SUMMARY OF THERMAL CONDITIONS AND PHYTOPLANKTON VOLUMES MEASURED IN MONTEREY BAY, CALIFORNIA 1961–1966

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For thirteen years under the California Cooperative Oceanic Fisheries Investigations Program the Hopkins Marine Station of Stanford University has monitored the marine climate and phytoplankton of Monterey Bay. Approximately weekly cruises to six regular stations on the bay are made on the R/V TAGE. The information gathered is compiled and distributed to interested organizations and individuals in the form of mimeographed quarterly and annual data reports. A previous paper (Bolin and Abbott, 1963) describes the stations occupied and the procedures followed in sampling and analysis, and presents a summary of results obtained through December 1960. The present report summarizes some of the findings in the period January 1961 through December 1966, and brings up-to-date the curves shown in Figures 2A-B and 5A of the earlier paper.

Thermal conditions are shown in Figures 1A and 1B of the present report. In Figure 1A, the middle of the three curves depicts the monthly average of all surface temperatures taken on all cruises during each month. The upper curve (average monthly maximum) shows monthly averages of the warmest surface temperature recorded on each cruise during the month. The lower curve (average monthly minimum surface temperature) is similarly derived.

The main hydrographic seasons on the bay are clearly indicated by the curves in Figures 1A and 1B. Divergence between average monthly maximum and average monthly minimum surface temperatures (upper and lower curves in Figure 1A, solid line in Figure 1B) occurs when upwelling of colder water over the Monterey Submarine Canyon lowers the temperatures in the center of the bay without bringing about correspondingly large drops in surface temperatures at the northern and southern limits of the bay. Upwelling is also accompanied by a marked increase in the thermal gradient in the upper 50 meters (Figure 1B, broken line). The thermal gradient may persist for a time in the late summer and early fall after upwelling has declined (compare solid and broken lines, Figure 1B, for August through October

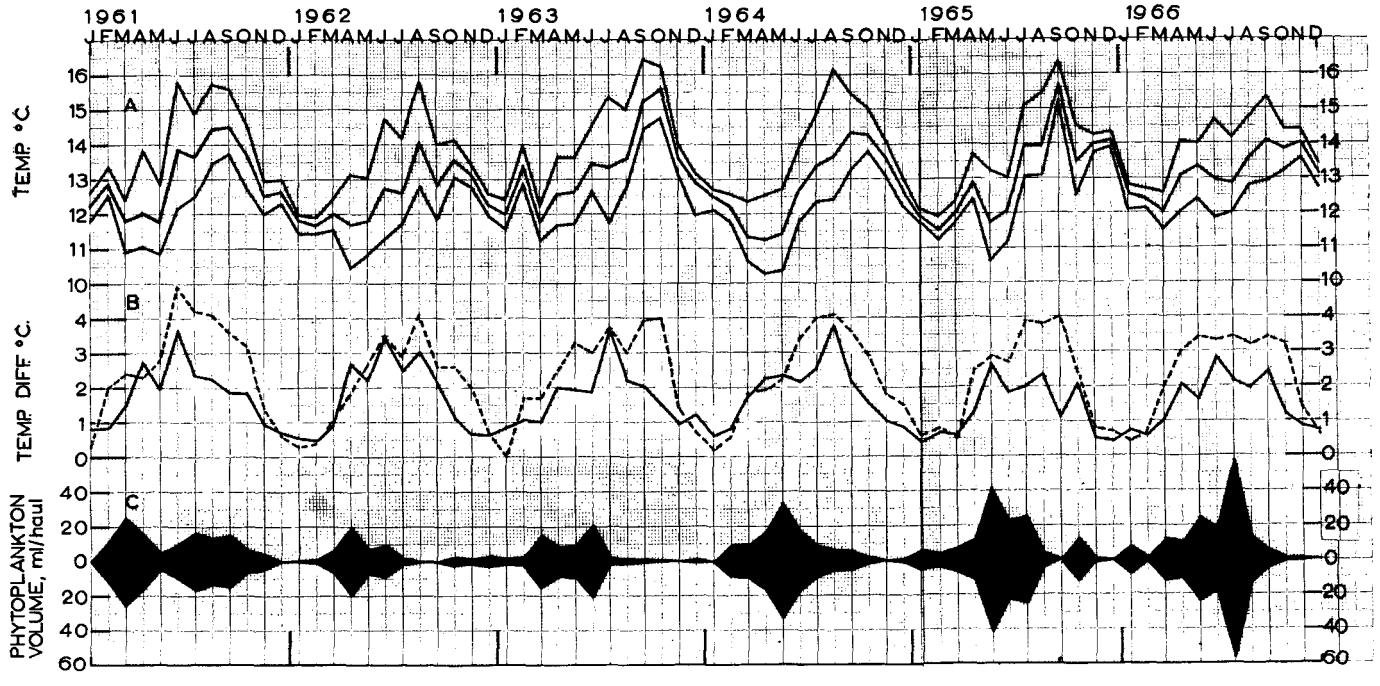

FIGURE 1. Monthly averages of temperature conditions and the volume of the phytoplankton standing crop in Monterey Bay, California, 1961 through 1966. A. Surface temperature (°C), showing monthly means, average monthly maxima, and average monthly minima. B. Solid line—temperature difference (°C) between average monthly maximum and average monthly minimum surface temperatures; broken line—temperature difference (°C) between monthly means of temperatures at the surface and those at 50 meters depth. C. Monthly averages of the volume of the phytoplankton standing crop (ml/haul).

especially for the years 1961 and 1963); as upwelling ceases fog also decreases, and with sunnier weather and little turbulence a thermocline often develops which tends to preserve a temperature gradient. Also during these months, flushes of warmer oceanic water from offshore may flow in on the surface of the bay. The Davidson Current period of the winter months is clearly indicated in Figures 1A and 1B by the marked decline in surface temperatures, the close similarity of average monthly maximum and minimum surface temperatures, and the nearly uniform temperature conditions prevailing in the upper 50 meters as a result of mixing.

In Figure 1C the phytoplankton volumes represent monthly averages of wet settled volumes of phytoplankton per haul, 15 meters to the surface, taken in a $\frac{1}{4}$ meter net of 173 meshes/inch. Larger diatoms and dinoflagellates are retained, but not nannoplankton. Major increases in standing crop occur in spring and summer. For the 13-year period 1954–1966, maximum crops appeared most frequently in June, but in different years peaks fell in all months from March through July. *Chaetoceros* is usually the predominant genus in the bay in spring and early summer.

The most notable irregularity in the general seasonal temperature pattern shown in Figure 1A is the unusual warm peak which occurred in February 1963. This unseasonal warming, one phenomenon among many in a winter of unusual weather, appears in the records of shore temperatures taken along much of the temperate Pacific coast (Scripps Institution of Oceanography, 1964). February temperatures at most shore temperature stations in California, Oregon, and Washington exceeded temperatures recorded for that month in any year through 1966 since the warm years 1957–1959. In Monterey Bay this warm pulse was accompanied by conspicuous red tides and luminescence; the phytoplankton was dominated by *Peridinium*, with lesser numbers of *Ceratium* and *Gonyaulax* (Hopkins Marine Station, 1963). Red tides extended at least as far north as Point Montara and in southern California were prevalent from near San Diego to Santa Barbara (California Marine Resources Operations, 1963). No unusual mortality of fishes or other marine organisms was noted, in Monterey Bay or elsewhere in California, but phytoplankton volumes obtained in Monterey Bay rose sharply in March.

A less conspicuous warm pulse during the Davidson Current period occurred in February 1961 (Figure 1A), and was reflected in shore temperatures taken at many points along the coast (Scripps Institution of Oceanography, 1962). In contrast to the situation in 1963, dinoflagellates formed less than 2% of the phytoplankton bloom accompanying and following the warm conditions. Instead, the phytoplankton consisted of a mixed population of diatoms characteristic of coastal waters; *Chaetoceros* and *Skeletonema* predominated, accompanied by lesser numbers of *Asterionella, Thalassiosira, Nitzschia,* and other forms. The character of the phytoplankton in the March bloom of 1963 suggests the growth of organisms brought in from oceanic waters offshore, while the March bloom of 1961 represents growth of resident populations characteristic of Californian coastal waters.

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