819	2	33
Amphora hyalina	1683	975	2300	713	240	126	+	13
Nitzschia "seriata"	340	972	1290	1138	1500	346	0	20
Calyptrosphaera sp.	424	673	1026	393	126	40	22	33
Syracosphaera sp.	672	381	920	260	153	13	11	0
Rhizosolenia delicatula	146	1688	1360	1350	1380	313	0	1
Asterionella glacialis	60	266	400	466	520	287	0	33
Thalassiosira rotula	13	511	800	433	800	600	0	26
Chaetoceros socialis + radians	0	66	180	766	1280	0	0	0
Chaetoceros compressus	0	0	48	1433	240	86	0	0
Nitzschia closterium (+ recta)	393	744	227	116	113	33	0	13
Rhizosolenia stolterfothii	132	161	394	272	406	173	0	1
Thalassionema nitzschioides	13	244	146	116	133	184	0	40
Ditylum brightwelli	12	77	200	39	140	44	0	7
Skeletonema costatum	20	22	280	66	120	0	0	0
Peridinium cf. trochoideum	99	322	187	33	60	13	0	12
Cryptomonas cf. pseudobaltica	140	232	133	116	20	0	0	0
Gyrodinium fusiforme	20	61	93	33	73	40	22	+
Rhizosolenia shrubsolei	1	57	6	+	120	13	+	+
Helicosphaera sp.	65	50	20	27	33	6	21	13
Lauderia annulata	20	83	20	0	13	66	0	0
Torodinium robustum	26	44	13	33	0	0	0	0
Eucampia cornuta (+ zoodiccus)	0	65	153	16	0	20	11	0
Stephanopyxis palmeriana + turris	0	66	1	0	83	0	0	0
Hemiaulus indicus (+ sp.)	13	0	40	16	80	80	0	0
Rhizosolenia fragilissima	0	53	50	+	+	20	0	0
Coccolithus pelagicus	20	0	26	5	13	46	0	13
Dictyocha fibula	1	1	7	50	20	20	0	0
Distephanus speculum	7	0	0	16	40	7	0	0
Prorocentrum triestinum	13	22	40	39	0	0	0	0
Exuviaella baltica	60	33	7	0	6	0	0	0
Thalassiothrix longissima	20	33	26	0	0	0	0	0
Actinocyclus subtilis	60	50	40	+	+	7	1	1
Diplopsalis asymmetrica	+	11	1	1	1	40	+	+
Peridinium steinii	20	28	1	16	0	0	0	0
Coscinodiscus sp.	0	6	+	+	1	+	0	0
Planktoniella sol	27	0	+	0	0	+	+	0
Stauroneis membranacea	0	0	0	66	4	0	0	0
Streptotheca tamesis	0	1	+	66	1	40	0	0
Mesoporos perforatus	0	44	+	5	7	0	0	0
Pseudoeunotia doliolus	0	16	40	16	0	0	+	0
Asteromphalus arachne	0	5	52	1	0	0	0	0
Cyclococcolithus sp.	7	0	6	5	+	+	0	0
Peridinium diabolus	0	+	1	16	1	0	0	0
Chaetoceros peruvianus	0	0	1	+	7	7	0	0
Ceratium furca	2	2	3	1	1	1	0	0
Ceratium fusus	+	+	1	+	7	+	0	0
Eutreptiella sp.	7	5	0	0	0	0	0	0
Prorocentrum rostratum	0	13	0	0	0	0	0	+
Rhizosolenia cylindrus	0	35	0	0	0	0	0	0
Prorocentrum obtsidens+ovale+dentatum	40	33	533	16	14	0	0	0

Other species, less abundant and less frequent: Achnanthes sp., Asteromphalus heptactis, Bacteriastrum sp., Biddulphia mobiliensis, Ceratium falcatiforme, minutum, tripos, Chaetoceros lorenzianus, Ch. atlanticus, Ch. rostratus, Climacodium frauenfeldianum, Cochlodinium brandti, Detonula sp., Dinophysis caudata, D. sacculus, D. tripos, Gephyrocapsa sp., Gonyaulax digitale, G. monacantha, Guinardia flaccida, Gymnaster pentasterias, Gymnodium splendens, Gyrodinium spirale, Heteraulacus polyedricus, Navicula sp., Noctiluca scintillans, Oxytoxum mediterraneum, O. scolopax, Peridinium brochi, P. claudicans, P. conicum, P. depressum, P. divergens, P. pellucidum, P. pentagonum, Paralia sulcata, Podolampas spinifer, Pronoctiluca spinifera, Prorocentrum micans, P. scutellum, Pleurosigma sp., Pseudophalacroma nasutum, Pyrophacus steinii, Rhizosolenia alata, Rh. robusta, Rh. setigera.

TABLE 11.—Cruise ATLOR II, March 1973. Single station 33. Area *C* («cryptomonads»).

Cells per 100 ml at depth, m	0	10	20	30	40	75	100
Cryptomonas cf. pseudobaltica	9ooo	35o	1oo	1oo	33	2oo	1oo
Flagellatae, small	26oo	12oo	6oo	1166	8oo	5oo	4oo
Dinoflagellates, small	12oo	1235	1735	14oo	1o66	266	2oo
Mesodinium (ciliate)	153o	36o	3oo	33	33	o	o
Oscillatoria thiebautii (mm trichom)	28.2	o	o	o	o	o	o
Exuviaella baltica	6oo	126o	733	165	1oo	29	1oo
Thalassiosira sp.	533	36	133	9oo	1566	233	1oo
Peridinium cf. trochoideum	233	1oo	266	66	o	o	o
Coccolithus huxleyi	1oo	136	66	233	766	2oo	166
Calyptrosphaera cf. brandti	266	13o	33	166	33	33	o
Gyrodinium fusiforme	66	133	33	63	2oo	33	o
Rhizosolenia alata	o	33	2oo	2oo	133	33	o
Nitzschia "delicatissima"	o	33	633	53o	66	o	o
Holicosphaera sp.	66	233	o	133	2oo	66	66
Coccolithus pelagicus	33	o	66	133	33	33	33
Prorocentrum ovale	133	33	1oo	33	66	o	o
Guinardia flaccida	o	o	1	3o	3o	33	1
Actinocyclus subtilis	o	o	66	+	2oo	5	1
Syracosphaera sp.	o	1oo	33	33	o	33	1oo
Thalassiothrix longissima	o	o	66	33	33	o	o
Cyclococcolithus sp.	o	o	33	o	33	+	33
Climacodium frauenfeldianum	o	5	5	1oo	o	o	o
Amphora hyalina	o	o	33	33	33	o	o
Cerataulina pelagica	o	o	66	o	33	o	o
Rhizosolenia shrubsolei	o	o	o	66	33	o	o
Pyrophacus steinii	o	1	o	1	o	o	1
Ceratium furca	4	o	o	o	1	o	o
Nitzschia sp.	o	o	o	o	133	o	o
Rhizosolenia stolterfothii	o	o	o	o	1oo	o	o
Chaetoceros densus	o	o	o	o	1oo	o	o
Oxytoxum variabile	o	o	o	o	66	o	c
Rhizosolenia fragilissima	o	o	o	33	σ	o	o

Other species, less abundant: Asteromphalus heptactis, Ceratium falcatum, C. fusus, C. massiliense, Ceratocorys armata, Cochlodinium sp., Dinophysis tripos, Diplopsalis asymmetrica, Exuviaella vaginula, Fragilaria sp., Gonyaulax sp., Navicula sp., Nitzschia «seriata», Peridinium steinii, Planktoniella sol, Prorocentrum sp., Rhizosolenia acuminata, Rh. hebetata, Thalassionema nitzschioides, Tropidoneis sp.

TABLE 12. — Cruise ATLOR II, March 1973. Averages of 5 stations (numbers 18, 27, 28, 32, 38). Area *S* («Southern»).

Cells per 100 ml at depth, m	0	10	20	30	40	50	75	100
Flagellates, small	1310	1829	1462	597	746	263	231	21o
Dinoflagellates, small	1431	145o	1o38	717	524	244	133	66
Coccolithus huxleyi	338	472	1937	241	154	122	133	88
Amphora hyalina	474	1o58	773	41	66	44	22	o
Thalassiosira sp. pl., mostly small	2o5	259	24o	263	225	88	33	13
Chaetoceros sp. pl., mostly small	288	223	34	66	22o	44	22	o
Nitzschia "delicatissima"	3o4	116o	474	352	288	44	22	o
Exuviaella baltica	23o	112	65	58	33	11	o	o
Calyptrosphaera sp.	33	73	42o	2o	o	o	o	o
Rhizosolenia stolterfothii	58	53	6o	132	88	11	11	o
Nitzschia "seriata"	8	165	73	91	33	o	o	o
Asterionella mediterranea	1	53	416	16	11	o	o	o
Navicula cf. wawrikae	57	132	2o	91	32	o	o	o
Stauroneis membranacea	22	95	62	58	1	o	o	o
Helicosphaera sp.	25	7	53	17	55	33	11	o
Syracosphaera sp.	140	+	53	33	22	o	+	o
Cyclococcolithus sp.	8	7	7	17	66	22	22	22
Chaetoceros sp., very small	17	182	13	o	22	o	o	o
Thalassiothrix longissima	8	93	12	17	o	22	+	o
Rhizosolenia delicatula	8	26	+	17	33	22	o	o
Thalassionema nitzschioides	16	13	7	16	o	11	+	+
Guinardia flaccida	9	7	13	1o	11	+	11	o
Actinocyclus subtilis	+	25	+	8	33	33	2	1
Planktoniella sol	33	14	7	1	5	13	1	o
Rhizosolenia shrubsolei	8	2	53	17	11	33	o	o
Gyrodinium fusiforme	9	66	13	o	33	+	11	o
Prorocentrum ovale (+ other sp.)	25	33	6o	25	11	o	o	o
Peridinium cf. trochoideum	8	13	+	33	22	22	o	11
Ceratium furca	11	5	1o	3	11	+	o	o
Ceratium fusus	2	1	+	+	o	+	1	o
Chaetoceros peruvianus	17	o	+	8	22	o	o	o
Chaetoceros coarctatus	8	o	7	8	33	o	o	o
Rhizosolenia sp.	o	7	7	8	+	1	+	o
Rhizosolenia hebetata	1	o	o	o	+	22	2o	o
Climacodium frauenfeldianum	25	13	+	1	o	o	o	o
Rhizosolenia fragilissima	8	6	o	o	11	22	o	o
Rhizosolenia alata	o	+	o	8	o	+	o	+
Eucampia cornuta	8	13	o	o	o	o	o	o
Peridinium steinii	17	14	1	o	o	+	o	o
Asteromphalus arachne	1	o	o	1	+	+	o	o
Tropidoneis sp.	+	13	+	9	1	o	o	o
Coccolithus pelagicus	o	13	7	o	o	11	o	11
Cochlodinium brandti	o	4o	7	o	o	o	o	o
Leucocryptos marina	o	o	o	o	11	11	o	o
Coscinodiscus alborani ?	o	7	+	17	o	o	o	o
Lauderia annulata	8	o	2o	o	o	o	o	o
Dictyocha fibula	o	o	7	8	o	+	o	o
Oxytoxum variabile	o	o	7	o	11	o	o	o
Cerataulina pelagica	1	o	7	o	o	o	o	o
Ceratium kofoidii	o	o	+	o	11	o	o	o
Prorocentrum rostratum	o	+	o	17	o	o	o	o
Gephyrocapsa oceanica	o	o	o	o	11	o	o	o
Bacteriastrum sp.	o	o	o	17	o	o	o	o

Other species, with lower abundances and lower frequencies: Amphidoma cf. nucula, cells like Ankistrodesmus, Asteromphalus heptactis, Ceratium candelabrum, C. falcatum, C. horridum, C. massiliense, C. trichoceros, C. tripos, Chaetoceros atlanticus, Ch. brevis, Ch. decipiens, Ch. pseudobrevis, Coscinodiscus oculusiridis, C. sp., Dinophysis sacculus, D. tripos, Diplopsalis asymmetrica, Erythropsis sp., Exuviaella compressa, E. vaginula, Fragilaria sp., Gonyaulax diegensis, G. fragilis, G. polyedra, G. spinifera, Heteraulacus polyedricus, Leptocylindrus danicus, Navicula sp., Nitzschia sp., Oxytoxum mediterraneum, Peridinium brochi, P. diabolus, P. divergens, P. excentricum, P. inflatum, P. globulus, P. oceanicum, P. oviforme, Pleurosigma sp., Podolampas palmipes, Prorocentrum triestinum, Prorocentrum sp., Rhizosolenia robusta, Rh. styliformis, Rh. sp., Scaphodinium mirabile.