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PHYTOPLANKTON ABUNDANCE AND DISTRIBUTION IN SANTA MONICA BAY

Phytoplankton are microscopic plants that drift with ocean currents and respond to physical and chemical changes in the environment by rapidly increasing or decreasing their numbers. The use of phytoplanktons as indicators of change in southern California coastal waters, however, has been difficult because of their patchy distribution. If uniform patterns of seasonal and geographical change could be detected in the coastal plankton, it would be possible to explain deviations from the patterns on the basis of such factors as waste discharge and stream runoff.

Analysis of phytoplankton samples collected from Santa Monica Bay by Hyperion Treatment Plant personnel between 1957 and 1971 has provided very useful information on how abundance and distribution vary from season to season and from offshore to inshore. The number of phytoplankton cells increases in the Bay during late winter and early spring. Increases are also observed in some summers. Lowest cell densities occur in late fall and early winter.

THE COASTAL PHYTOPLANKTON

Two groups of phytoplankton dominate the net plankton in southen California coastal waters: diatoms, which are generally most abundant offshore, and dinoflagellates, which dominate near shore waters. The diatoms are relatively nonmotile forms that are encased in silicate sheaths called "frustules", which may be elongated (the pennate diatoms) or barrel-shaped (the centric diatoms). Diatoms may occur as individual, free-living cells or in chains.

The dinoflagellates are characterized by having two whiplike structures, flagella, which enable them to migrate through the water column. Some are covered by calcareous plates called armor, and others are "naked". A few of the naked forms, at various times, secrete extremely powerful toxins into the water. Although many species of dinoflagellates can cause "red tides" when they accumulate in the water, only a few secrete toxins that may cause fish kills and be a hazard to bathers.

Phytoplankton obtain much of their nutrition autotrophically (making food by photosynthesis). Yet scientists are continually finding examples of heterotrophy (use of preformed organic food) among the phytoplankton. It was recently discovered that one dinoflagellate, *Noctiluca milaris*, is a predator on copepod eggs (Kimor 1979). This combination of plant and animal characteristics has resulted in the phytoplankton being considered in a separate kingdom, called Protista.

Some common coastal phytoplankton are shown in Figure 1.

SANTA MONICA BAY DATA SET

Phytoplankton samples were collected each week between 1957 and 1971 at 18 stations (Figure 2) in Santa Monica Bay by the staff of Hyperion Treatment Plant as part of a water quality monitoring program. A No. 20 silk plankton net was lowered 15 meters into the water and towed vertically to the surface at each station. The "catch" was allowed to settle in centrifuge tubes; organisms were then identified and counted in the laboratory.

For many years, this valuable historical record was only partially analyzed. It is now being examined for use as a base of information on planktonic and pelagic food webs of Santa Monica Bay.

PATTERNS IN THE PHYTOPLANKTON

The data from the Hyperion plankton collections were reported as volumes (milliliters) of organisms per tow. Weekly volumes of diatoms at an offshore station (7C) and of dinoflagellates at an inshore station (3C) are plotted in Figure 3. The plots are based on samples collected in 1965, a year representative of average phytoplankton abundances in Santa Monica Bay. Diatom volumes increased and decreased sharply over brief intervals of time. Sometimes changes of more than two orders of magnitude occurred within 1 or 2 weeks, suggesting that "blooms" were occurring. A bloom is a sharp increase in the number of organisms present as a function of rapid reproduction. Diatom blooms occurred most frequently during spring and summer. Although data on growth rates are not available, clearly the sharp increases in phytoplankton abundance shown in Figure 3 are indicative that bloom-type growth occurred or was occurring at the time of sampling. Therefore, in this report, a bloom will be considered as an order of magnitude increase in sample volume (to 1 ml or more) over a time period of 1 week.

Periods of dinoflagellate and diatom blooms coincided, occurring between late winter and early spring (Figure 3). Summer blooms occurred in 1965 but not during 1970 and several other years. Changes in dinoflagellate abundance, however, were less dramatic than those in diatom abundance. That is, the volume of dinoflagellates in the tows rarely fell below 0.2 ml or exceeded 5 ml from February to October.

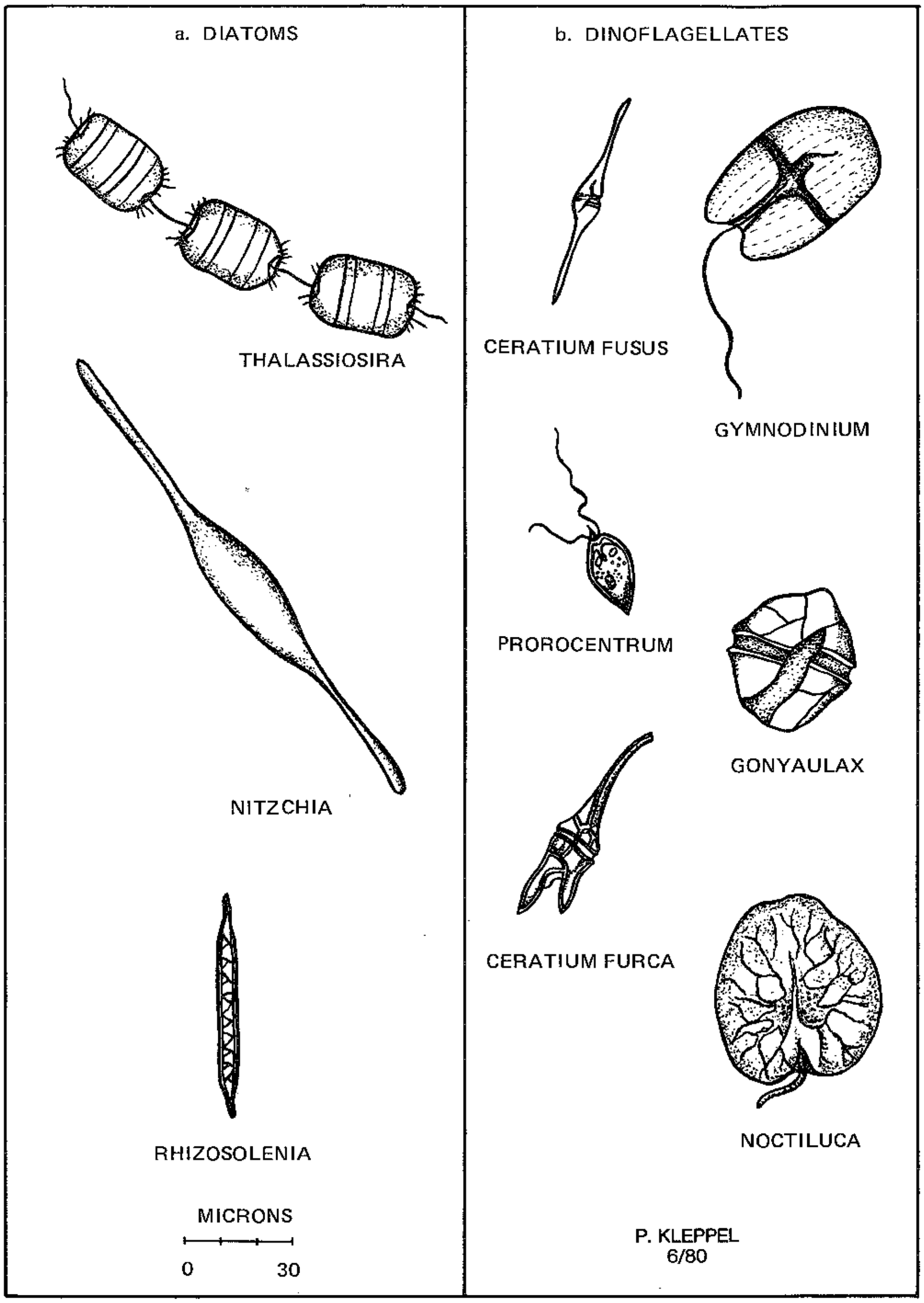

Figure 1. Common phytoplankton in southern California coastal waters.

Both diatoms and dinoflagellates were less abundant during late fall and early winter.

Figure 4a is a plot of mean monthly diatom volumes at eight stations along lines 7,3, and 2 (inshore-offshore transects, indicated by dashed lines in Figure 2). The data from the months presented were considered representative of seasonal conditions. In general, diatom volumes were higher at offshore stations than at inshore stations. During the fall, relatively higher inshore diatiom volumes (predominately *Chaetoceros* sp.) were noted at Stations 2B, 2C, 3B, and 3C; dinoflagellates were also more abundant inshore than offshore (Figure 4b). Maximum volumes were routinely noted in the vicinity of Marina del Rey (2C), the 1-mile Hyperion outfall (3B), and the Chevron Oil Corporation outfall at El Segundo (3C).

ENVIROMNMENTAL REGULATION OF PHYTOPLANKTON

Phytoplankton respond to cues in the environment by increasing or decreasing their numbers, and different groups of phytoplankton respond to different cues or sets of cues.

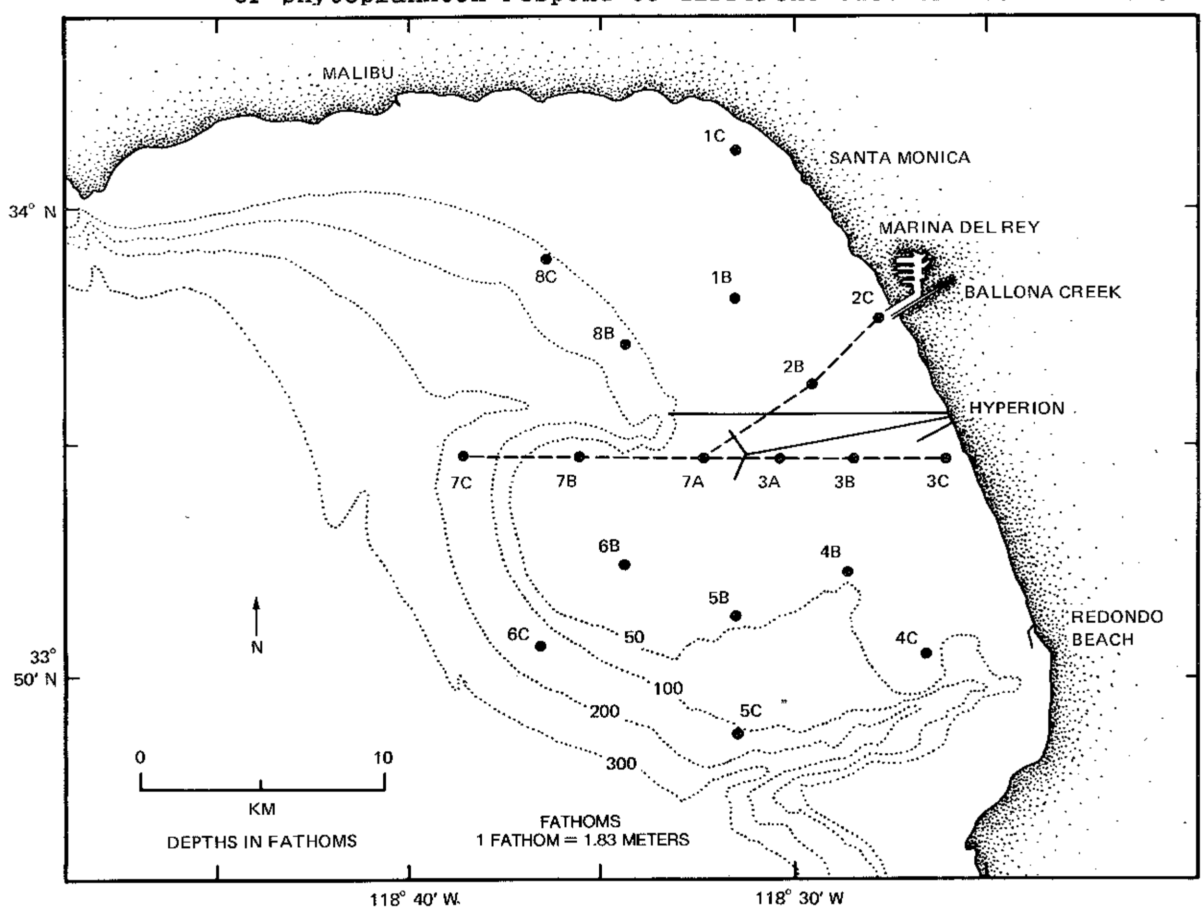

Figure 2. Stations sampled each week from 1957 to 1972 in Santa Monica Bay. Dashed lines connect stations considered in Figure 3.

These cues are individual and interacting physical, chemical, and biological factors, many of which occur with seasonal regularity within a predictable range of variability (examples are upwelling and water stratification). By understanding the relationships between some important environmental parameters (such as light, temperature, and nutrients) and the abundance of various groups of phytoplankton, the reasons behind some to the discontinuities seen in the abundance and distrbution of the plankton become clear. For instance, we do not yet know why a diatom bloom occurs in some summers but not in others, However, we have noticed that summer blooms are more frequent when the differnce between surface and deeper water (43 meters) tempratures are less than 5.0°C for part of the summer period.

It has been suggested the nitrogen from municipal outfall discharges at 60 meters diffuses through thermal strata and reaches the surface directly above the outfall, resulting in a constant enhancement of phytoplankton biomass (Eppley et al. 1977). Hendricks (1975) proposed that this is unlikely. Based on the differences in diatom and dinoflagellate distrbutions (Figure 4), it would appear that inshore-offshore parameter differences determine these distributions. Inshore waters contain proportionately more

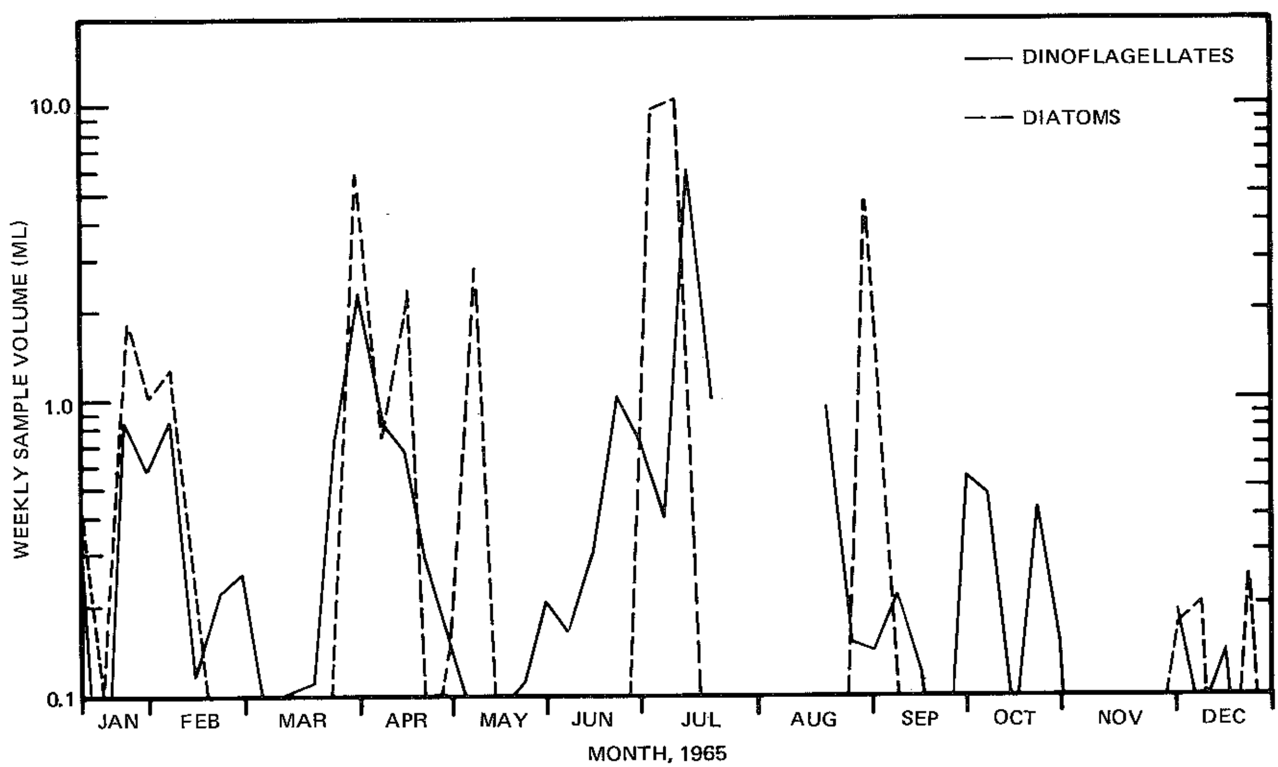

Figure 3. Weekly sample volumes of diatoms from an offshore station (7C), and dinoflagellates from an inshore station (3C) in Santa Monica Bay during 1965. Samples were collected using a No. 20 net towed vertically from 15 meters to the surface.

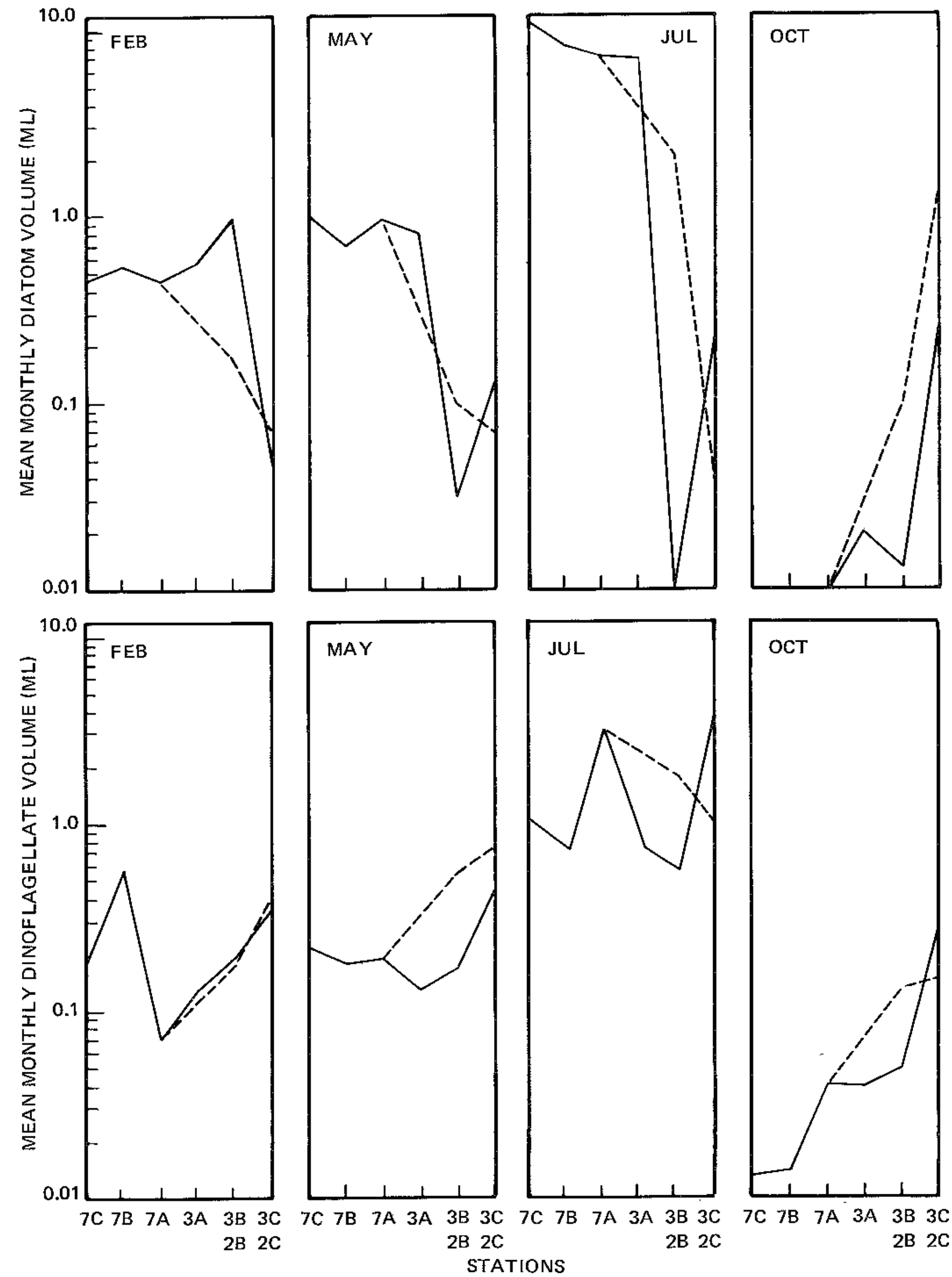

Figure 4. Inshore-offshore patterns of phytoplankton abundance during four seasonally representative months in 1965, as indicated by mean monthly diatom and dinoflagellate volumes (a measure of abundance) along the line-7-3-2 transect shown in Figure 2. In general, diatoms decreased from offshore to inshore. In the fall (October), apparent diatom enhancement inshore may be due to dilution of offshore waters with cell-free oceanic water. Only during July was the dinoflagellate pattern suggestive of enhancement above the outfall indicated.

ammonium than offshore waters, and the increase in the relative abundance of ammonium may be a "tag" for the set of cues that result in dinoflagellate growth (Kleppel 1979). Ammonium is also very abundant in sewage. Hence, if sewage reaches the surface around an outfall, one would expect to observe large numbers of dinoflagellates in the vicinity of the outfall. It is apparent from Figure 3b that such enhancement does not normally occur. Only during brief periods in July and August were there increases in dinoflagellate abundance around the 5-mile Hyperion outfall that were discontinuous with inshore-offsore distribution patterns.

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