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Microplankton species assemblages at the Scripps pier from March to November 1983 during the 1982-1984 El Niño event.

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(NASA-CR-175553) MICROPLANKTON SPECIES ASSEMBLAGES AT THE SCRIPPS PIER FROM MARCH TO NOVEMBER 1983 DURING THE 1982-1984 EL NINO EVENT (Scripps Institution of Oceanography, La Jolla) 29 p HC A03/MF A01 G3/51
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Introduction

Recent microplankton studies in the Southern California Bight have included consideration of vertical distribution (Beers et al., 1980), chlorophyll maximum and surface studies (Cullen et al., 1982), spatial patterns (Reid et al., 1978; Eppley et al., 1984a, 1984b), chlorophyll maximum mechanics (Cullen and Eppley, 1981), and estimations of carbon biomass (e.g., Reid et al., 1970). Prior to this, the main body of work on microplankton, especially phytoplankton, was by Allen and associates in the 1920s to 1940s, when daily quantitative sampling of near-surface water was carried out at the end of the Scripps Institution of Oceanography pier. This resulted in a large amount of data on dinoflagellates and diatoms, published in many papers by Allen and others. Allen (1928, 1936, 1940, 1941) summarized from 5 to 20 years of data producing useful "baseline" information for the organisms included in his survey. Sverdrup and Allen (1939) and Sargent and Walker (1948) related the distribution of diatoms to water masses and currents off Southern California. Modern computer analyses are currently being applied to this data by D. Goodman and S. Tont. The 20-year fluctuations in the abundance of diatoms on the California coast have been considered in Tont (1976) and Tont and Platt (1979). Balech (1960) compared the species composition at the Scripps pier during a "warm" period (1957-1958) with that of a "cold" period (1938-1939), using Allen's samples for the latter.

The occurrence of the El Niño event beginning in late 1982 (McGowan, 1984) in the northeast Pacific was the impetus for the initiation of a semiweekly pier sampling program by the Marine Life Research Group

(MLRG) of Scripps Institution of Oceanography (SIO). This paper is based on data collected from March to November 1983, but the pier program is continuing to the present. The following questions were posed: What was the general taxonomic structure of the microplankton at the pier during 1983? Did the samples cluster into assemblages of species; if so, what were the patterns? Does the pier phytoplankton reasonably represent that seen offshore? Was the pattern affected by the increase in water temperature caused by the El Niño condition?

Methods

From the beginning of 1983, water samples and net concentrated samples have been collected every 3-4 days at the SIO pier, usually at mid-morning. For the net samples, approximately 20 litres (occasionally 40 litres) were siphoned from the centre of the water mass in the flume located at the seaward end of the SIO pier. The flume water is pumped from a depth which depends on the state of the tide but is roughly 4.5 m. Water depth at the end of the pier was estimated to average 6 m. The sample was collected in a carboy prior to filtration through a small conical screen of 24µ-mesh which was immersed in a perforated bucket of water to reduce pressure on the contained organisms. A jar was inverted on the screen and the sample rinsed into the jar with 200 ml of filtered sea water. The sample was preserved with 12.5 ml of sodium borate-buffered formalin. An unconcentrated sample for plankton and chlorophyll determination was collected in a 1.3 l Nansen bottle at a depth of from 1 to 1.5 m. Surface temperature and wind speed were measured, and wave height and water transparency were estimated. Chlorophyll was determined fluorometrically as described by Venrick and Hayward (1984).

For this report the net-sample microplankton data are considered. Subsamples were examined in a Sedgewick-Rafter chamber for species identification and enumeration of cells. *Bacteriastrum* spp., *Chaetoceros* spp., *Skeletonema costatum* and *Planktoniella muriformis* were counted as chains or colonies. Counting was done at 150x magnification in strips delineated by an ocular grid until at least 200 cells had been seen. The entire slide was scanned for rare species. The data considered here extend from March 1983 to November 1983 (samples 59-779), since during that time the microplankton net-samples were enumerated by a single person (M.W.).

Whittaker's (1952) percent similarity index was used to compare samples and subsequently a dendrogram was constructed to show clusters of samples (groups 1 through 7) with similar species assemblages, using the method of weighted pair groups of Sokal and Sneath (1963) (Figure 1).

During the period under consideration there were monthly cruises by the California Cooperative Fisheries Investigations (CalCOFI) in the Southern California Bight (CalCOFI line 90, cruises 8304-WE, 8305-EB, 8306-EB, 8308-EB, 8309-EB, 8310-EB, 8311-EB, 8312-NH) during which surface samples were collected for microplankton analysis. They were filtered and treated as above. Chlorophyll determinations were made on separate samples. Microplankton data are compared with those from the pier.

Results

Figure 1 shows the dendrogram of the PSI between samples. Seven groups (1,2,3,4,5,6,7) and six subgroups (4A,4B, 5A,5B,7A,7B) were subjectively determined. Within each group the samples were basically arranged chronologically. Five samples did not fall into these groups (numbers 59, 229, 359, 649 and 779). Major groupings can be associated with particular species assemblages (Figure 2), and compared with the records of temperature (Figures 3 and 4) and chlorophyll (Figure 5).

A total of 148 taxa (see Figures 2 and 6) was identified, some of them consisting of species associations (e.g., N. seriata "group", Bacteriastrum spp.); some of unidentified species (e.g., Protoperidinium sp. Q); and some of larger taxonomic groups (e.g., Unidentified naked dinoflagellates).

Figure 2 shows the total number of microplankton cells per liter recorded for each of the samples and the temporal variations in the abundance of the 24 most important taxa. The criterion for inclusion of a taxon into the category "important" was that its numerical abundance represented $\geq$ 10% of the total microplankton in at least two of the 76 samples studied. These taxa accounted for an average of 65% of the total cell numbers, and, as shown in Figure 6, the majority of the remaining 124 taxa accounted for less than 6%. If we compare the occurrences of these species with the groups of Figure 1, we can assume that every group of samples was characterized throughout the year by a distinctive microplanktonic assemblage (see Figure 2).

Group 1 (Mar 15-Mar 22; samples 69-89): Chaetoceros spp. "small", Skeletonema costatum and Nitzschia seriata "group" were the most prominent diatom taxa during this period.

Group 2 (Mar 25-Apr 4; samples 99-129) was mainly characterized by several diatom taxa (Asteromphalus heptactis, Asterionella glacialis, Chaetoceros spp. "small", Cylindrotheca closterium, N. seriata "group", Thalassionema nitzschioides).

In general terms, for both groups, microplankton abundances were moderately high (between 7000 and 30000 cells/l).

Group 3 (Apr 7-May 2; samples 139-209) comprised the samples with highest records of microplankton cells/l (up to 10^5) and highest chlorophyll values (see Figure 5). Several diatom species were frequently recorded (especially A. glacialis, Chaetoceros spp. "large", Chaetoceros spp. "small", Hemiaulus sinensis; see also Figure 6 for other taxa), while others, Eucampia zodiacus, Rhizosolenia stolterfothii, were present only during this period.

Although the boundaries between these first 3 groups did not seem to coincide with major changes in species composition, or were at least not as sharp as the ones observed later on during the year (see below), there were some changes in the relative abundance of individual species, which determined the clustering into different groups. For example, S. costatum was rare outside group 1, T. nitzschioides exhibited its highest abundance in group 2, and E. zodiacus and R. stolterfothii belonged nearly exclusively to group 3.

Group 4 (May 6-Jun 21; samples 219-349) was unusual in that the arrangement of samples was not in chronological order. Thus, for example, subgroup A, which mainly enclosed mid-period samples, also included earliest sample 219, and subgroup B comprised early- and late-period samples. This pattern can be related to fluctuations of the dinoflagellate Prorocentrum micans . This species was reported from March through November; it was the most prominent species in subgroup B representing > 70% of the entire microplankton. On the other hand, subgroup A can be distinguished by the frequent occurrence of Unidentified cell CO which, although present throughout the year, exhibited here its highest abundance.

Microplankton abundance was highest during the P. micans dominance (subgroup B) and lowest in subgroup A, with the exception of sample 229.

The sudden increase and later decrease of P. micans marked the 3-4 and 4-5 boundaries, respectively.

Group 5 (Jun 28-Aug 12; samples 369-499) can be clearly separated into at least two subgroups: A (samples 369-409), and B (samples 419-499). While the dinoflagellates Ceratium furca and C. cf. divaricatum were the dominant forms during the first period (A), the second period (B) was characterized by relatively high abundance of Laboea spp. (ciliates), Protoperidinium divergens (dinoflagellate), A. glacialis, C. closterium and Triceratium sp. (diatoms). In addition, Unidentified cell CO was frequently recorded throughout this period.

Microplankton abundance varied widely (from 2 000-30 000 cells/l) within subgroup A, while consistently low values (< 1000) were recorded within subgroup B, with one exception: sample 459.

Group 6 (Aug 16-Sep 1; samples 509-549) was characterized by A. glacialis, which had maximal abundance (> 10^4 cells/l) in August 19 (sample 519). With the exception of this sample, total microplankton abundance was generally low (<4000 cells/l).

Large changes in A. glacialis abundance marked the 5-6 and 6-7 boundaries.

Group 7 (Sep 6-Nov 17; samples 559-769): Several warm water species (especially Hemiaulus membranaceus, H. sinensis, Ceratium extensum) exhibited highest abundances; others, such as Leptocylindrus mediterraneus, Dictyocha fibula, Umbilicosphaera sibogae were very rare outside this group. Relatively large changes in diatom (H. membranaceus), silicoflagellate (D. fibula) and dinoflagellate (C. furca) abundance marked the A (samples 559-709)-B (samples 719-769) boundary.

Total microplankton abundance was low (<3000 cells/l).

As indicated above, the boundaries between groups of samples did not always coincide with major changes in taxonomic associations but rather with changes in the relative abundance of individual species. Our observations on the "important taxa" allow us to define tentatively a general pattern: Diatom cell numbers and species were consistently high from March through early May, moderately high in mid-June, end July, mid-August and end November, and low during the remaining part of the year. Dinoflagellates, on the other hand, exhibited highest abundances from May through early July, and in November. Silicoflagellates showed highest values in November, and coccolithophorids, with few exceptions, were recorded only in October-November.

As shown in Figures 1-3 and 5, some of the samples were clustered separately or fell out of the chronological sequence. The reason for this relates to the specific content of these samples (see Figure 6), which is different from the general pattern described above (Figure 2). The environmental parameters (water temperature, wind speed) were not notably different during the anomalous sampling periods (samples 59, 229, 359, 649, 779). Therefore, we cannot assume that they were implicated in the dissimilarities.

Temperature (Figures 3 and 4)

For the year 1983 there seems to be some relation between changes in temperature and the major shifts in the numbers of microplankton cells per liter (Figure 2), and the sample groups designated in Figure 1 and characterized in Figure 2.

Temperature changes $\geq 0.5^\circ$ C were noted at the boundaries between groups 2-3, 3-4, 4-5, 5-6 and 6-7. No accompanying temperature change was seen at the boundary between groups 1 and 2; however, changes in the species assemblage were noted (see above). In addition, large ($>3^\circ$ C) temperature changes within group 4 marked the A-B boundary, which was clearly associated with different species dominances (P. micans and Unidentified cell CO, see above). In contrast, the temperature drop (from 22.5 to 18.2° C) within group 6 was not accompanied by changes in the species assemblage. The temperature differences at the boundaries of subgroups A and B within groups 5 and 7 were not as large as the ones described above.

In general terms, the microplankton pulse (mid-March through June) came during a period of moderate temperatures (14-19° C), while highest temperatures (18-23° C) , recorded from July through mid-November, were associated with lowest numbers of microplankton cells/l.

An interesting feature of the temperature records is that they remained well above the 63-year mean during several weeks of the year 1983, especially in March, and from September through mid-November.

Chlorophyll (Figure 5)

Highest chlorophyll values (> 3 mg/m^3) were measured in early March, April and June; and moderate values ($\geq$ 1.5 mg/m^3) in late March, late April through May and early July. During the remaining part of the year chlorophyll _a_ values were low (<1 mg/m^3). The values represent total phytoplankton chlorophyll: Thus a relationship to the limited taxa discussed here is tenuous. However, changes in chlorophyll _a_ mg/m^3 can be seen at each group boundary (with the exception of boundaries 5-6 and 6-7), with the largest change between 2 and 3. In addition, moderate changes took place within groups 4 and 5, marking the subgroups A-B boundaries. No chlorophyll change marked the A-B boundary of group 7. The clear drop within group 3 was accompanied by a drop in the microplankton cells/l recorded (Figure 2); no major changes in the species assemblage we studied could be detected.

Taxonomic notes

Ceratium cf. *divaricatum* is probably synonymous with *C. tripos* as used by Allen and other workers, and with *C. dens* as used by, for example, Reid *et al.*, 1970. This organism varies in cell size and shape depending on the stage of its life cycle.

Laboea spp. is a general term used for sheathed oligotrichous ciliates of varying sizes.

Unidentified Cell CO. We have been unable to determine the nature of Unidentified cell CO. It is unclear whether it is a phytoplankter or a zooplankter. It consists of a central sphere surrounded by smaller spheres, and measures 20-30 μm. It stains with Rose Bengal, and could possibly be related to *Collozoum* sp. or a formalin-damaged naked dinoflagellate.

Discussion and Conclusion

The complex hydrographic and topographic conditions of the Southern California Bight confound attempts to understand the structure of the microplankton populations in both time and space. Spatial patchiness was studied by Food Chain Research Group (Eppley et al., 1984a; "KIS" program - unpublished) on the shelf, in October 1981, in February, March 1983 and in February 1984. Continuously pumped samples were taken from dawn to dusk along a 75 km line at the 50-m isobath. This produced a quasi-synoptic picture of microplankton structure and reduced the effects of short-period temporal variability. Variation at a fixed point has been studied by anchoring a ship for four days in Augut 1978 (Eppley et al., 1984b) and sampling water at intervals as it passed. Our work at the Scripps pier was carried out over a much longer period. Use of the pier also facilitated collection of larger-volume water samples, though only one depth was sampled.

The current patterns in the Southern California Bight are variable. Sverdrup and Allen (1939), using data for February through December 1938, described the California Countercurrent flowing northwestward a few kilometers offshore, except in intensive upwelling periods which occurred from March through May at the latitude of the Scripps pier. They associated the southeast-flowing, cold, upwelled water with a shallow mixed layer and found that it contained high diatom abundance. The long-term means (Wyllie, 1966) confirm this general picture of the water movements in the Bight. The situation closer inshore, at the pier, is less well understood. Winant and Bratkovich (1981) placed current meters about 10 km north of the Scripps pier within 3.6 km of

Abstract

A semiweekly sampling program at the Scripps Institution of Oceanography pier was begun in 1983 during an "El Niño" event. Microplankton data for March to November 1983 show a temporal sequence of species assemblages of the 24 "important" taxa, with a residence time of 1 to 4 weeks. From March to early September the assemblages consisted of typical neritic taxa. From mid-September to mid-November the presence of oceanic warm-water species was associated with positive temperature anomalies characteristic of the "El Niño" condition. During the period studied numerical abundances were low.

the shoreline at the 15-, 30- and 60-m isobaths, during 1978 and 1979. They found the main longshore currents to be usually southward with occasional northward components in the fall. The development of eddies further confuse the picture. Sargent and Walker (1948) studied diatom populations in eddies in the spring months of 1941. They related patchy distributions to cyclonic eddies of freshly upwelled water. Abundance diminished more sharply to the west because of lateral mixing with offshore lower-nutrient water.

The temporal sequence of species assemblages shown by our data is chronological with a few exceptions. The assemblages are not repeated during the nine months of this study, and their sequence is dependent upon qualitative and/or quantitative changes (Figures 1 and 2). The fact that these assemblages did not repeat over this period is in general agreement with the statement of Goodman et al. (1984) that each water parcel would be expected to transport a characteristic species assemblage. They suggested that diatom-dominated phytoplankton assemblages persist from 1 to 3 weeks. Our data for microplankton lead us to a similar conclusion (1 to 4 weeks). This is seen in Figure 1, in which the period represented by two adjacent samples is about a week.

The spring diatom increase described for this and other areas (e.g., Allen, 1928, 1936; Reid et al., 1970) occurred in 1983, even though positive temperature anomalies were recorded. The dinoflagellate peak was in May-June. However, microplankton abundance at the pier was frequently lower than the ones reported in previous years (for example, Allen, 1922a, 1922b, 1927a, 1927b; Dorman, 1927). Allen (1940) stated that "warm years" (e.g., 1926 and 1931) were unfavorable for diatoms and especially for dinoflagellates. It is difficult to compare numerical data due to differences in sampling techniques and the inclusion of disparate taxa. However, our data suggest an overall reduction in numbers of all taxa (Figure 2).

The species which Allen noted as major contributors are present among our 24 "important" taxa (*e.g.*, *Asterionella glacialis* (=*japonica*), *Eucampia zodiacus*, *Nitzschia seriata*, *Skeletonema costatum*, *Thalassionema nitzschioides*, *Ceratium furca*, *C.* cf. *divaricatum* (=*tripos*?), *Prorocentrum micans*, *Protoperidinium* (=*Peridinium*) *divergens*). Except for *A. glacialis* and *E. zodiacus*, the occurrence of the other taxa is similar to that found in Allen's data (Allen, 1928, 1936, 1941). The uncertain identification of *C. tripos* (see Allen, 1941) makes it difficult to compare occurrences, but it is present in the summer months in both sets of data. Similarly, the combination of *Chaetoceros* species precludes useful comparisons.

Concurrent with some of the pier work, similar samples were collected along CalCOFI line 90 (stations 90.37, 90.53, 90.55, 90.65) during the "CalCOFI" cruises of April, May, June, August, September, October, November and December 1983. The species content of these samples, and especially the dominant forms, differed from those seen at the pier. However, some taxa were important in both sets of data at almost the same time. For example, *Chaetoceros* spp. "large", *Ch.* spp. "small", *Nitzschia seriata* "group", *Skeletonema costatum* and *Thalassionema nitzschioides* were important at the pier in March and April (Figure 2), and in April and May in offshore locations. *Umbilicosphaera sibogae* and *Ceratium extensum* were frequently and consistently recorded .

offshore from September through November, and *Dictyocha fibula* during November and December. These three species were important at the pier in October and November.

One month before the start of the pier sampling, in early February, the "KIS" transect along the coast 5 km offshore showed a microplankton population dominated by dinoflagellates and tintinnids from Dana Point to San Diego. Many oceanic forms were included in the assemblages and there was little resemblance to the early groups in the pier analysis. Unfortunately, there was no temporal overlap in these data, but since the first pier samples (early March) had low abundances (< 3000 cells/l) it is possible that there was a major change at the end of February, when the pier temperatures were already well above the mean (Figure 4).

A preliminary scan of material from a second transect ("KIS" studies) in mid-March shows a more normal coastal spring diatom population, with *Chaetoceros* spp. increasing. A more thorough zooplankton analysis of the same transect (Brooks and Mullin, pers. comm.) indicates a change from the oceanic conditions seen in February. Previous investigations were equivocal, suggesting close resemblances between inshore and offshore phytoplankton catches at some times (Allen, 1928) and recognizable differences at others (Allen, 1941).

Balech (1960) related the presence of oceanic warm-water microplankton in inshore waters from August 1957 to May 1958 to the "El Niño" condition, exemplified by high temperatures at the Scripps pier (Figure 4). The temperature profile for 1983 showed similar positive anomalies. Our records of some species (*Hemiaulus membranaceus*, *Umbilicosphaera* sibogae, Ceratium extensum), usually associated with oceanic warm-water conditions, occurred mainly during October and November 1983 (see Figure 2). Matrai (1984) studied Ceratium species collected in January 1983 on a line from the Central Gyre across the California Current to the coast and concluded that oceanic, warm-water species did not move east to the California coast as much as they did during the 1957-1958 "El Niño" event (Balech, 1960).

The "El Niño" condition shown from temperature anomalies began to fade in the Equatorial Pacific in early 1984 (Oceanographic Monthly Summary, 1983, 1984). However, the unusually high temperatures have persisted in the California Current (Simpson and Lynn, manuscript) and at the Scripps pier through December 1984 (Figure 4) Chlorophyll measurements at the pier also remained generally lower than 1 mg/m^3 until 1985 (MLRG, unpubl. data).

In spite of the temperature increase during the "El Niño" year 1983, the species composition was not unusual, except possibly from mid-September through mid-November, when some oceanic warm-water species occurred. Whether these species were advected in from the west or south, or whether seed stocks were activated by the higher temperatures is still in doubt. To date we have no microplankton data for 1984, so we are unable to ascertain whether the persisting high temperature and low chlorophyll a measurements at the pier are related to unusual species assemblages at that time.

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Captions for Figures

Figure 1: Dendogram grouping of phytoplankton net samples according to the percent similarity index (PSI). Subjective groups and subgroups are indicated by numbers (1,2,3,4,5,6,7) and letters (A,B), following a chronological sequence. Arrowed sample numbers indicate samples that fell out of sequence.

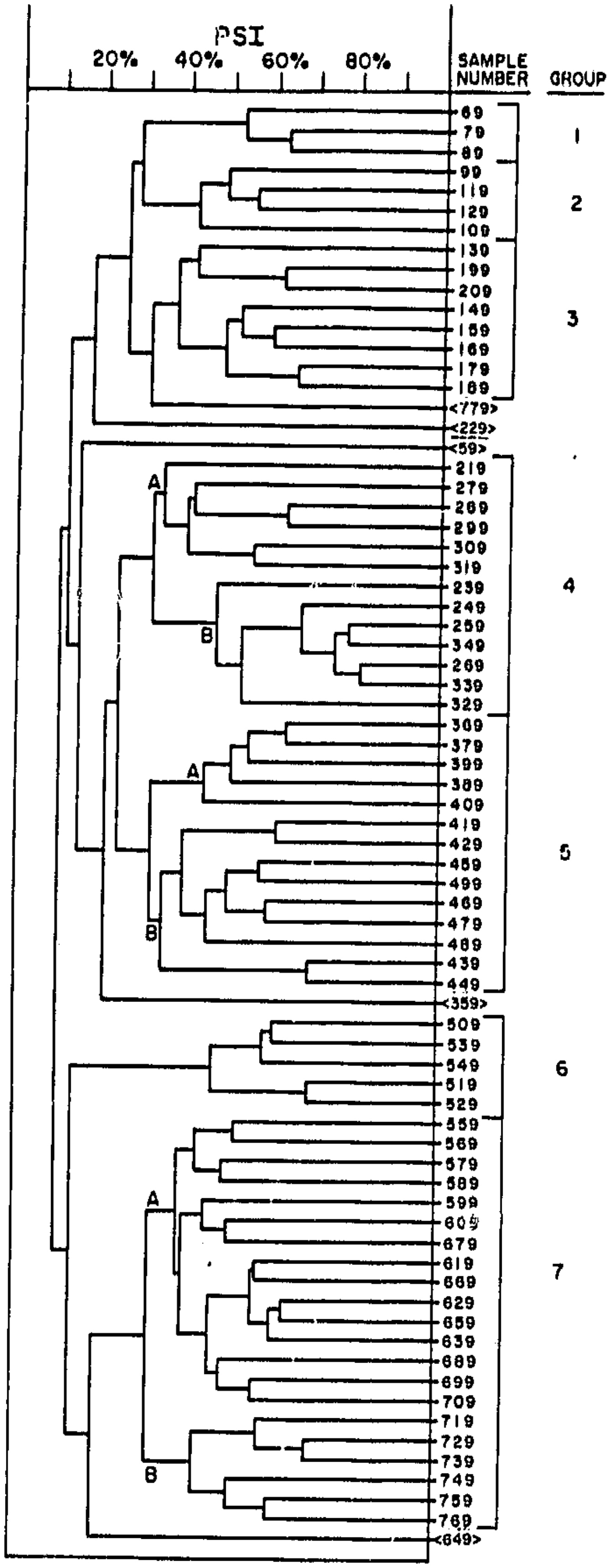
Figure 2: Occurrence and abundance (as a percent of the total microplankton) of the 24 "important" taxa, and fluctuations of total microplankton abundance (cells/l, note scale change). Numbers (1-7) and letters (A,B) refer to the groups and subgroups in Figure 1.

Figure 3: Temperature records at Scripps pier (solid line: temperatures of 1983; broken line: 63-year mean (1920-1982) temperatures). Numbers 1 to 7 refer to groups in Figure 1. Asterisks indicate samples that fell out of sequence.

Figure 4: Temperature profiles at the Scripps pier for two "El Niño" events. Dotted line represents 63-year mean (1920-1982) temperature. Shaded areas indicate periods of positive temperature anomalies. Shaded block indicates the period dealt with in this paper.

Figure 5: Total chlorophyll a measurements at Scripps pier, 1983. Numbers 1 to 7 refer to groups in Figure 1. Asterisks indicate samples that fell out of sequence.

Figure 6: Occurrence and abundance (as a percent of the total microplankton) of the 124 taxa not included in Figure 2.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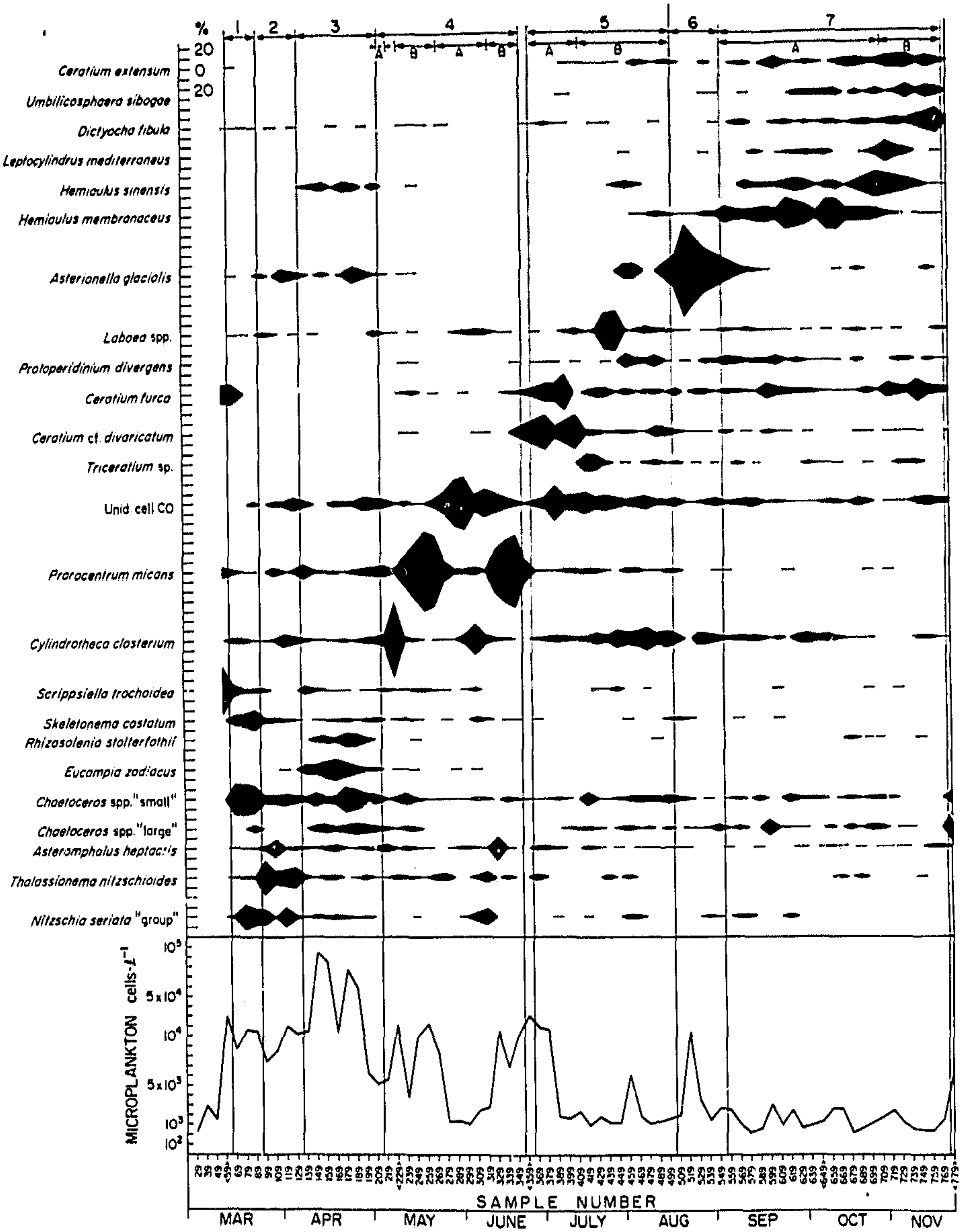
B
A
B
A
B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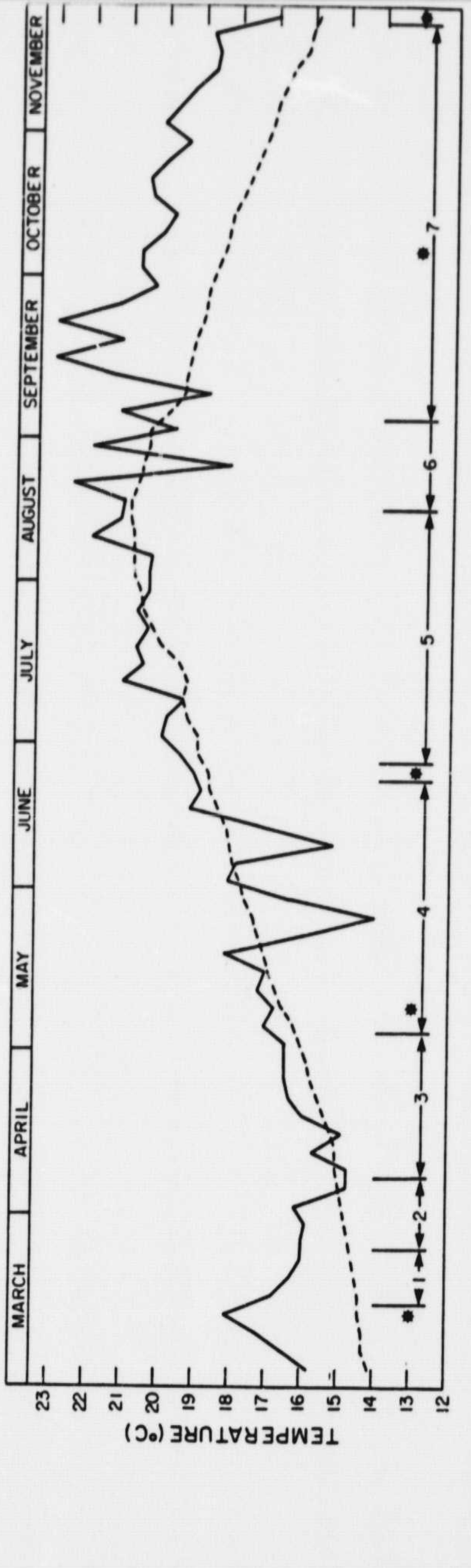
B
Ceratium extensum
Umbilicosphaera sibogae
Dictyocha fibula
Leptocylindrus mediterraneus
Hemiaulus sinensis
Hemiaulus membranaceus
Asterionella glacialis
Laboea spp.
Protoperidinium divergens
Ceratium furca
Ceratium cf. divaricatum
Triceratium sp.
Unid. cell CO
Prorocentrum micans
Cylindrotheca closterium
Scrippsiella trochoidea
Skeletonema costatum
Rhizosolenia stolterfothii
Eucampia zodiacus
Chaetoceros spp. "small"
Chaetoceros spp. "large"
Asteromphalus heptactis
Thalassionema nitzschioides
Nitzschia seriata "group"
MICROPLANKTON cells·ℓ⁻¹
10⁵
5x10⁴
10⁴
5x10³
10³
10²
SAMPLE NUMBER
MAR
APR
MAY
JUNE
JULY
AUG
SEP
OCT
NOV

3



MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
TEMPERATURE (°C)
23
22
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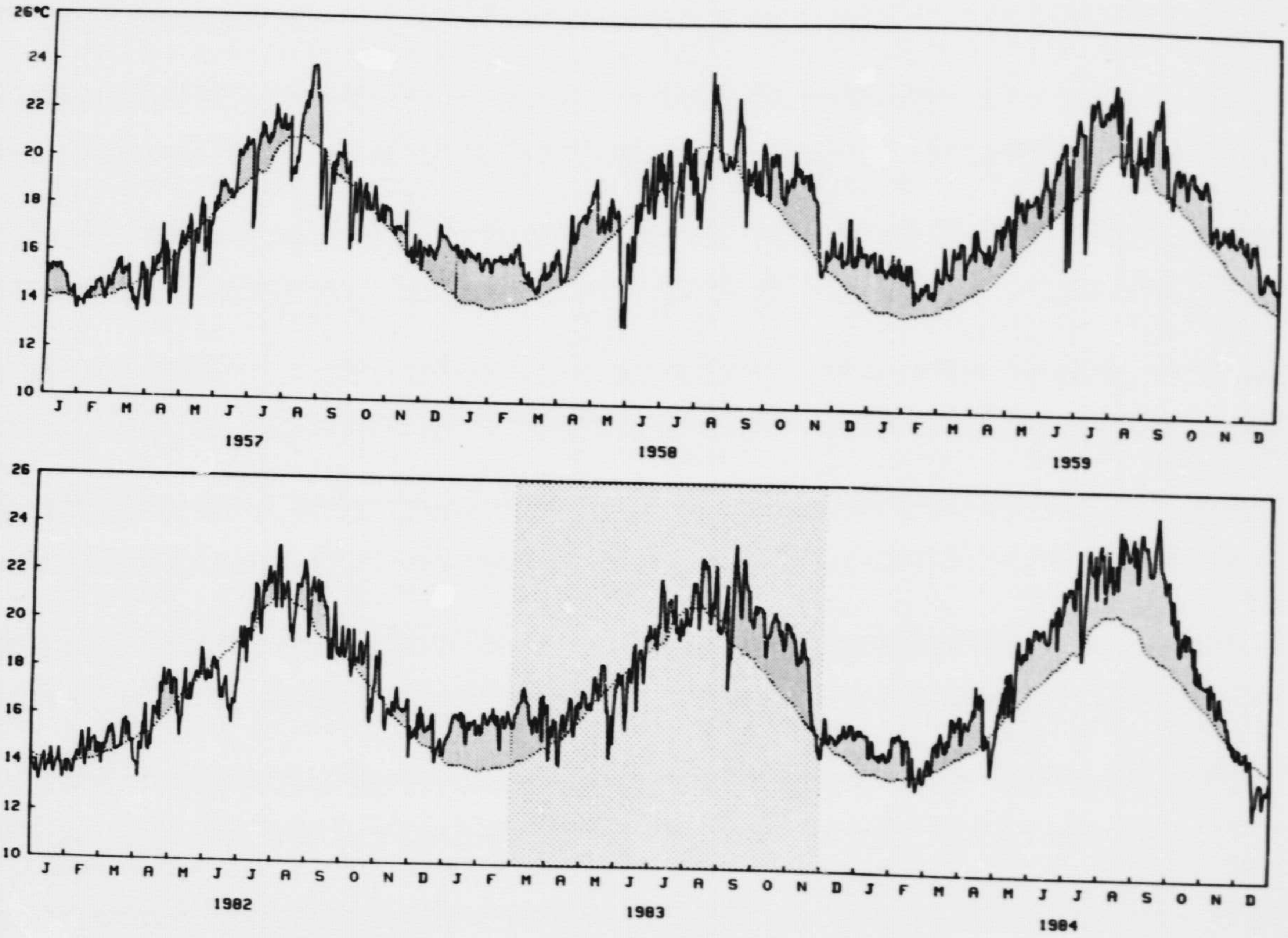
20
19
18
17
16
15
14
13
12
1
2
3
4
5
6
7


26°C
24
22
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18
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12
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J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1957
1958
1959
26
24
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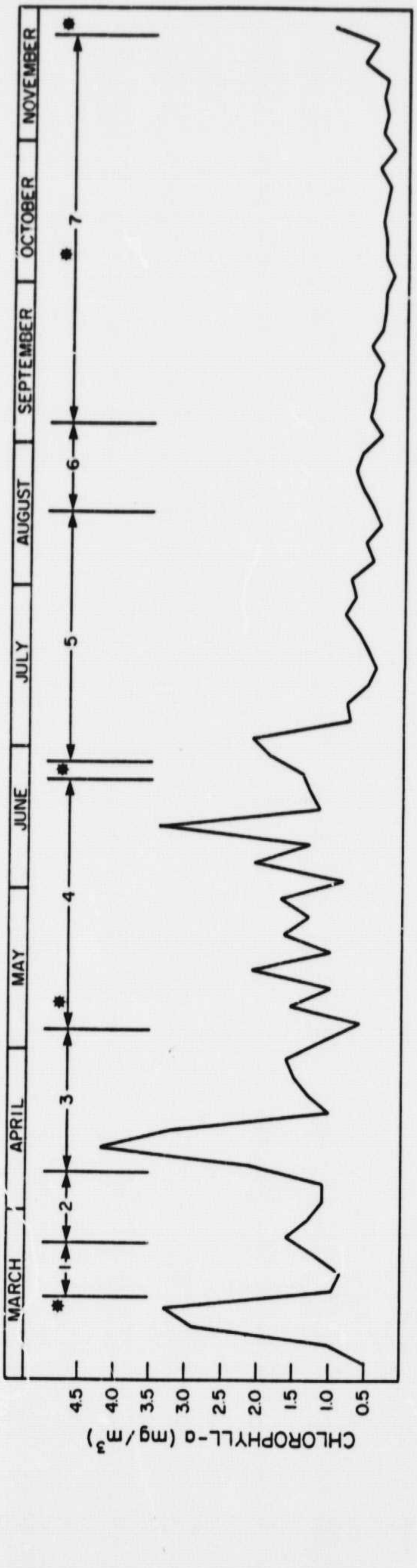
1982
1983
1984


MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
1
2
3
4
5
6
7
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CHLOROPHYLL-a (mg/m³)

ORIGINAL PAGE IS
OF POOR QUALITY