ban sources (such as the disruption of surface dust by urban automobile traffic) may make clean air standards (75 μg/m^3) difficult to attain. In addition, the increased concentrations of ultragiant particles over and immediately downwind of large cities may partially explain the rainfall enhancement associated with urban areas (*2*).

Particles were collected by exposing a small (1.0 by 7.5 cm) glass slide covered with a thin layer of high-viscosity silicone oil to the free airstream outside the skin of the aircraft. Each slide was exposed for 3 minutes. At normal aircraft speeds this corresponds to a sampling path length of 13.5 km. Particles captured on the slides were counted and sized manually from photographs taken of each slide. Only particles with diameters larger than 5 μm were analyzed in order to minimize corrections for nonunity collection efficiencies for small particles. To ensure accurate counting statistics, an upper size limit of 55 μm was imposed. The resulting diameter range between 5 and 55 μm was evenly divided into ten size categories.

Measurements of the concentrations of aerosol particles upwind and downwind of the St. Louis urban area were obtained on each of 11 days in July 1975. Upwind and downwind locations were chosen from reported surface winds, confirmed by visual observations of smoke plumes and by on-board measurements of the concentration of Aitken particles at each location. Upwind data were typically taken in rural areas 20 to 30 km upwind of the center of the city. Downwind samples were usually taken immediately downwind of the industrial areas along the Mississippi River. A total of 15 upwind and 19 downwind slides were analyzed. If more than one upwind or downwind slide was exposed on a particular day, the results were averaged to get a single upwind and a single downwind particle size distribution for that day. The volume concentrations corresponding to each particle distribution are shown in Table 1. Although there is considerable day-to-day variation in the volume loading of the air, the city air is consistently dirtier than upwind air. Assuming an average particle density of 2.0 g/cm^3, these measurements indicate that the concentrations of particles between 5 and 55 μm in diameter average 31 μg/m^3 upwind and 55 μg/m^3 downwind of St. Louis.

In recent studies of suspended particulate matter in air it has generally been concluded that the volume (or mass) distribution of these particles is bimodal (*3*). The average upwind and downwind volume distributions (Fig. 1) show good resolution of the upper volume mode and clearly illustrate the increased particulate loading over the city. The location and shape of the upper mode in Fig. 1 are in general agreement with the surface measurements of Okita (*4*) and Jaenicke and Junge (*5*), and with Hindman's aircraft measurements in a paper mill plume (*6*). These results indicate typical number concentrations of airborne particles larger than 10 μm in diameter of 7,500 m^{-3} upwind and 11,000 m^{-3} downwind of the city. Particles larger than 30 μm in diameter were found in concentrations of 200 m^{-3} upwind and 425 m^{-3} downwind of the city. Such large concentrations show that sedimentation is relatively ineffective in removing these ultragiant particles from the air during periods of active mixing in the boundary layer. Unless scavenged by rain or ingested into clouds, giant and ultragiant urban aerosol particles will affect the quality not only of city air but also of air for many tens of kilometers downwind.

Table 1. Daily volume concentrations of particles with diameters between 5 and 55 μm upwind and downwind of the St. Louis urban area.

Date (July 1975)	Volume concentration (μm^3/cm^3)	
	Upwind	Downwind
1	13.6	20.9
2	17.1	29.3
3	20.4	23.4
7	4.4	8.4
8	14.6	26.7
9	15.6	30.8
10	23.3	41.8
11	16.2	42.3
12	6.6	28.8
16	23.6	27.6
18	12.5	20.5

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Short-Period Climatic Fluctuations: Effects on Diatom Biomass

Abstract. *An analysis of the weekly averages of diatom biomass measured near the coast of Southern California (32°50'N, 117°10'W) during the period from 1928 through 1939 indicates that three major blooms account for 85 percent of each year's diatom biomass. The average duration of a single bloom is 5.5 weeks. The diatom blooms coincide with upwelling, but their individual characteristics depend on the detailed features of the circulation patterns of the water masses. That is, if upwelling takes place after a large influx of subtropical or even tropical water because of the slackening California Current, the resulting diatom blooms are smaller by several orders of magnitude than those observed when the flow of the current is strong. This influx of subtropical water into the region is reflected in positive anomalies of temperature, salinity, and sea level.*

Short-period climatic fluctuations often result in major changes in the chemical and physical parameters of the oceans (*1*). Most studies of the effects of such variations on the biological populations in the oceans have dealt with fishes (*2*). I describe here the effects of short-period climatological changes on the abundance of diatoms, at lower trophic levels than fishes, near the coast of Southern California during the period from 1928 through 1939. The phytoplankton ecology of this region has been extensively studied over periods ranging from hours to several months (*3*). I attempt to show here that, in addition to short-term variations in diatom biomass as noted by these investigators, there are also year-to-year changes caused by climatological fluctuations.

The response of the diatom growth rate to environmental changes can be rapid (a few days or weeks). A data set based on daily or weekly samples acquired over a period of several years is therefore needed in order that a thorough analysis of the relationship between fluctuations in environmental factors and in diatom abundance can be carried out. Recently I gained access to the original data records of the net tow phytoplankton collections of W. E. Allen (*4*). Gathered from the end of the pier at Scripps Institution of Oceanography (32°50′N, 117°10′W) over a period of 20 years, this data set probably constitutes the largest time series of phytoplankton counts ever collected. Other data sources are mentioned in (*5*). All the data discussed in this report are based on daily measurements.

An investigation of Allen's data shows that easily identifiable, distinct blooms of relatively short duration make up the major portion of each year's diatom biomass. These blooms coincide with upwelling, a wind-induced process in which surface waters are replaced by nutrient-rich subsurface waters. An example of this correlation (Fig. 1) indicates that during 1936 three major blooms accounted for nearly 90 percent of the net diatom production and a fourth bloom of much smaller magnitude occurred during upwelling, as manifested by large decreases in the surface temperature.

On a year-by-year basis, three blooms contribute 85 percent [σ (standard deviation) = $\pm$ 10 percent] to each year's biomass. The average duration of a single bloom is 5.5 weeks ($\sigma = \pm 2.4$).

Not only are there significant size differences among the blooms of a single year, for example, 1936 (Fig. 1), but year-to-year differences are even more pronounced (Fig. 2). For example, the largest bloom of 1931 had 7.8×10^4 cells per liter at its maximum as compared to 1.4×10^6 cells per liter for the principal bloom in 1936.

Although each year's major blooms, no matter how small, are correlated with upwelling (not shown except for 1936 in Fig. 1), there is no indication that periods of low diatom productivity are the result of a lack of upwelling. Upwelling in this region results not only in lower sea surface temperatures but also in slightly higher surface salinities (*6, 7*). Thus simultaneous increases in both salinity and sea surface temperatures, such as the ones observed during 1931, cannot be explained on the basis of a cessation of upwelling.

Among the notable factors that control diatom (phytoplankton) abundance and dominance are solar irradiance, predation, and antimetabolites. It might be asked whether changes in these parameters can explain the long-period fluctuation of the diatom biomass.

It is clear that solar irradiance is not the controlling factor in diatom abundance in this region. For example, a bloom of considerable size, over 10^6 cells per liter, can take place when solar irradiance is only ~ 300 langley/day (first bloom in 1937, Fig. 2). Furthermore, the solar irradiance values during 1934, where the diatom biomass is very low, are not smaller than those measured in 1936 when the diatom biomass is anomalously high (*8*).

Unfortunately, we do not have complementary data from the same period to ascertain the effect of grazing by the herbivores. However, as Fogg (*9*) pointed out: "There is a delay in zooplankton increase [in temperate waters] until the algae reach the threshold density necessary for its reproduction, and the rate of multiplication is slow compared with that of the algae. The effect of grazing therefore is likely to be appreciable only

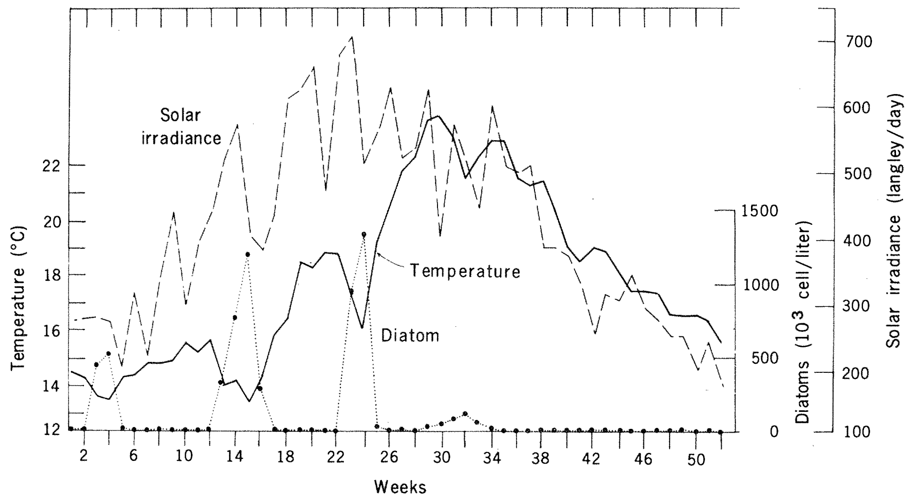

Fig. 1. Solar irradiance, sea surface temperature, and diatom biomass at 32°50′N, 117°10′W for 1936.

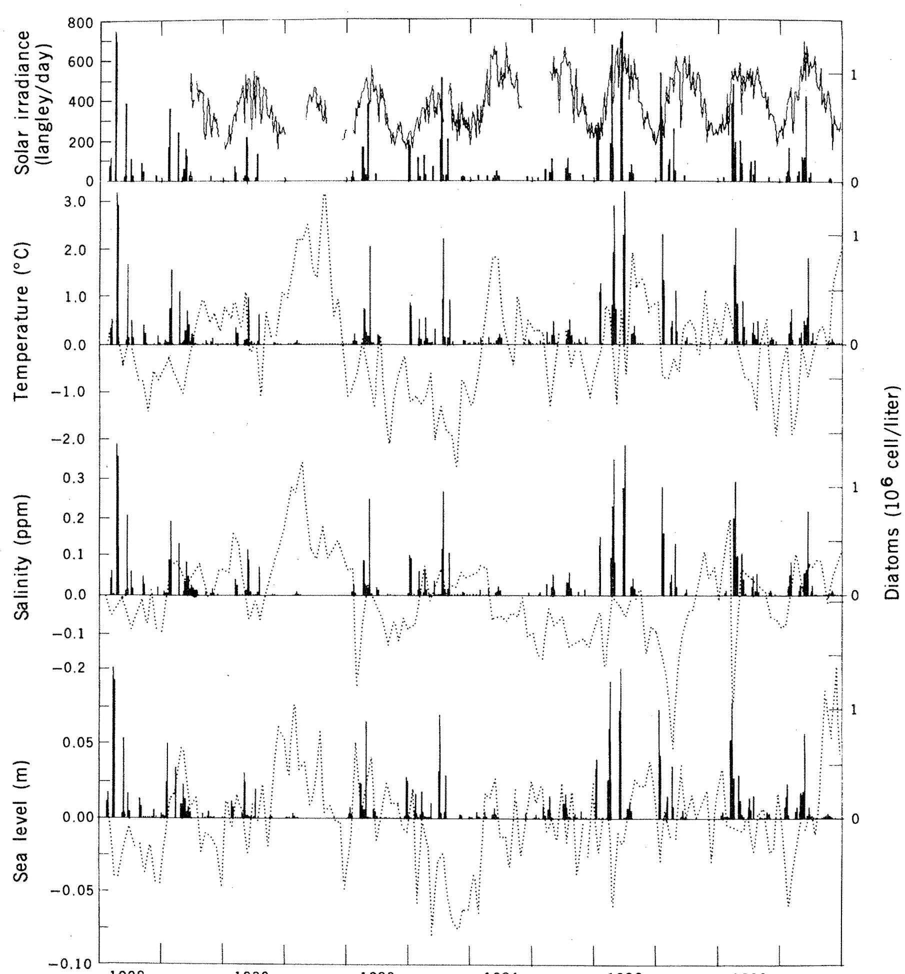

Fig. 2. Diatom biomass (vertical bars); weekly averages of solar irradiance (top curve); monthly temperature, salinity, and sea level anomalies (dotted lines) at 32°50′N, 117°10′W.

in the later stages of spring growth." We also lack data to ascertain the effects of antimetabolites on the diatom populations.

The circulation patterns of the major water masses that affect this region may be responsible for the long-term fluctuations in diatom biomass. Excluding deeper circulation, Reid *et al.* (*7*) recognized four water masses distinguishable by their temperature, salinity, oxygen content, and phosphate content in the California Current. These come from the north, west, south, and below (due to upwelling). Namias and Huang (*10*) and Huang (*11*) concluded that, because of climatic fluctuations, a lessening of north-to-south wind stress results in more eastward oceanic flow from the subtropics and less flow from the California Current system which in turn results in positive sea level anomalies.

Cold and low-salinity water masses brought down by the California Current from the higher latitudes are rich in nutrients (*7*) and consequently support a large phytoplankton population. On the other hand, water masses originating in the west are warmer and more saline and the nutrients in their surface layers are nearly exhausted (*7*). Thus, when the upwelling follows a large influx of nutrient-poor water, the resultant diatom blooms are smaller than those observed when the flow of the California Current is strong.

Several parameters shown in Fig. 2 support this conclusion. Diatom blooms are considerably smaller when large positive salinity and temperature values prevail (*12*). A strong southerly flow, combined with upwelling, further cools the water and results in a lowering of the sea level through isostatic adjustment to changes in the specific volume of the water column (*13*). Thus large diatom blooms would be expected to take place when the sea level is relatively low. Indeed, there is a significant correlation between diatom biomass and sea level values (*14*).

Since diatoms are hydrodynamically passive organisms, the influx of water masses and the consequent mixing processes should result in changes in the total diatom biomass and in the species composition as well. Balech (*15*) reexamined the species composition from Allen's samples collected during the cold periods from 1938 through 1939 and compared those with his own collection sampled from 1957 through 1958 when anomalously high temperatures prevailed. His findings indicate that an abundance of warm-water and tropical species prevailed during the warmer period; however, during the colder period these species were largely absent. He concluded that warm-water species in 1957 through 1958 were not generated locally but were transported from a center of subtropical or even tropical water. My limited analysis of species composition confirms his findings. For example, Balech reported the presence of the warm-water species *Chaetoceros peruvianus* during the period 1957 through 1958. According to Allen's records, this species first appeared during week 28 of 1930, was found only occasionally before week 52 of 1932, and was not seen again during the remaining observation period.

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Risk of Communicable Disease Infection Associated with Wastewater Irrigation in Agricultural Settlements

Abstract. *The incidence of enteric communicable diseases in 77 kibbutzim (agricultural communal settlements) practicing wastewater spray irrigation with partially treated nondisinfected oxidation pond effluent is compared with that in 130 kibbutzim practicing no form of wastewater irrigation. The incidence of shigellosis, salmonellosis, typhoid fever, and infectious hepatitis is two to four times higher in communities practicing wastewater irrigation. No significant differences are found for the incidence of streptococcal infections, tuberculosis, and laboratory-confirmed cases of influenza. Nor are differences found for enteric disease rates during the winter nonirrigation season. Strong wastewater treatment measures, including effective bacterial and viral inactivation through disinfection, are recommended for all cases of sewage irrigation or land disposal near residential areas in light of the potential public health risks involved.*

The subject of airborne microorganisms from wastewater and their health significance was recently investigated by Hickey and Reist (*1*). They reviewed the relevant literature extensively and concluded that aerosols that contain a variety of virulent pathogenic bacteria are emitted and spread from aerated wastewater processes to nearby areas that may be populated. They pointed out, however, that "present evidence does not conclusively confirm or negate the existence of health risk from viable wastewater aerosols," and they stress the need for further investigation. More recently, the lack of conclusive epidemiologic research on disease risks of occupational exposure to sewage was emphasized (*2*).

Wastewater aerosols are formed not only during treatment processes, but also during irrigation with sewage effluents, in particular where the spray or sprinkler system is used. Agricultural irrigation with wastewater is practiced extensively in a number of countries that suffer from water shortage, but the increasing rate of wastewater pollution of natural surface water sources in the majority of countries leads to indirect irriga-