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Factors Effecting Phytoplankton Assemblages in the Lafayette River Estuary

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FACTORS EFFECTING PHYTOPLANKTON ASSEMBLAGES IN THE LAFAYETTE RIVER ESTUARY

by

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ABSTRACT

FACTORS EFFECTING PHYTOPLANKTON ASSEMBLAGES
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Director: Dr. Harold G. Marshall

Chemical and physical parameters were measured with phytoplankton species composition and abundance in the Lafayette River from August to October 1981. Stations located in four distinct areas of the river were statistically analyzed to determine data relationships. Environmental factors considered as potentially influencing the presence and numbers of phytoplankton were salinity, temperature, Secchi depth, tidal phase, orthophosphate, combined nitrates and nitrites, ammonia, and reactive silicates.

The River mouth had higher salinity and nutrient values, with lower temperatures than the other river sections. Diatoms were the dominant cells in this section of the River. At mid-river, salinity and nutrient concentrations decreased, with higher temperatures noted. Common to this area were diatoms and a larger number of phytoflagellates. In the two River branches, flagellated cells were dominant, with increasing numbers of chlorophytes and cyanophytes. Environmental conditions associated with

these areas were low salinity, high temperatures and increased nutrient levels.

Discriminant Function and Pearson Correlation analyses were conducted separately on environmental and biological data sets. Adjacent stations were not significantly different environmentally. However, in areas located other than next to one another, clusters were statistically different at the $\alpha < .05$ level. In analyses using the phytoplankton data set, all areas were statistically different at the $\alpha < .005$ level of significance.

Visual comparisons between the two sets of analyses showed that stations grouped in the same cluster 75% of the time. Of the remaining fraction, half of the cases were associated with severe storm conditions.

DEDICATION

To my parents: Marion and Terrence Kalenak

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Chapter 1

INTRODUCTION

The purpose of this study was to determine existing relationships between the phytoplankton composition and environmental parameters of the Lafayette River from August to October 1981. No previous studies have been conducted in this river to associate seasonal phytoplankton assemblages to specific chemical or physical parameters. However, the influence of water chemistry and other factors on phytoplankton populations has been well documented. For instance, the presence and concentrations of various nutrients have been reported to directly influence the growth of phytoplankton (Raymont, 1980).

Seasonal composition and abundance changes in response to environmental fluxes are also common (Riley, 1947; Pratt, 1965; Frey and Small, 1980). These variations can significantly alter the primary productivity of an area. Specifically, in the Lafayette River estuary, Purcell (1973) noted a bimodal distribution of cells and their abundance. Phytoplankton, in terms of numbers, were elevated during spring and autumn. Summer was characterized by a series of pulses, with numbers low in autumn and winter. Correspondingly, Montgomery (1972) found relatively high levels of phosphate, nitrate, and nitrite during spring and summer in the Lafayette River when compared to other local estuarine systems. He attributed the elevated values to sewage outfall, runoff, and increased use of lawn fertilizer. Lowest concentrations were noted during autumn and winter months.

In many natural water systems, low concentrations of one or more nutrients can limit phytoplankton growth. However, in the Lafayette River, the major nutrients (phosphorus and nitrogen) have been abundant (Montgomery, 1972). Nielson and Sturm (1978) attributed these high values partially to wastewater discharged from local sewage treatment plants. This additional input from runoff and sewage discharge, combined with a low flushing rate would increase eutrophication in the Lafayette River. Initially, this may enhance phytoplankton growth, but with the additional production of organic matter and oxygen depletion, this pattern becomes detrimental (Hodges, 1977). Subsequently, phytoplankton concentrations may decrease, reducing the productivity of the area.

In order to determine relationships between phytoplankton and environmental conditions, both spatial and temporal changes must be investigated. Specific environmental differences were noted by White (1972) in his study of the Lafayette River. He divided the River into four sections based on physical parameters and shoreline contour. Each region had characteristic mixing processes, current velocity, and water density. It is surmised that these factors may also influence the types and numbers of phytoplankton in these waters.

Chapter 2

LITERATURE REVIEW

Studies of phytoplankton in the Chesapeake Bay area began with Wolfe et al. (1926). The authors found five types of variation within the community. These consisted of temporal (hourly), vertical, spatial (horizontal), diurnal, and seasonal differences. Peaks in numbers were found to correspond with periods of increased rainfall in late spring and fall. The first peak was characterized by small sized diatoms indicative of good growing conditions. The autumn peak included diatoms, with the dinoflagellate genera *Ceratium*, *Prorocentrum*, and *Peridinium* (*Protoperidinium*) abundant. Patten, Mulford, and Warinner (1963) found diatoms to be important during colder months, with phyto-flagellates dominant in summer. At stations in the lower Chesapeake Bay, the authors found the autumn peak associated with high dissolved orthophosphate concentrations.

Marshall (1980) also noted a bimodal pattern of phyto-plankton composition in the lower Chesapeake Bay. He found *Skeletonema costatum* dominant in autumn and winter. In spring, dominance shifted to other diatoms, with the genera *Asterionella*, *Thalassiosira*, *Cyclotella*, and *Ceratulina* being common. In summer, the dinoflagellates *Gymnodinium* spp. and *Gyrodinium* spp. were abundant. He also noted that population exchanges occurred between the waters of the Bay and Old Plantation Creek.

Similar growth patterns and species composition have been noted in Virginia coastal waters (Mulford and Norcross, 1971). In addition, Purcell (1973) and Golub (1972) found chain-like diatoms present in high numbers during all but summer months in the Lafayette River. At this time, the phytoflagellates became the dominant cells. Marshall (1966, 1967a, 1967b, and 1968) found many of these same species common in the James River, Willoughby Bay and Hampton Roads, the Elizabeth and Lafayette Rivers. At these sites, small, chain-like diatoms were noted in high numbers between January and August. Phytoflagellates then became dominant during warmer months.

Golub (1972) found temporal changes in dominant species over a year period in the Lafayette River. For most of this time, diatoms were most numerous in his centrally located station. During the summer, however, phytoflagellates increased and became dominant until autumn. Purcell (1973) noted a similar pattern at his stations in the Lafayette River.

Phytoplankton populations are subject to change as influenced by the local physical, chemical, biological, and geological factors. A change in one or more of these variables may initiate a change in the population structure of the phytoplankton and the degree of temporal heterogeneity for an area (Raymont, 1980; Smayda, 1958). Hulburt (1970) noted that different marine systems had different diversities and abundances of phytoplankton. He found that, in shallow estuaries, the competition for nutrients would often lead to the dominance of one species over others. The elimination of some species would eventually ensue. If the availability of nutrients varies, species composition may also vary. For instance, in the Forge River, Barlow, Lorenzen, and Myren (1963) found added nutrients from runoff promoted a pattern of algal growth. This development also influenced the adjacent population of downstream, coastal waters, where cell concentrations increased.

In nearshore systems, nitrogen has been shown to limit phytoplankton growth (Williams, 1972). Williams found nutrient enrichment caused a shift in species to those adapted to high nutrient levels. Taft, Elliot, and Taylor (1977) determined that the nitrogen fluxes within the Chesapeake Bay were cyclic events. The net flux of ammonia and nitrate-nitrogen was seaward in the winter and landward in spring. Pratt (1965) monitored levels of nitrogen, phosphorus, and silica over several years in the Narragansett Bay. The diatom maximum seen during the spring bloom appeared to be regulated by nitrogen and silica concentrations. Cell numbers increased until the nitrogen sources were exhausted. However, the final number of diatoms was a function of the initial silicate concentration. The maximum nutrient levels were reached about two weeks before bloom conditions were attained.

In nutrient enrichment studies conducted under laboratory conditions, Thayer (1974) and Frey and Small (1980) found both phosphorus and nitrogen limiting in certain estuarine waters. Thayer found nitrogen the most severely limiting nutrient; however, the most increased growth occurred with additions of both nutrients. Frey and Small found both major and micronutrients limiting, but final yields depended on only initial major nutrient levels.

Many physical parameters of estuarine systems have been related to community structure changes in phytoplankton. Temperature and salinity are the most discussed factors that potentially alter the presence and numbers of these populations. Harrison and Platt (1980) noted in a Canadian inlet that forty percent of the variation in phytoplankton assimilation number was attributed to temperature. Although the number of cells per liter correlated to changes in water temperature, changes in species composition had no apparent relationship. In similar analyses, Platt, Dickie, and Trites (1970) found high cell numbers associated with high temperatures and high salinities.

In cultures exposed to different salinities, Paasche (1975) reported cell metabolism was altered as the salt content changed. Paasche concluded that salinity was an important factor influencing cell growth, especially in zones between salt and fresh water. In a field study, Ryther et al. (1958) found the dominance of diatoms was inversely related to salinity in a small tidal creek.

Water column depth and Secchi depth values were important parameters associated with phytoplankton assemblages in the Saint-Lawrence Estuary (Sinclair, Subba Rao, and Couture, 1981). Rainfall and the amount of runoff were also considered important to a lesser degree. However, samples taken at frequent intervals did not reveal what caused changes in these phytoplankton populations. Pingree et al. (1977) found thermocline formation, light penetration, and mixing processes were influential in determining types and abundances of cells. Other factors relating to changes in algal community structures were wind stress (Therriault, Lawrence, and Platt, 1978), rainfall (Reimold and Diaber, 1967), and density fronts (Incze and Yentsch, 1981).

Interactions between phytoplankton and other biota can also help determine the numbers and kinds of cells present. Of these, the most obvious is the relationship between predator and prey. Bainbridge (1953) found zooplankton grazing important in the spatial heterogeneity of algal cells. Steele (1974) based his model of heterogeneity on the continual changes in phytoplankton and zooplankton populations. As copepod numbers increased, phytoplankton decreased in numbers due to grazing. In adjacent areas, grazing pressure was relaxed, and cell growth increased. In St. Margaret's Bay, Nova Scotia, Therriault and Platt (1978) noted differential zooplankton grazing was an important factor in creating and maintaining heterogeneity among phytoplankton.

Interactions between members of the phytoplankton community can also determine numbers and species present (Haury, McGowan, and Wiebe, 1978). If a reproductive rate is at a maximum, or a species can out-compete all others, that species will become dominant. Each species has a set of environmental conditions that are optimal for growth. As the conditions change, the species present and their numbers correspondingly change. Diurnal migratory patterns, sinking, and competitive exclusion may also influence which species will survive in an area.

The most reliable population studies include a full array of ecological variables that may effect phytoplankton growth and survival. Riley's (1947) model includes both physical and biological parameters noted to affect changes in the phytoplankton community off Georges Bank. Riley takes into consideration the rates of respiration and grazing, nutrient concentrations, and physical parameters. In a review of studies describing factors affecting the distribution of cells, Smayda (1958) indicated most studies included the same measurements as used in the present study. The majority of studies examined various nutrient and physical factors in relation to the changing phytoplankton population. Jeffries (1962) also noted compositional changes in the plankton community of the Raritan Bay with the fluctuation of environmental factors.

Chapter 3

HYDROGRAPHY

The Lafayette River estuary is located in Norfolk, Virginia. It joins the Elizabeth River in entering Hampton Roads, which connects with the lower Chesapeake Bay (Figure 1). The River has a length of approximately 11 km, and has two branches. Water depth at mid channel ranges from 0.3 to 7.0 m, and width from 115 to 638 m. The mean water volume is 2.66×10^7 m^3 (White, 1972).

The surrounding area is primarily urban, with modest industrial development and several small marinas along its shoreline. Discharge pipes from local storm sewers empty into the main river section and both branches. Commercial and private fishing has been prohibited in the Lafayette due to pollution by industry and local runoff. In addition, several sewage treatment plants (Figure 1) discharge wastes into nearby waters.

Classification of this estuary ranges from B/C (partially mixed) to D, sectionally homogeneous and well-mixed (White, 1972). It is also tidally influenced, with a mean tidal range of 0.82 m. Using White's net non-tidal current velocity measurement of 0.0061 meters per second out of the estuary, a flushing time of 2.10 days is determined. The amount of time needed to totally replace the water on a volume to volume ratio is slightly greater than 2 months, assuming 100% of the average yearly rainfall. With a reduction to 60% of the average yearly rainfall, this time would increase to over 10 months (White, 1972). Since the River received a rainfall well below this average in 1981, this replacement time would be approximately four months.

Chapter 4

METHODS AND MATERIALS

Weekly cruises were made during the period of study in the Lafayette River, where 15 stations were established (Figure 2). Visitations were made from 17 August to 26 October 1981 on the skiff ODU-3. Cruises began at 1000 hours and ended no later than 1600 hours. Stations were occupied for approximately 15 minutes apiece. Stations were a distance of 1 km apart, Station 1 being located at the mouth of the River. In both branches, the distance between stations was decreased to 0.5 km. Samplings were conducted at the visual center of the River, since cross-sectional homogeneity exists (White, 1972).

At each station salinity, temperature, water transparency, column depth, and tidal phase were recorded. Salinity and temperatures were measured using a Beckman inductive salinometer, model RS-5. Water transparency was determined using a Secchi disk.

Water samples were collected using 1.5 liter polypropylene NIO water bottles. Surface and bottom samples were taken at those stations where the water depth was 2 m or greater. At stations with depths less than 2 m, one mid-depth sample was taken. For each depth a 500 ml sample was placed in a polyethylene bottle and preserved with a modified Lugol's solution (Verduin, 1962). Triplicate water samples were taken for nutrient analysis and placed in 250 ml polyethylene bottles. At stations 1, 4, 9, and 13 triplicate 250 ml samples were taken for use in the analysis of reactive silicates.

Samples for nutrient analyses were filtered with a vacuum pump using Gelman A/E glass fiber filters upon returning to the laboratory. Silicate samples were vacuum filtered using Millipore membrane filters. Nutrient analyses were completed within 48 hours of sampling.

Nutrient analyses for ammonia, nitrates and nitrites, and orthophosphate were done using an auto-analyzer, Scientific Instruments, model 200, with associated manifolds. Reactive silicate analysis was done according to Strickland and Parsons (1977) using a Beckman DU spectrophotometer.

In order to more efficiently evaluate the number of phytoplankton samples, the environmental data were statistically grouped. To standardize these data, numbers obtained were divided by the highest values seen for each variable. In doing this, the high concentrations found for one parameter could be treated the same as the low values for another without the first overshadowing the second. In addition, a log transform was performed on all environmental parameters. A non-hierarchal cluster analysis (Gauch, 1979) was used to group like stations. A program to condense the data for input into this Compclus program (Singer and Gauch, 1979) was also implemented. The clustering method was repeated until the lowest number of clusters was obtained.

The data set was then split into those stations at which silicates had been determined and stations with silicate removed from the analysis. This was employed because the clustering program used did not allow for the missing silicate values. Unfortunately, the latter data set exceeded the capacity of the SPSS programs used and no further analyses could be used. Thus, all analyses referred to include only those stations where reactive silicates were measured. Data from the other set are included in the appendices.

Output from the Compclus program also included a priority listing of factors important to each group. The SPSS version of Discriminant Function Analysis (Nie et al., 1975) was performed on the data to determine whether the clusters found were statistically different. This also indicated if those variables listed in the Compclus output truely distinguished stations. A Pearson Correlation (Nie et al., 1975) was then conducted to determine the relationship between the discriminant functions obtained and the original environmental parameters.

Since the lowest number of collections in any cluster was eight, eight phytoplankton samples from each group were chosen randomly for analysis. Water samples obtained had been allowed to settle and siphoned to a volume between 20 and 40 ml. The concentrate was transferred to a glass vial and labelled. Because of the dense phytoplankton population, a dilution process was necessary to allow for more reliable identification and enumeration of cells. Phytoplankton were identified using a modified Utermohl method and a Zeiss inverted microscope. Random fields were examined at 312X and 500X. This was repeated until a minimum of 10 fields or 200 cells were observed. Major keys used to identify cells included Cupp (1943), Drouet (1973), Prescott (1951), and Schiller (1933, 1937). Abundance was determined as the number of cells per liter.

Initial clustering of phytoplankton data proved inconclusive because the analysis grouped stations using the species of higher numbers as a priority criterion. However, these species were ubiquitous and were removed from the data set. Also, species that were found less than three times during the sampling period were deleted using a screening program (Gaugh, 1973), for similar reasons. Discriminant and Pearson Correlation Analyses were then performed on the cell counts, as with the environmental parameters. All patterns defined by the analyses of biological and environmental data sets were compared visually, as no statistical test is available.

Chapter 5

RESULTS

The physical data from the four stations that were sampled per cruise and used in the statistical analyses are listed in Table 1. Collections occurred during all phases of the tidal cycle. Water column depth ranged from 4.5 m at the River mouth to 0.5 m in the River branches. Secchi depth readings decreased up river, indicating increased turbidity. Temperature ranged over the study from a high of 27.58°C to a low of 15.27°C, with water temperatures always highest at stations No. 9 and 13, the stations furthest up river. Temperature decreased as sampling continued into autumn. Salinity ranged from 14.23 to 23.40°/oo, with lowest values in the branches of the Lafayette River. Values below 16°/oo represent periods of increased rainfall and fresh water input into the system. During this period of time, the Norfolk area was subject to severe storm action and increased precipitation. At these times, salinity was markedly decreased, particularly in the branches.

The results of chemical analyses are given in Table 2 for stations 1, 4, 9, and 13. These are shown graphically in Figures 3-6. Ammonia concentrations ranged from 0.28 to 226.81 μg N/liter. These amounts varied with the location of the River sampled. High values were noted during heavy rain conditions at stations where storm sewers were abundant along river banks. These conditions existed at stations 1 and 9. Lowest values were observed at station 13. Combined nitrate and nitrite values ranged from 100 to 1900 µg N/liter. Highest concentrations were at the mouth of the Lafayette River, and were possibly influenced by discharge from local sewage treatment plants. Lowest values were at stations located in both river branches. Orthophosphate concentrations ranged from 64.08 to 1697.96 µg P/liter. Highest values were observed at the mouth of the River, and may also be associated with sewage effluents mixing with these waters. Lowest values were recorded at station 4, located midway up the River, with concentrations increasing in the branches. Reactive silicate values ranged from 8.85 to 84.00 µg Si/liter. These values followed the same pattern as nitrate/nitrite values, being high at the River mouth and lower in the branches.

Four different groups representing the four areas of the River sampled were obtained from the Compclus clustering program. These are indicated by the separate histograms in Figure 7. Factors used in separating these stations are listed in order of importance in Table 3. In the River mouth, high nitrogen and phosphate nutrient values distinguished this area from others. At station 4, reactive silicates, salinity, and temperature were important in identifying this region. In the southern branch (station 9), low nitrogen and high phosphate values were characteristic, whereas the northern branch (station 13) had moderate concentrations of the major nutrients.

Discriminant Analysis results are given in Figure 7. The first discriminant function formed from this program separated groups along the X-axis. Since this was the only function of three that was statistically significant, it is the only one considered in further analyses. This explained nearly 80% of the variation in the data. The histograms represent the frequency of discriminant scores of each cluster. Groups 1 and 3, 1 and 4, 2 and 4, and 3 and 4 were significantly different at the α=.05 level. However, groups 1 and 2, and 2 and 3 were not statistically different. This indicates a continuum, rather than separated, distinct areas. Results of the Pearson Correlation are listed on the X-axis of the graph in Figure 7. The variables listed represent environmental parameters important in determining the discriminant function and are listed in order of importance. An asterisk indicates the variable was statistically important in the Pearson Correlation Analysis. Reactive silicate was not included in the first discriminant function, but was significant in the Pearson Correlation, presumably because it followed the same pattern as another variable. Salinity was noted to be the factor explaining most of the variance between stations. Temperature, tide, combined nitrates and nitrites, ammonia, Secchi depth, and orthophosphate respectively were of decreasing importance in explaining differences in the data set.

The bars above the initial clusters represent the 95%

confidence regions calculated according to Sokol and Rohlf (1981). The X's indicate locations of groups centroids (means). The bars represent the probability that 95% of the time the group centroids would fall within these ranges if the entire experiment were repeated. Those bars that overlap on the X-axis indicate areas of the River not clearly separated by the discriminant functions.

Results from the phytoplankton identification and enumeration are listed in Tables 4-35. These are shown graphically in Figures 8-11. Ubiquitous species were Cylindrotheca closterium, Cryptomonas sp., Leptocylindrus minimus, Pyramimonas sp., and Gymnodinium nelsonii. In addition, an unidentified nanoplankton fraction was present at all stations. These cells, noted as "Green Spheres" in the tables, were separated by size.

Cells important to the four clusters are listed in Table 36. High concentrations of diatoms were characteristic of the stations forming the first cluster. These stations, located at the mouth of the Lafayette River, also had low numbers of phytoflagellates. Common species were Cylindrotheca closterium, Leptocylindrus minimus, Skeletonema costatum, and Thalassiosira nana. At mid-river stations, diatoms remained dominant, with phytoflagellates increasing in number. Actinoptychus senarius, Nitzschia delicatissima, Plagiogramma staurophorum, Amphidinium acutum, and Calycomonas spp. were abundant at these stations. In the southern branch of the River (station 13), low diatom and high phytoflagellate concentrations were noted. Gymnodinium nelsonii, Prorocentrum minimum and Scrippsiella tricoidea increased in number, with the euglenoid Eutreptia lanowii also important. Although not statistically important to this cluster of stations, an increase of blue-green cells was noted. At station 9, located in the northern branch of the Lafayette, phytoflagellates and an unidentified chlorophyte were reported. Common species included Amphidinium acutum, Prorocentrum minimum, and Scrippsiella tricoidea.

In terms of numbers, total cells per liter increased up river. This was mainly due to the unidentified nanoplankton fraction. Total phytoplankton concentration ranged from an average of nearly 5 million cells per liter at the River mouth to 13.5 million in River branches.

The results of all statistical analyses on cell counts are given in Figure 12. The numbers 1 through 4 represent clusters formed by the Compclus program. The X-axis separates these groups according to the first discriminant function formed. The second discriminant function is shown on the Y-axis. Together, these explain 99.9% of the variation in the data set. All groups were statistically different at the $\alpha<.005$ level. The results of the Pearson Correlation are those factors significantly related to the discriminant functions. These are listed along the axes. Those species important to the Pearson Correlation Analysis are indicated by an asterisk. Cylindrotheca closterium,

<u>Eutreptia lanowii</u>, <u>Tabellaria fenestrata</u>, <u>Prorocentrum micans</u>, and the unknown centrales (>20 µm) were not included in the Discriminant Analysis, but significant in the Pearson Correlation. It is presumed these species follow a pattern similar to species significant in the Discriminant Analysis, but do not separate groups as well.

Confidence regions at the α=.05 significance level are represented by the ellipses enclosing discriminant scores of like collections (Sokal and Rohlf, 1981). These represent the probability that 95% of centroids (means) from any group would fall within its respective region if the experiment were repeated. For example, in a similar experimental procedure, 95% of the time the centroid of the discriminant scores from Group 1 would fall within the ellipse for group 1.

Table 37 represents the comparison between stations based on environmental and biological variables. A total of 75% of all stations were grouped alike for both data sets. Table 38 represents the classification of all clusters, indicating where incorrectly grouped collections were found. Of the stations clustered differently, half were associated with severe storm surges. High winds and excess rainfall may have altered either the environmental or biological characteristics of the various areas of the Lafayette River.

Chapter 6

DISCUSSION

Spatial differences were found between all stations analyzed. The four regions of the Lafayette River were separated by both environmental and biological factors. These areas consisted of the River mouth, mid-river, and each of two branches. Stations located in any of these areas consistently had a characteristic set of variables over time.

The River mouth was defined as an area of high salinities, with measurements near 23°/oo being common. Water temperature was low compared to stations upriver. Major nutrient concentrations were highest at Station 1. Reactive silicates had lower concentrations in this region. Characteristic of the mid-river area were lower salinities (19-21°/oo) and higher temperatures. Nitrogen and phosphorus levels were slightly decreased from concentrations in the mouth of the River. Silicate values were elevated from 10-20 μg Si/l at the mouth to 20-30 μg Si/l at Station 4 in the second division of the River. Salinity decreased as sampling continued into both River branches. Values between 16 and 19°/oo were common, with the water temperature highest in the branches. High levels of nutrients were consistently noted at stations in the two branches, indicating input from up river.

These results agree with past studies conducted in the Lafayette River. Montgomery (1972) found high phosphate concentrations at stations in the River mouth and again in the branches. Ranges agreed with those found in the present study. Mid-river had lower concentrations, also indicating inputs from both sources. High values at the mouth were attributed to sewage wastewater mixing with local estuarine waters. The increasing values noted in the branches may have been caused by either industrial waste or runoff containing fertilizer. Neilson and Sturm (1978) also noted that nitrogen and phosphorus concentrations were high in the Lafayette River. However, their nutrient ranges were lower than those in the present study. One reason for this difference could be the sampling period. Neilson and Sturm sampled only once, whereas weekly samplings were taken to obtain a range of values over time in this study. Neilson and Sturm could have missed high values with one time sampling. Neilson (1975) notes long residence times for pollutants in adjacent areas. This condition, combined with a low flushing rate, would concentrate these substances in the River. Since the pollutants noted by Neilson contain both nitrogen and phosphorus, these elements may be accumulating over time, accounting for increased concentrations.

Biologically, the River mouth was characterized by a dominance of diatoms, with low concentrations of phytoflagellates. At Station 4, mid-river, diatoms remained abundant, with an increasing number of phytoflagellates. In both River branches, phytoflagellates were dominant, with diatoms low in number. Chlorophytes and cyanophytes had high concentration at Stations 9 and 13, the southern and northern branches. In terms of numbers per liter, abundance increased up river. This was mainly due to an increase in numbers of the unidentified nanoplankton component.

Purcell (1973) also noted high diatom concentrations at his station in the mouth of the River. The diatoms preferred cooler, more saline waters. At Purcell's Station No. 2, located between mid-river and the branches, an increase in phytoflagellates was noted, but diatoms remained dominant. The same pattern was observed in this study. Flagellated cells appeared to flourish in warmer, less saline waters. The large amount of species overlap between stations was attributed to the closeness of stations. However, abundance of phytoplankton in terms of numbers was very different in the two studies. This may be due to the different methods used for enumeration of cells. Purcell counted cells at 350X. In this study, random fields at 500X enabled the enumeration of a nanoplankton component not accounted for in previous studies.

Although adjacent areas of the Lafayette River were separated by the cluster analysis, these were not statistically different environmentally. However, the discriminant function analysis did distinguish stations not adjacent to each other. One reason for this may be a continuum exists. For instance, stations located in the River mouth may be different from those at mid-river, but some overlap occurs. This was particularly evident during periods of increased rainfall and high winds. These factors may have horizontally mixed waters to establish more uniform conditions. Another reason this would be if a parameter not measured in this study effected the area enough to distinguish these stations. In this case, the factors measured separated areas enough to form different clusters, but did not form statistically significant groups. For example, White (1972) divided the River into the same four areas by shoreline contour, eddy currents, and mixing processes. It is possible these parameters may separate areas significantly if taken into consideration.

Although various environmental factors were important in separating clusters, overall separation, as indicated by the Discriminant Function and Pearson Correlation analyses, found salinity the most significant factor distinguishing stations. Temperature was of secondary importance. These two factors varied consistently throughout the sampling period. The River mouth had high salinities and low temperatures as compared to stations up river. These results agree with Platt, Dickie, and Trites (1970) who found a direct correlation between chlorophyll a values and salinity. However, Paasche (1975) found an inverse relationship between salinity and phytoplankton growth. Differences in these results may be attributed to the measurement of different aspects of phytoplankton dynamics or the fact that other variables may be effecting cells.

Nutrient concentrations were of lesser importance in separating areas of the Lafayette River. Since major nutrients were elevated in concentration throughout the River, these are unlikely to be limiting in the system. With this abundant nutrient supply, the small variations noted in regions may not distinguish stations as well as salinity and temperature.

Stations separated by presence and numbers of phytoplankton corresponded to those separated by environmental parameters. However, all areas of the River were significantly different, including adjacent stations. Those species important in forming each cluster were determined to be statistically significant in Discriminant Function and Pearson Correlation analyses. These included 18 diatoms, 6 dinoflagellates, 2 euglenoids, 1 chlorophyte, 1 cyanophyte, and 2 other phytoflagellates. Diatoms significant at the $\alpha < .05$ level were Cylindrotheca closterium, Gyrosigma fasciola, Navicula sp., Pleurosigma sp., Tabellaria fenestrata, and an unidentified centrales between 20 and 100 μm. Flagellated cells also statistically important at the same α level were Eutreptia lanowii, E. viridis, Prorocentrum minimum, Pyramimonas sp., and Scrippsiella tricoidea. The presence and numbers of these species explain 99.9% of the variation between stations in the

Lafayette River.

In comparing the two sets of completed analyses, stations were classified in the same cluster 75% of the time. During cruises where stations grouped similarly for both environmental and biological parameters, weather conditions were relatively calm. Of the remaining 25%, those stations clustering in different groups, severe weather conditions prevailed. It may be that measured parameters explain phytoplankton population differences under fair weather conditions, while severe storm action, although sporadic, may be of overriding importance. Another reason these stations did not group together could be a lack of distinguishing parameters. Those factors accounted for in the present study may separate these areas most of the time, but other factors not considered may be necessary to explain 100% of the variation between stations. Zooplankton presence and numbers, rainfall, currents, mixing processes, pollutant concentrations, and other factors may account for the remaining variation in the data set.

Although a cause and effect relationship is indicated by comparison, this cannot be shown by the methods used. It appears that a certain set of environmental conditions is associated with specific phytoplankton assemblages, but whether these conditions cause the presence and numbers of cells remains a question. Further study of the Lafayette River system, involving the frequent monitoring of changing environmental and biological conditions, as well as the incorporation of other variables, may advance our knowledge of this and other similar systems.

During the sampling period, a temporal variation in the data set was expected. This was because samplings began during late summer and continued into early fall. At least two groups, defined by these time frames, seemed apparent (Golub, 1975). However, changes in stations over time were not observed during this study. Initial clustering of both data sets showed no change in either environmental or biological water composition at any one area of the River over time. This may be because the sampling period was not long enough to show such differences. Also, since 1981 was a year of low rainfall, the changing parameters associated with the oncoming autumn season may not have been as easily detected.

Changes in phytoplankton community structure may be influenced by changes in various physical and chemical factors. Although a causative relationship cannot be shown, it is indicated that given a particular set of environmental conditions, the presence of certain cells can be expected. Variations from the relationships seen may be caused by other factors not measured, such as pollutant toxicity or oxygen content of the waters. These potentially alter phytoplankton growth and productivity and warrant further study in the Lafayette River estuarine system.

Chapter 7

CONCLUSION

Areas of the Lafayette River were separated in space by both environmental and biological factors. The River mouth was characterized by high salinities and nutrient concentrations, with low temperatures. High numbers of diatoms were noted, with low phytoflagellate concentrations. Mid-river areas had decreased salinity and nutrient concentrations, and increasing temperatures. Although diatoms remained dominant, an increase in flagellated cells was noted. Branches had fairly high nutrient levels and temperatures, with low salinities. The northern Branch had high phytoflagellate concentrations, with an increasing occurrence of chlorophytes. The southern branch also had high numbers of flagellates, with cyanophytes common.

Statistically, stations not adjacent to one another were significantly different in all analyses conducted. However, adjacent areas of the River were statistically different when considering the phytoplankton data base only. Factors not accounted for in this study may be necessary to separate stations on the basis of environmental factors alone. It is also possible that a continuum exists along the River, with conditions being different enough to be associated with different phytoplankton communities.

In comparing results, similar clusters were obtained for 75% of the stations sampled. Stations grouped in different environmental and biological clusters were often associated with increased rainfall and high winds. These factors may be of greater importance than those measured in separating areas of the Lafayette River. It is also possible these storms alter the environmental conditions too rapidly for the phytoplankton population to react accordingly before sampling took place.

Although a cause and effect relationship cannot be shown, it appears that each set of environmental conditions is associated with a certain phytoplankton community structure. Further study is needed to determine if other variables are important to cells within the system.

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TABLES

Table 1. Physical data from Stations 1, 4, 9, and 13 for all cruise dates.

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (‰)	Temperature (°C)
17 August 1981	Storm	1	1.5	0.46	22.85	26.84
	Spring	4	1.0	0.15	21.96	27.22
	High	9	1.0	0.61	20.89	27.58
		13	1.5	0.30	21.12	27.31
24 August 1981	Storm	1	4.0	1.22	22.12	23.40
	Neap	4	2.5	0.46	19.30	23.05
	Low	9	0.5	0.30	14.23	23.14
		13	1.0	0.15	14.42	23.14
31 August 1981	Lower	1	4.0	0.46	22.13	25.38
	Spring	4	2.5	0.46	21.58	26.80
	High	9	2.0	0.30	21.01	26.83
		13	2.0	0.23	20.42	27.30
7 September 1981	Higher	1	3.0	0.76	22.35	25.48
	Neap	4	2.0	0.30	22.00	25.57
	Low	9	1.0	0.61	21.02	25.95
		13	1.0	0.15	21.30	26.45
14 September 1981	Higher	1	2.5	0.91	21.35	26.19
	Spring	4	3.5	0.46	20.92	26.19
	High	9	3.0	0.61	17.52	27.20
		13	1.5	0.30	18.63	26.78

Table 1. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity ($^{o}/oo$)	Temperature (^{o}C)
21 September 1981	Storm	1	4.0	0.76	21.04	21.62
	Neap	4	3.0	0.30	20.54	21.54
	Low	9	1.5	0.61	18.58	21.08
		13	1.0	0.30	19.20	22.00
28 September 1981	Lower	1	4.0	0.91	21.55	21.55
	Spring	4	3.0	0.30	21.48	21.88
	High	9	2.0	0.46	20.41	22.21
		13	2.0	0.46	20.55	21.89
5 October 1981	Higher	1	3.0	0.76	21.41	17.58
	Neap	4	2.5	0.30	21.10	17.50
	Low	9	1.5	0.61	19.64	17.53
		13	2.0	0.30	19.99	18.10
12 October 1981	Storm	1	5.0	1.07	23.20	16.51
	Spring	4	4.5	0.46	22.78	16.10
	High	9	2.0	0.91	20.75	15.58
		13	1.5	0.46	20.89	15.38
19 October 1981	Lower	1	5.0	1.37	23.40	15.85
	Neap	4	2.5	0.46	23.08	16.00
	Low	9	2.5	0.61	22.17	16.37
		13	2.0	0.30	22.29	16.35

Table 1. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (°/oo)	Temperature (°C)
26 October 1981	Lower	1	4.0	1.07	22.39	15.27
	Spring	4	2.5	0.46	21.42	15.35
	High	9	1.5	0.46	14.84	16.30
		13	1.5	0.15	12.38	17.15

Table 2. Chemical data from stations 1, 4, 9, and 13 for all cruise dates.

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l	Reactive Silicates µg Si/l
17 August 1981	1	1	117.01	210.00	508.34	22.18
		2	51.94	240.00	728.59	22.79
		3	32.82	220.00	636.74	22.51
	4	1	32.82	190.00	718.46	40.43
		2	28.98	190.00	741.83	36.01
		3	32.94	210.00	940.26	41.05
	9	1	1.23	360.00	1308.01	84.00
		2	0.35	260.00	1453.93	80.08
		3	0.28	220.00	1430.59	78.40
	13	1	0.28	240.00	1465.62	48.05
		2	0.28	160.00	1453.93	52.81
		3	0.28	180.00	1395.56	59.36
24 August 1981	1	1	126.94	120.00	318.49	26.94
		2	120.85	120.00	389.51	29.01
		3	116.28	120.00	346.89	28.34
	4	1	111.72	120.00	375.32	33.71
		2	102.59	120.00	432.14	42.22
		3	111.72	120.00	460.50	41.55
	9	1	111.72	440.00	460.54	49.50
		2	113.25	300.00	417.94	45.08
		3	105.64	400.00	460.54	40.32
	13	1	126.94	300.00	659.37	26.26
		2	120.85	300.00	630.97	25.20
		3	113.25	260.00	630.97	24.36

Table 2. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l	Reactive Silicates µg Si/l
31 August 1981	1	1	162.29	360.00	178.37	11.65
		2	136.72	260.00	240.31	11.03
		3	141.85	220.00	260.99	10.70
	4	1	119.67	240.00	240.31	15.18
		2	114.56	160.00	116.37	14.45
		3	124.80	180.00	199.02	15.57
	9	1	92.40	120.00	116.37	27.94
		2	97.51	120.00	95.73	28.84
		3	95.82	120.00	95.73	26.54
	13	1	99.22	120.00	137.05	25.98
		2	107.74	120.00	116.37	30.07
		3	100.91	120.00	137.05	29.34
7 September 1981	1	1	126.92	440.00	511.44	16.86
		2	115.43	300.00	589.81	14.73
		3	122.33	400.00	623.40	14.17
	4	1	97.03	300.00	802.50	18.93
		2	101.64	300.00	802.50	18.93
		3	80.95	260.00	813.69	20.78
	9	1	122.33	260.00	1418.13	20.66
		2	126.92	260.00	1406.97	19.66
		3	120.04	170.00	1440.51	17.75
	13	1	170.60	120.00	1686.77	12.60
		2	189.00	170.00	1697.96	10.53
		3	189.00	120.00	1686.77	11.09

Table 2. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l	Reactive Silicates µg Si/l
14 September 1981	1	1	196.62	1270.00	280.39	9.80
		2	186.76	1160.00	335.88	9.46
		3	191.69	1160.00	280.39	8.85
	4	1	107.81	1160.00	280.39	10.36
		2	122.61	1040.00	280.39	10.42
		3	102.89	1270.00	280.39	9.86
	9	1	117.68	1380.00	502.35	11.42
		2	97.94	1040.00	502.35	10.42
		3	88.09	930.00	465.34	11.37
	13	1	83.15	930.00	502.35	15.29
		2	102.89	930.00	483.85	15.23
		3	93.02	710.00	502.35	15.90
21 September 1981	1	1	226.81	630.00	518.16	19.54
		2	208.84	630.00	480.19	17.69
		3	199.85	720.00	461.19	17.92
	4	1	208.84	190.00	423.21	13.16
		2	202.85	360.00	461.19	14.34
		3	208.84	190.00	461.19	15.68
	9	1	178.88	280.00	347.23	39.26
		2	172.89	190.00	309.26	37.74
		3	175.88	100.00	309.26	35.06
	13	1	190.86	100.00	347.23	27.05
		2	193.86	100.00	309.26	23.30
		3	178.88	100.00	309.26	23.80

Table 2. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l	Reactive Silicates µg Si/l
28 September 1981	1	1	98.84	1160.00	767.00	20.72
		2	89.38	1260.00	767.00	20.49
		3	89.38	1160.00	767.00	19.71
	4	1	94.11	640.00	767.00	31.30
		2	84.66	530.00	767.00	33.04
		3	79.93	530.00	767.00	32.48
	9	1	30.27	320.00	932.88	28.67
		2	27.89	320.00	767.00	28.22
		3	32.62	220.00	767.00	26.71
	13	1	27.89	120.00	601.09	32.09
		2	25.54	320.00	767.00	28.67
		3	32.62	220.00	767.00	30.07
5 October 1981	1	1	92.06	1060.00	404.05	28.78
		2	92.06	1060.00	438.28	25.20
		3	95.91	950.00	438.28	25.87
	4	1	40.01	640.00	221.53	26.54
		2	40.01	740.00	221.53	24.30
		3	41.94	840.00	221.53	25.31
	9	1	55.44	1900.00	164.45	37.46
		2	57.36	1370.00	164.45	37.02
		3	51.58	1680.00	153.05	37.02
	13	1	55.44	1480.00	118.82	28.06
		2	51.58	1370.00	118.82	26.21
		3	57.36	1480.00	118.82	25.20

Table 2. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l	Reactive Silicates µg Si/l
12 October 1981	1	1	130.06	1280.00	196.97	28.00
		2	130.06	1380.00	196.97	29.62
		3	130.06	1480.00	196.97	32.42
	4	1	70.46	900.00	108.38	35.67
		2	73.30	800.00	108.38	34.72
		3	77.56	800.00	64.08	34.89
	9	1	47.77	610.00	108.38	25.42
		2	50.60	700.00	108.38	19.43
		3	49.18	520.00	108.38	18.31
	13	1	78.99	520.00	108.38	37.63
		2	90.19	520.00	86.24	40.00
		3	97.85	420.00	108.38	37.41
19 October 1981	1	1	109.34	1460.00	1126.66	32.70
		2	90.19	1380.00	1116.15	35.50
		3	97.85	1460.00	1116.15	34.66
	4	1	90.19	770.00	1032.08	34.61
		2	90.19	840.00	1042.59	35.34
		3	90.19	770.00	1032.08	37.35
	9	1	97.86	460.00	958.52	36.34
		2	97.86	380.00	958.52	38.42
		3	97.86	460.00	948.01	36.23
	13	1	74.87	310.00	727.32	45.14
		2	86.37	310.00	716.81	44.58
		3	74.87	310.00	727.32	46.20

Table 2. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/1	Nitrates and Nitrites µg N/1	Ortho-phosphate µg P/1	Reactive Silicates µg Si/1
26 October 1981	1	1	147.81	850.00	352.04	14.39
		2	143.84	850.00	352.04	14.28
		3	118.01	850.00	374.17	15.90
	4	1	121.97	670.00	263.44	32.59
		2	121.97	670.00	241.30	33.54
		3	119.99	670.00	241.30	29.12
	9	1	145.82	300.00	185.91	48.27
		2	139.86	300.00	208.07	55.16
		3	139.86	300.00	230.21	59.92
	13	1	181.58	300.00	329.90	37.86
		2	175.62	300.00	385.27	40.88
		3	175.62	300.00	407.40	42.34

Table 3. Environmental factors important in distinguishing areas of the River from the Compclus program.

Cluster 1. River Mouth	Cluster 2. Mid-River
Ammonia	Reactive Silicates
Orthophosphate	Salinity
Nitrates and Nitrites	Tidal Phase
Tidal Phase	Secchi Depth
Salinity	Temperature

Cluster 3. Southern Branch	Cluster 4. Northern Branch
Ammonia	Nitrates and Nitrites
Nitrates and Nitrites	Orthophosphate
Tidal Phase	Ammonia
Orthophosphate	Tidal Phase
Temperature	Salinity

Table 4. Phytoplankton composition and abundance from Station 1 on 17 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	7,769
Actinoptychus senarius Ehrenberg	15,537
Amphora sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	38,843
Gyrosigma fasciola (Ehrenberg) Cleve	128
Leptocylindrus minimus Gran	186,447
Navicula cancellata Donkin	23,306
Paralia sulcata (Ehrenberg) Cleve	512
Pleurosigma elongatum W. Smith	256
Pleurosigma sp.	15,537
Rhizosolenia delicatula Cleve	15,537
Skeletonema costatum (Greville) Cleve	15,537
Synedra sp.	256
Thalassionema nitzschioides Hustedt	256
Thalassiosira eccentrica (Ehrenberg) Cleve	7,769
Thalassiosira nana Lohmann	1,920
Unknown centrales (<20 μm)	62,149
Unknown pennales #2 (>20 μm)	23,306
Dinophyceae	
Prorocentrum minimum (Pavillard) Schiller	23,306
Chlorophyceae	
Unknown Chlorophyte	15,537
Cyanophyceae	
Oscillatoria erythraea (Ehrenberg) Kutzing	256
Euglenophyceae	
Eutreptia lanowii Steuer	147,604
Eutreptia viridis Perty	31,074
Others	
Calycomonas ovalis Wulff	285,683
Calycomonas wulfii Conrad and Kufferath	25,971
Cryptomonas sp.	955,540
Green spheres (<3 μm)	3,220,429
Green spheres (3-5 μm)	2,129,628
Green spheres (5-10 μm)	623,309
Pyramimonas sp.	467,482
Total Cells per Liter	8,341,012

Table 5. Phytoplankton composition and abundance from Station 1 on 31 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	30,298
Amphora sp.	64
Asterionella glacialis Castracane	25,248
Chaetoceros compressum Lauder	65,645
Chaetoceros constrictum Gran	1,536
Chaetoceros gracile Schutt	5,050
Chaetoceros sp.	128
Coscinodiscus centralis Ehrenberg	128
Coscinodiscus sp.	64
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	131,290
Ditylum brightwellii (West) Grunow	10,099
Eucampia zoodiacus Ehrenberg	512
Gyrosigma fasciola (Ehrenberg) Cleve	1,024
Leptocylindrus danicus Cleve	512
Leptocylindrus minimus Gran	328,224
Navicula cancellata Donkin	5,050
Nitzschia pungens Grunow	576
Paralia sulcata (Ehrenberg) Cleve	320
Plagiogramma staurophorum (Gregory) Heilberg	10,099
Pleurosigma angulatum (Quekett) W. Smith	5,050
Pleurosigma sp.	256
Rhizosolenia calcar-avis Schultze	192
Rhizosolenia delicatula Cleve	704
Skeletonema costatum (Greville) Cleve	313,075
Streptotheca thamensis Shrubsole	512
Tabellaria fenestrata (Lyngbye) Kutzing	256
Thalassionema nitzschioides Hustedt	25,248
Thalassiosira eccentrica (Ehrenberg) Cleve	64
Thalassiosira gravida Cleve	256
Thalassiosira nana Lohmann	100,992
Unknown centrales (<20 μm)	55,546
Unknown centrales (>20 μm)	64
Unknown pennales #4 (>20 μm)	10,099
Unknown pennates #6 (>20 μm)	15,149
Dinophyceae	
Ceratium lineatum (Ehrenberg) Cleve	64
Gymnodinium nelsonii	5,050
Gymnodinium sp.	15,149
Prorocentrum minimum (Pavillard) Schiller	15,149
Chlorophyceae	
Unknown Chlorophyte	20,198

Table 5. (continued)

	Number Cells per Liter
Euglenophyceae	
Eutreptia lanowii Steuer	15,149
Others	
Calycomonas ovalis Wulff	12,986
Cryptomonas sp.	212,083
Green spheres (<3 μm)	1,688,128
Green spheres (3-5 μm)	1,064,819
Green spheres (5-10 μm)	337,626
Pyramimonas sp.	623,309
Total Cells per Liter	5,153,040

Table 6. Phytoplankton composition and abundance from Stationll on 7 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	64
Actinoptychus senarius Ehrenberg	31,074
Amphora sp.	64
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	50,496
Ditylum brightwellii (West) Grunow	7,769
Gyrosigma fasciola (Ehrenberg) Cleve	64
Leptocylindrus minimus Gran	271,902
Navicula cancellata Donkin	64
Pleurosigma sp.	64
Skeletonema costatum (Greville) Cleve	2,112
Streptotheca thamensis Shrubsole	320
Tabellaria fenestrata (Lyngbye) Kutzing	768
Thalassiosira nana Lohmann	62,149
Unknown centrales (<20 μm)	11,653
Unknown pennales #2 (>20 μm)	3,884
Unknown pennales #4 (>20 μm)	3,884
Unknown pennales #5 (>20 μm)	11,653
Dinophyceae	
Amphidinium acutum Lohmann	3,884
Gymnodinium sp.	3,884
Prorocentrum minimum (Pavillard) Schiller	7,769
Chlorophyceae	
Unknown Chlorophyte	7,769
Euglenophyceae	
Eutreptia lanowii Steuer	15,537
Eutreptia viridis Perty	11,653
Others	
Cryptomonas sp.	295,207
Green spheres (<3 μm)	1,506,330
Green spheres (3-5 μm)	779,136
Green spheres (5-10 μm)	181,798
Pyramimonas sp.	129,856
Total Cells per Liter	3,400,807

Table 7. Phytoplankton composition and abundance from Station 1 on 14 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	20,198
Amphora sp.	6,733
Coscinodiscus centralis Ehrenberg	384
Coscinodiscus marginatus Ehrenberg	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	20,198
Ditylum brightwellii (West) Grunow	128
Gyrosigma fasciola (Ehrenberg) Cleve	128
Leptocylindrus minimus Gran	740,608
Navicula cancellata Donkin	6,733
Plagiogramma staurophorum (Gregory) Heilberg	6,733
Pleurosigma angulatum (Quekett) W. Smith	6,733
Pleurosigma sp.	384
Skeletonema costatum (Greville) Cleve	7,936
Tabellaria fenestrata (Lyngbye) Kutzing	384
Thalassiosira nana Lohmann	53,862
Unknown centrales (<20 μm)	67,328
Unknown pennales #2 (>20 μm)	6,733
Unknown pennales #5 (>20 μm)	6,733
Dinophyceae	
Amphidinium acutum Lohmann	128
Gymnodinium sp.	6,733
Chlorophyceae	
Unknown Chlorophytes	6,733
Euglenophyceae	
Eutreptia lanowii Steuer	20,198
Others	
Cryptomonas sp.	484,762
Green spheres (<3 μm)	3,116,544
Green spheres (3-5 μm)	1,636,186
Green spheres (5-10 μm)	441,510
Pyramimonas sp.	25,971
Total Cells per Liter	6,690,829

Table 8. Phytoplankton composition and abundance from Station 1 on 21 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	7,481
Actinoptychus senarius Ehrenberg	18,702
Amphora sp.	11,221
Chaetoceros gracile Schutt	256
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	93,511
Gyrosigma fasciola (Ehrenberg) Cleve	384
Leptocylindrus minimus Gran	321,678
Navicula cancellata Donkin	11,221
Nitzschia delicatissima Cleve	11,221
Nitzschia pungens Grunow	7,481
Pleurosigma sp.	7,481
Skeletonema costatum (Greville) Cleve	89,771
Unknown centrales (<20 μm)	14,962
Unknown centrales (>20 μm)	3,740
Unknown pennales #2 (>20 μm)	18,702
Unknown pennales #4 (>20 μm)	18,702
Unknown pennales #6 (>20 μm)	14,962
Dinophyceae	
Amphidinium acutum Lohmann	11,221
Gymnodinium nelsonii Martin	512
Prorocentrum ovum (Schiller) Dodge	3,740
Euglenophyceae	
Eutreptia viridis Perty	128
Others	
Cryptomonas sp.	112,213
Green spheres (<3 μm)	3,350,285
Green spheres (3-5 μm)	1,636,186
Green spheres (5-10 μm)	467,482
Pyramimonas sp.	103,885
Total Cells per Liter	6,337,128

Table 9. Phytoplankton composition and abundance from Station 1 on 5 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	2,405
Amphora sp.	4,809
Biddulphia aurita (Lyngbye) Brebisson	2,405
Coscinodiscus sp.	4,873
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	38,473
Ditylum brightwellii (West) Grunow	192
Gyrosigma fasciola (Ehrenberg) Cleve	64
Leptocylindrus minimus Gran	62,519
Navicula cancellata Donkin	4,809
Navicula sp.	64
Plagiogramma staurophorum (Gregory) Heilberg	4,809
Pleurosigma sp.	128
Skeletonema costatum (Greville) Cleve	2,176
Thalassionema nitzschioides Hustedt	12,023
Thalassiosira eccentrica (Ehrenberg) Cleve	64
Unknown centrales (<20 μm)	33,664
Unknown pennales #2 (>20 μm)	9,618
Unknown pennales #4 (>20 μm)	9,618
Unknown pennales #6 (>20 μm)	14,427
Dinophyceae	
Gymnodinium nelsonii Martin	7,214
Gymnodinium sp.	4,809
Prorocentrum sp.	64
Chlorophyceae	
Unknown Chlorophyte	48,091
Euglenophyceae	
Eutreptia lanowii Steuer	4,809
Eutreptia viridis Perty	2,405
Others	
Cryptomonas sp.	293,358
Green spheres (<3 μm)	1,973,811
Green spheres (3-5 μm)	1,207,661
Green spheres (5-10 μm)	168,813
Pyramimonas sp.	38,957
Total Cells per Liter	3,957,132

Table 10. Phytoplankton composition and abundance from Station 1 on 26 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	2,295
Amphora sp.	4,590
Asterionella glacialis Castracane	100,992
Biddulphia aurita (Lyngbye) Brebisson	32
Chaetoceros constrictum Gran	4,590
Chaetoceros curvisetum Cleve	288
Chaetoceros gracile Schutt	11,476
Chaetoceros pendulum Karsten	64
Chaetoceros spp.	512
Corethron criophilum Castracane	2,295
Coscinodiscus lineatus Ehrenberg	160
Coscinodiscus sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	52,791
Ditylum brightwellii (West) Grunow	4,590
Eucampia zoodiacus Ehrenberg	288
Leptocylindrus minimus Gran	22,953
Navicula cancellata Donkin	128
Plagiogramma staurophorum (Gregory) Heilberg	128
Pleurosigma angulatum (Quekett) W. Smith	96
Pleurosigma sp.	2,327
Rhaphoneis amphiceros Ehrenberg	2,295
Rhizosolenia delicatula Cleve	256
Rhizosolenia stolterfothii Peragallo	224
Schroederella delicatula (Peragallo) Pavillard	1,344
Skeletonema costatum (Greville) Cleve	9,280
Streptotheca thamensis Shrubsole	224
Tabellaria fenestrata (Lyngbye) Kutzing	896
Thalassionema nitzschioides Hustedt	512
Thalassiosira eccentrica (Ehrenberg) Cleve	64
Unknown centrales (<20 μm)	2,295
Unknown pennales #2 (>20 μm)	4,590
Unknown pennales #4 (>20 μm)	32
Unknown pennales #6 (>20 μm)	2,295
Dinophyceae	
Gymnodinium nelsonii Martin	96
Gymnodinium sp.	32
Prorocentrum compressum (Bailey) Abe	32
Prorocentrum dentatum Stein	2,295
Prorocentrum micans Ehrenberg	2,295
Prorocentrum minimum (Pavillard) Schiller	2,295
Protoperidinium sp.	32

Table 10. (continued)

	Number Cells per Liter
Euglenophyceae	
Eutreptia lanowii Steuer	2,295
Eutreptia viridis Perty	2,295
Others	
Calciosolenia granii Schiller	2,295
Cryptomonas sp.	201,984
Green spheres (<3 μm)	876,528
Green spheres (3-5 μm)	623,309
Green spheres (5-10 μm)	19,478
Total Cells per Liter	1,970,291

Table 11. Phytoplankton composition and abundance from Station 4 on 17 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	512
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	20,198
Diploneis crabro Ehrenberg	256
Gyrosigma fasciola (Ehrenberg) Cleve	128
Leptocylindrus minimus Gran	403,968
Paralia sulcata (Ehrenberg) Cleve	1,024
Pleurosigma elongatum W. Smith	256
Pleurosigma sp.	10,099
Skeletonema costatum (Greville) Cleve	4,352
Thalassiosira nana Lohmann	2,304
Unknown centrales (<20 µm)	60,595
Unknown pennales #2 (>20 µm)	20,198
Unknown pennales #6 (>20 µm)	20,198
Dinophyceae	
Amphidinium acutum Lohmann	128
Gymnodinium nelsonii Martin	424,166
Prorocentrum compressum (Bailey) Abe	128
Prorocentrum minimum (Pavillard) Schiller	30,298
Chlorophyceae	
Unknown Chlorophyte	50,496
Euglenophyceae	
Eutreptia lanowii Steuer	20,198
Eutreptia viridis Perty	20,198
Others	
Calycomonas ovalis Wulff	25,971
Calycomonas wulfii Conrad and Kufferath	25,971
Cryptomonas sp.	1,070,515
Green spheres (<3 µm)	5,324,096
Green spheres (3-5 µm)	2,726,976
Green spheres (5-10 µm)	1,792,013
Pyramimonas sp.	259,712
Total Cells per Liter	12,314,954

Table 12. Phytoplankton composition and abundance from Station 4 on 31 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	15,149
Chaetoceros constrictum Gran	512
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	60,595
Ditylum brightwellii (West) Grunow	832
Gyrosigma fasciola (Ehrenberg) Cleve	5,050
Leptocylindrus minimus Gran	388,819
Navicula sp.	64
Plagiogramma staurophorum (Gregory) Heilberg	15,149
Pleurosigma angulatum (Quekett) W. Smith	192
Skeletonema costatum (Greville) Cleve	156,538
Streptotheca thamensis Shrubsole	128
Tabellaria fenestrata (Lyngbye) Kutzing	20,198
Thalassiosira eccentrica (Ehrenberg) Cleve	64
Unknown centrales (<20 μm)	25,248
Unknown pennales #4 (>20 μm)	15,149
Unknown pennales #5 (>20 μm)	15,149
Dinophyceae	
Amphidinium acutum Lohmann	5,050
Gymnodinium nelsonii Martin	5,050
Gymnodinium sp.	5,050
Prorocentrum minimum (Pavillard) Schiller	15,149
Scrippsiella tricoidea (Stein) Loeblich III	20,198
Chlorophyceae	
Unknown Chlorophyte	5,050
Euglenophyceae	
Eutreptia lanowii Steuer	40,397
Others	
Cryptomonas sp.	414,067
Green spheres (<3 μm)	2,908,774
Green spheres (3-5 μm)	1,610,214
Green spheres (5-10 μm)	662,266
Pyramimonas sp.	1,506,330
Total Cells per Liter	7,916,431

Table 13. Phytoplankton composition and abundance from Station 4 on 7 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	3,607
Chaetoceros decipiens Cleve	320
Chaetoceros gracilis Schutt	3,607
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	25,248
Ditylum brightwellii (West) Grunow	192
Grammatophora sp.	7,214
Gyrosigma fasciola (Ehrenberg) Cleve	64
Leptocylindrus minimus Gran	371,506
Nitzschia delicatissima Cleve	28,855
Plagiogramma staurophorum (Gregory) Heilberg	7,214
Pleurosigma sp.	256
Skeletonema costatum (Greville) Cleve	2,624
Unknown centrales (<20 μm)	3,607
Unknown pennales #6 (>20 μm)	3,607
Dinophyceae	
Amphidinium acutum Lohmann	128
Gymnodinium nelsonii Martin	320
Gymnodinium sp.	10,821
Prorocentrum micans Ehrenberg	3,607
Prorocentrum minimum (Pavillard) Schiller	3,607
Euglenophyceae	
Eutreptia lanowii Steuer	14,427
Others	
Cryptomonas sp.	248,873
Green spheres (<3 μm)	1,207,661
Green spheres (3-5 μm)	1,999,782
Green spheres (5-10 μm)	168,813
Pyramimonas sp.	25,971
Total Cells per Liter	4,141,931

Table 14. Phytoplankton composition and abundance from Station 4 on 14 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	128
Actinoptychus senarius Ehrenberg	256
Amphora sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	50,496
Ditylum brightwellii (West) Grunow	256
Leptocylindrus minimus Gran	504,960
Melosira moniliformis (Muller) Agardh	640
Navicula cancellata Donkin	8,416
Paralia sulcata (Ehrenberg) Cleve	768
Plagiogramma staurophorum (Gregory) Heilberg	16,832
Pleurosigma sp.	512
Skeletonema costatum (Greville) Cleve	5,888
Thalassiosira nana Lohmann	14,208
Unknown centrales (<20 μm)	67,328
Unknown centrales (>20 μm)	128
Unknown pennales #4 (>20 μm)	8,416
Unknown pennales #5 (>20 μm)	16,832
Dinophyceae	
Amphidinium acutum Lohmann	25,248
Gymnodinium nelsonii Martin	16,832
Gymnodinium sp.	16,832
Prorocentrum minimum (Pavillard) Schiller	25,248
Euglenophyceae	
Eutreptia lanowii Steuer	42,080
Others	
Cryptomonas sp.	934,176
Green spheres (<3 μm)	4,051,507
Green spheres (3-5 μm)	2,856,832
Green spheres (5-10 μm)	337,626
Pyramimonas sp.	77,914
Total Cells per Liter	9,080,487

Table 15. Phytoplankton composition and abundance from Station 4 on 28 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	10,099
Actinoptychus senarius Ehrenberg	768
Biddulphia aurita (Lyngbye) Brebisson	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	302,976
Leptocylindrus minimus Gran	333,274
Navicula cancellata Donkin	10,099
Paralia sulcata (Ehrenberg) Cleve	640
Plagiogramma staurophorum (Gregory) Heilberg	30,298
Pleurosigma sp.	384
Skeletonema costatum (Greville) Cleve	242,381
Thalassiosira nana Lohmann	7,936
Unknown centrales (<20 μm)	60,595
Unknown centrales (>20 μm)	128
Unknown pennales #2 (>20 μm)	10,099
Unknown pennales #4 (>20 μm)	60,595
Unknown pennales #5 (>20 μm)	121,190
Dinophyceae	
Gymnodinium nelsonii Martin	60,595
Prorocentrum minimum (Pavillard) Schiller	128
Chlorophyceae	
Unknown Chlorophyte	30,298
Euglenophyceae	
Eutreptia lanowii Steuer	30,298
Others	
Cryptomonas sp.	1,282,598
Green spheres (<3 μm)	5,324,096
Green spheres (3-5 μm)	3,506,112
Green spheres (5-10 μm)	805,107
Total Cells per Liter	12,230,822

Table 16. Phytoplankton composition and abundance from Station 4 on 12 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Amphora sp.	15,946
Chaetoceros constrictum Gran	1,152
Coscinodiscus sp.	10,631
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	122,253
Gyrosigma fasciola (Ehrenberg) Cleve	384
Leptocylindrus minimus Gran	10,631
Nitzschia delicatissima Cleve	10,631
Plagiogramma staurophorum (Gregory) Heilberg	10,631
Pleurosigma sp.	128
Skeletonema costatum (Greville) Cleve	15,946
Thalassionema nitzschioides Hustedt	10,631
Unknown pennales #4 (>20 μm)	5,315
Unknown pennales #6 (>20 μm)	15,946
Dinophyceae	
Amphidinium acutum Lohmann	10,631
Gymnodinium nelsonii Martin	26,577
Cyanophyceae	
Oscillatoria erythraea (Ehrenberg) Kutzing	5,315
Euglenophyceae	
Eutreptia viridis Perty	10,631
Others	
Cryptomonas sp.	818,567
Green spheres (<3 μm)	4,570,931
Green spheres (3-5 μm)	2,181,581
Green spheres (5-10 μm)	363,597
Pyramimonas sp.	51,942
Total Cells per Liter	8,269,997

Table 17. Phytoplankton composition and abundance from Station 4 on 26 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	2,525
Actinoptychus senarius Ehrenberg	96
Amphora sp.	2,525
Asterionella glacialis Castracane	37,872
Bacillaria paxillifer (Muller) Hendey	352
Chaetoceros decipiens Cleve	96
Chaetoceros gracile Schutt	288
Chaetoceros sp.	160
Coscinodiscus lineatus Ehrenberg	32
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	40,397
Ditylum brightwellii (West) Grunow	32
Gyrosigma fasciola (Ehrenberg) Cleve	2,525
Leptocylindrus minimus Gran	22,723
Paralia sulcata (Ehrenberg) Cleve	160
Plagiogramma staurophorum (Gregory) Heilberg	7,574
Pleurosigma elongatum W. Smith	64
Rhizosolenia stolterfothii Peragallo	64
Schroederella delicatula (Peragallo) Pavillard	832
Skeletonema costatum (Greville) Cleve	25,248
Tabellaria fenestrata (Lyngbye) Kutzing	10,099
Thalassionema nitzschioides Hustedt	10,099
Thalassiosira eccentrica (Ehrenberg) Cleve	64
Unknown centrales (>20 μm)	2,525
Unknown pennales #6 (>20 μm)	2,525
Dinophyceae	
Amphidinium acutum Lohmann	5,050
Gymnodinium nelsonii Martin	7,574
Gymnodinium sp.	30,298
Prorocentrum micans Ehrenberg	32
Prorocentrum minimum (Pavillard) Schiller	5,050
Cyanophyceae	
Agmenellum thermale (Kutz) Drouet and Daily	5,248
Oscillatoria erythraea (Ehrenberg) Kutzing	32
Euglenophyceae	
Eutreptia lanowii Steuer	2,525
Others	
Cryptomonas sp.	416,592
Green spheres (<3 μm)	954,442

Table 17. (continued)

	Number Cells per Liter
Green spheres (3-5 μm)	564,874
Green spheres (5-10 μm)	38,957
Pyramimonas sp.	38,957
Total Cells per Liter	2,238,508

Table 18. Phytoplankton composition and abundance from Station 9 on 17 Autust 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	30,298
Amphora sp.	256
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	30,298
Navicula cancellata Donkin	10,099
Pleurosigma angulatum (Quekett) W. Smith	256
Pleurosigma sp.	20,198
Skeletonema costatum (Greville) Cleve	4,096
Thalassiosira nana Lohmann	768
Unknown centrales (<20 μm)	60,595
Unknown pennales #2 (>20 μm)	128
Unknown pennales #5 (>20 μm)	30,298
Dinophyceae	
Amphidinium acutum Lohmann	20,198
Gymnodinium nelsonii Martin	1,020,019
Prorocentrum minimum (Pavillard) Schiller	40,397
Scrippsiella tricoidea (Stein) Loeblich III	20,198
Chlorophyceae	
Unknown Chlorophyte	20,198
Euglenophyceae	
Eutreptia viridis Perty	40,397
Others	
Calycomonas ovalis Wulff	25,971
Cryptomonas sp.	1,181,606
Green spheres (<3 μm)	7,142,080
Green spheres (3-5 μm)	5,038,413
Green spheres (5-10 μm)	1,298,560
Pyramimonas sp.	103,885
Total Cells per Liter	16,139,212

Table 19. Phytoplankton composition and abundance from Station 9 on 31 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	256
Amphora sp.	128
Chaetoceros constrictum Gran	640
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	18,362
Gyrosigma fasciola (Ehrenberg) Cleve	128
Leptocylindrus minimus Gran	128,535
Navicula cancellata Donkin	9,181
Navicula sp.	128
Paralia sulcata (Ehrenberg) Cleve	896
Pleurosigma angulatum (Quekett) W. Smith	256
Pleurosigma elongatum W. Smith	128
Skeletonema costatum (Greville) Cleve	10,496
Thalassiosira nana Lohmann	36,724
Unknown centrales (>20 μm)	18,362
Unknown pennales #2 (>20 μm)	128
Unknown pennales #4 (>20 μm)	18,362
Unknown pennales #5 (>20 μm)	18,362
Dinophyceae	
Ceratium fusus (Ehrenberg) Dujardin	128
Gymnodinium nelsonii Martin	174,441
Gymnodinium sp	27,543
Prorocentrum minimum (Pavillard) Schiller	36,724
Scrippsiella tricoidea (Stein) Loeblich III	523,322
Chlorophyceae	
Crucigenia fenestrata Schmidle	9,181
Unknown Chlorophyte	18,362
Euglenophyceae	
Eutreptia lanowii Steuer	55,087
Others	
Calycomonas ovalis Wulff	51,942
Calycomonas wulfii Conrad and Kufferath	103,885
Cryptomonas sp.	1,221,085
Green spheres (<3 μm)	6,103,232
Green spheres (3-5 μm)	4,181,363
Green spheres (5-10 μm)	986,906
Pyramimonas sp.	986,906
Total Cells per Liter	14,741,179

Table 20. Phytoplankton composition and abundance from Station 9 on 14 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	20,198
Coscinodiscus sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	10,099
Leptocylindrus minimus Gran	515,059
Skeletonema costatum (Greville) Cleve	3,840
Unknown pennales #5 (>20 μm)	512
Unknown pennales #6 (>20 μm)	60,595
Dinophyceae	
Amphidinium acutum Lohmann	100,992
Gymnodinium nelsonii Martin	777,638
Prorocentrum minimum (Pavillard) Schiller	70,694
Scrippsiella tricoidea (Stein) Loeblich III	10,099
Chlorophyceae	
Crucigenia fenestrata Schmidle	20,198
Euglenophyceae	
Eutreptia lanowii Steuer	40,397
Others	
Cryptomonas sp.	1,161,408
Green spheres (<3 μm)	7,479,706
Green spheres (3-5 μm)	4,778,701
Green spheres (5-10 μm)	701,222
Pyramimonas sp.	363,597
Total Cells per Liter	16,115,083

Table 21. Phytoplankton composition and abundance from Station 9 on 28 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	384
Coscinodiscus sp.	10,099
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	1,454,285
Leptocylindrus minimus Gran	2,029,939
Navicula cancellata Donkin	128
Pleurosigma sp.	3,072
Skeletonema costatum (Greville) Cleve	40,397
Thalassiosira nana Lohmann	70,694
Unknown pennales #4 (>20 μm)	40,397
Unknown pennales #5 (>20 μm)	141,389
Dinophyceae	
Amphidinium acutum Lohmann	640
Gymnodinium nelsonii Martin	777,638
Gymnodinium sp.	10,099
Prorocentrum minimum (Pavillard) Schiller	10,099
Chlorophyceae	
Unknown Chlorophyte	272,678
Euglenophyceae	
Eutreptia lanowii Steuer	10,099
Others	
Cryptomonas sp.	1,181,606
Green spheres (<3 μm)	6,804,454
Green spheres (3-5 μm)	4,467,046
Green spheres (5-10 μm)	1,298,560
Pyramimonas sp.	181,798
Total Cells per Liter	18,805,501

Table 22. Phytoplankton composition and abundance from Station 9 on 5 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	256
Actinoptychus senarius Ehrenberg	128
Coscinodiscus lineatus Ehrenberg	256
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	624,314
Gyrosigma fasciola (Ehrenberg) Cleve	384
Nitzschia delicatissima Cleve	36,724
Pleurosigma elongatum W. Smith	18,362
Pleurosigma sp.	384
Thalassiosira eccentrica (Ehrenberg) Cleve	256
Unknown pennales #6 (>20 μm)	768
Dinophyceae	
Amphidinium acutum Lohmann	82,630
Gymnodinium nelsonii Martin	229,527
Gymnodinium sp.	9,181
Prorocentrum minimum (Pavillard) Schiller	55,087
Protoperidinium sp.	128
Scrippsiella tricoidea (Stein) Loeblich III	9,181
Others	
Cryptomonas sp.	835,479
Green spheres (<3 μm)	3,635,968
Green spheres (3-5 μm)	2,519,206
Green spheres (5-10 μm)	805,107
Pyramimonas sp.	51,942
Total Cells per Liter	8,915,268

Table 23. Phytoplankton composition and abundance from Station 9 on 12 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	5,050
Actinoptychus senarius Ehrenberg	5,050
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	287,827
Gyrosigma fasciola (Ehrenberg) Cleve	64
Leptocylindrus minimus Gran	10,099
Melosira moniliformis (Muller) Agardh	192
Navicula cancellata Donkin	5,050
Navicula sp.	128
Pleurosigma sp.	5,050
Thalassionema nitzschioides Hustedt	256
Unknown centrales (>20 µm)	5,050
Unknown pennales #5 (<20 µm)	5,050
Dinophyceae	
Amphidinium acutum Lohmann	757,440
Gymnodinium nelsonii Martin	50,496
Gymnodinium sp.	10,099
Scrippsiella tricoidea (Stein) Loeblich III	5,050
Chlorophyceae	
Scenedesmus quadricauda (Turpin) Brebisson	20,198
Others	
Cryptomonas sp.	701,894
Green spheres (<3 µm)	2,804,890
Green spheres (3-5 µm)	1,701,114
Green spheres (5-10 µm)	194,784
Pyramimonas sp.	25,971
Total Cells per Liter	5,069,802

Table 24. Phytoplankton composition and abundance from Station 9 on 26 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	128
Actinoptychus senarius Ehrenberg	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	151,488
Gyrosigma fasciola (Ehrenberg) Cleve	128
Navicula forcipata Greville	128
Pleurosigma sp.	20,198
Rhizosolenia fragilissima Bergon	640
Skeletonema costatum (Greville) Cleve	30,298
Unknown pennales #2 (>20 μm)	128
Unknown pennales #6 (>20 μm)	20,198
Dinophyceae	
Amphidinium acutum Lohmann	10,099
Gymnodinium nelsonii Martin	1,287
Gymnodinium sp.	20,198
Others	
Cryptomonas sp.	2,666,189
Green spheres (<3 μm)	8,518,554
Green spheres (3-5 μm)	5,038,413
Green spheres (5-10 μm)	337,626
Pyramimonas sp.	155,827
Total Cells per Liter	16,971,655

Table 25. Phytoplankton composition and abundance from Station 13 on 17 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	2,432
Amphora sp.	256
Coscinodiscus sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	121,190
Ditylum brightwellii (West) Grunow	128
Leptocylindrus minimus Gran	40,397
Pleurosigma elongatum W. Smith	256
Pleurosigma sp.	512
Skeletonema costatum (Greville) Cleve	5,376
Thalassionema nitzschioides Hustedt	256
Thalassiosira nana Lohmann	40,397
Unknown pennales #4 (>20 µm)	10,099
Unknown pennales #5 (>20 µm)	10,099
Dinophyceae	
Amphidinium acutum Lohmann	20,198
Gymnodinium nelsonii Martin	545,357
Gymnodinium sp.	40,397
Prorocentrum minimum (Pavillard) Schiller	50,496
Scrippsiella tricoidea (Stein) Loeblich III	30,298
Chlorophyceae	
Unknown Chlorophyte	20,198
Euglenophyceae	
Eutreptia lanowii Steuer	10,099
Eutreptia viridis Perty	2,304
Others	
Calycomonas ovalis Wulff	103,885
Calycomonas wulfii Conrad and Kufferath	25,971
Cryptomonas sp.	1,282,598
Green spheres (<3 µm)	8,051,072
Green spheres (3-5 µm)	4,830,643
Green spheres (5-10 µm)	1,298,560
Pyramimonas sp.	51,942
Total Cells per Liter	16,595,544

Table 26. Phytoplankton composition and abundance from Station 13 on 24 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	256
Actinoptychus senarius Ehrenberg	10,099
Amphora sp.	256
Coscinodiscus sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	30,298
Leptocylindrus minimus Gran	20,198
Melosira moniliformis (Muller) Agardh	512
Pleurosigma sp.	128
Skeletonema costatum (Greville) Cleve	1,024
Unknown centrales (<20 μm)	30,298
Unknown pennales #4 (>20 μm)	20,198
Unknown pennales #6 (>20 μm)	20,198
Dinophyceae	
Gymnodinium nelsonii Martin	4,261,862
Prorocentrum dentatum Stein	20,198
Scrippsiella tricoidea (Stein) Loeblich III	40,397
Dinoflagellate cysts	30,298
Cyanophyceae	
Oscillatoria splendida Greville	272,678
Euglenophyceae	
Eutreptia viridis Perty	212,083
Others	
Cryptomonas sp.	575,654
Green spheres (<3 μm)	8,570,496
Green spheres (3-5 μm)	4,467,046
Green spheres (5-10 μm)	883,021
Pyramimonas sp.	129,856
Total Cells per Liter	19,597,182

Table 27. Phytoplankton composition and abundance from Station 13 on 31 August 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	128
Amphora sp.	7,769
Coscinodiscus sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	27,190
Leptocylindrus minimus Gran	73,802
Nitzschia delicatissima Cleve	15,537
Pleurosigma sp.	3,884
Rhaphoneis surirella (Ehrenberg) Grunow	38,843
Skeletonema costatum (Greville) Cleve	5,888
Thalassionema nitzschioides Hustedt	384
Unknown centrales (>20 μm)	3,884
Dinophyceae	
Gymnodinium nelsonii Martin	341,819
Gymnodinium sp.	66,033
Prorocentrum minimum (Pavillard) Schiller	7,769
Chlorophyceae	
Unknown Chlorophyte	11,653
Cyanophyceae	
Nostoc commune Vauch	23,306
Euglenophyceae	
Eutreptia lanowii Steuer	11,653
Others	
Calycomonas ovalis Wulff	77,914
Cryptomonas sp.	167,025
Green spheres (<3 μm)	3,584,026
Green spheres (3-5 μm)	2,519,206
Green spheres (5-10 μm)	883,021
Pyramimonas sp.	15,537
Total Cells per Liter	7,886,399

Table 28. Phytoplankton composition and abundance from Station 13 on 7 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Amphora sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	15,537
Leptocylindrus minimus Gran	31,074
Thalassiosira eccentrica (Ehrenberg) Cleve	128
Unknown centrales (<20 μm)	23,306
Unknown pennales #2 (>20 μm)	7,769
Unknown pennales #5 (>20 μm)	7,769
Unknown pennales #6 (>20 μm)	15,537
Dinophyceae	
Amphidinium acutum Lohmann	69,918
Gymnodinium nelsonii Martin	77,686
Gymnodinium sp.	15,537
Prorocentrum minimum (Pavillard) Schiller	31,074
Chlorophyceae	
Crucigenia fenestrata Schmidle	7,769
Unknown Chlorophyte	7,769
Euglenophyceae	
Eutreptia lanowii Steuer	69,918
Others	
Calycomonas wulfii Conrad and Kufferath	25,971
Cryptomonas sp.	1,196,367
Green spheres (<3 μm)	5,220,211
Green spheres (3-5 μm)	4,467,046
Green spheres (5-10 μm)	1,116,762
Pyramimonas sp.	857,050
Total Cells per Liter	13,264,326

Table 29. Phytoplankton composition and abundance from Station 13 on 14 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Amphora sp.	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	10,099
Grammatophora sp.	20,198
Leptocylindrus minimus Gran	353,472
Navicula cancellata Donkin	256
Pleurosigma sp.	384
Thalassiosira eccentrica (Ehrenberg) Cleve	128
Thalassiosira nana Lohmann	1,536
Unknown centrales (>20 μm)	10,099
Unknown pennales #5 (>20 μm)	768
Unknown pennales #6 (>20 μm)	10,099
Dinophyceae	
Amphidinium acutum Lohmann	201,984
Gymnodinium nelsonii Martin	232,282
Gymnodinium sp.	10,099
Prorocentrum minimum (Pavillard) Schiller	40,397
Chlorophyceae	
Unknown Chlorophyte	10,099
Euglenophyceae	
Eutreptia lanowii Steuer	10,099
Others	
Cryptomonas sp.	1,141,210
Green spheres (<3 μm)	6,155,174
Green spheres (3-5 μm)	4,077,478
Green spheres (5-10 μm)	805,107
Pyramimonas sp.	623,309
Total Cells per Liter	13,714,405

Table 30. Phytoplankton composition and abundance from Station 13 on 21 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	256
Actinoptychus senarius Ehrenberg	128
Amphora sp.	10,099
Coscinodiscus marginatus Ehrenberg	10,099
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	90,893
Leptocylindrus minimus Gran	80,794
Pleurosigma sp.	896
Skeletonema costatum (Greville) Cleve	4,096
Thalassiosira nana Lohmann	3,840
Unknown pennales #4 (>20 μm)	10,099
Unknown pennales #5 (>20 μm)	60,595
Dinophyceae	
Gymnodinium nelsonii Martin	2,272,370
Gymnodinium sp.	10,099
Prorocentrum minimum (Pavillard) Schiller	640
Scrippsiella trichoidea (Stein) Loeblich III	20,198
Chlorophyceae	
Unknown Chlorophyte	70,694
Euglenophyceae	
Eutreptia lanowii Steuer	70,694
Others	
Cryptomonas sp.	1,322,995
Green spheres (<3 μm)	6,518,771
Green spheres (3-5 μm)	3,765,824
Green spheres (5-10 μm)	571,366
Pyramimonas sp.	207,770
Total Cells per Liter	15,103,216

Table 31. Phytoplankton composition and abundance from Station 13 on 28 September 1981.

	Number Cells per Liter
Bacillariophyceae	
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	1,282,598
Leptocylindrus minimus Gran	3,241,843
Navicula sp.	128
Pleurosigma elongatum W. Smith	30,298
Skeletonema costatum (Greville) Cleve	141,389
Thalassiosira nana Lohmann	30,298
Thalassiosira sp.	512
Unknown centrales (<20 μm)	30,298
Unknown centrales (>20 μm)	10,099
Unknown pennales #4 (>20 μm)	20,198
Unknown pennales #5 (>20 μm)	212,083
Unknown pennales #6 (>20 μm)	10,099
Dinophyceae	
Amphidinium acutum Lohmann	80,794
Gymnodinium nelsonii Martin	1,413,888
Gymnodinium sp.	20,198
Prorocentrum minimum (Pavillard) Schiller	20,198
Prorocentrum sp.	20,198
Scrippsiella tricoidea (Stein) Loeblich III	20,198
Chlorophyceae	
Unknown Chlorophyte	90,893
Others	
Cryptomonas sp.	424,166
Green spheres (<3 μm)	4,025,536
Green spheres (3-5 μm)	3,428,198
Green spheres (5-10 μm)	1,168,704
Pyramimonas sp.	233,741
Total Cells per Liter	15,946,555

Table 32. Phytoplankton composition and abundance from Station 13 on 5 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	10,099
Amphora sp.	10,099
Coscinodiscus marginatus Ehrenberg	384
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	444,365
Gyrosigma fasciola (Ehrenberg) Cleve	128
Leptocylindrus minimus Gran	20,198
Navicula sp.	128
Pleurosigma angulatum (Quekett) W. Smith	256
Pleurosigma sp.	10,099
Rhizosolenia setigera Brightwell	384
Skeletonema costatum (Greville) Cleve	20,198
Unknown pennales #4 (>20 µm)	20,198
Unknown pennales #5 (>20 µm)	20,198
Dinophyceae	
Amphidinium acutum Lohmann	141,389
Gymnodinium nelsonii Martin	595,853
Gymnodinium sp.	20,198
Prorocentrum minimum (Pavillard) Schiller	40,397
Scrippsiella tricoidea (Stein) Loeblich III	10,099
Chlorophyceae	
Unknown Chlorophyte	60,595
Euglenophyceae	
Eutreptia lanowii Steuer	60,595
Others	
Cryptomonas sp.	1,151,309
Green spheres (<3 µm)	5,324,096
Green spheres (3-5 µm)	3,480,141
Green spheres (5-10 µm)	493,453
Pyramimonas sp.	129,856
Total Cells per Liter	12,064,715

Table 33. Phytoplankton composition and abundance from Station 13 on 12 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Actinoptychus senarius Ehrenberg	256
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	383,770
Leptocylindrus minimus Gran	121,190
Pleurosigma elongatum W. Smith	128
Pleurosigma sp.	896
Skeletonema costatum (Greville) Cleve	512
Unknown pennales (<20 μm)	10,099
Unknown pennales #6 (>20 μm)	10,099
Dinophyceae	
Amphidinium acutum Lohmann	252,480
Gymnodinium nelsonii Martin	60,595
Gymnodinium sp.	30,298
Others	
Cryptomonas sp.	1,141,210
Green spheres (<3 μm)	7,713,446
Green spheres (3-5 μm)	3,843,738
Green spheres (5-10 μm)	779,136
Pyramimonas sp.	129,856
Total Cells per Liter	14,477,709

Table 34. Phytoplankton composition and abundance from Station 13 on 19 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Acanthes sp.	10,099
Chaetoceros gracile Schutt	384
Coscinodiscus lineatus Ehrenberg	128
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	252,480
Ditylum brightwellii (West) Grunow	256
Leptocylindrus minimus Gran	80,794
Nitzschia delicatissima Cleve	20,198
Paralia sulcata (Ehrenberg) Cleve	256
Pleurosigma elongatum W. Smith	128
Pleurosigma sp.	10,099
Skeletonema costatum (Greville) Cleve	20,198
Unknown centrales (<20 μm)	128
Unknown pennales #6 (>20 μm)	10,099
Dinophyceae	
Amphidinium acutum Lohmann	30,298
Gymnodinium nelsonii Martin	20,198
Prorocentrum minimum (Pavillard) Schiller	10,099
Others	
Cryptomonas sp.	1,797,658
Green spheres (<3 μm)	4,337,190
Green spheres (3-5 μm)	2,701,005
Green spheres (5-10 μm)	519,424
Pyramimonas sp.	25,971
Total Cells per Liter	9,847,090

Table 35. Phytoplankton composition and abundance from Station 13 on 26 October 1981.

	Number Cells per Liter
Bacillariophyceae	
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	158,702
Gyrosigma fasciola (Ehrenberg) Cleve	7,214
Leptocylindrus minimus Gran	57,710
Navicula cancellata Donkin	256
Nitzschia obtusa W. Smith	384
Nitzschia pungens Grunow	384
Paralia sulcata (Ehrenberg) Cleve	384
Pleurosigma angulatum (Quekett) W. Smith	7,214
Rhizosolenia hebetata f. *semispina* (Hensen) Gran	128
Unknown pennales #6 (>20 µm)	28,855
Dinophyceae	
Amphidinium schroederi Schiller	7,214
Gymnodinium nelsonii Martin	28,855
Gymnodinium sp.	7,214
Cyanophyceae	
Oscillatoria erythraea (Ehrenberg) Kutzing	768
Others	
Cryptomonas sp.	1,183,049
Green spheres (<3 µm)	2,662,048
Green spheres (3-5 µm)	1,796,341
Green spheres (5-10 µm)	151,499
Pyramimonas sp.	14,427
Total Cells per Liter	6,112,646

Table 36. Phytoplankton species important in distinguishing areas of the River from the COMPCLUS program.

Cluster 1 - River Mouth

Cylindrotheca closterium
Leptocylindrus minimus
Skeletonema costatum
Thalassiosira nana
Amphidinium acutum
Gymnodinium nelsonii
Gymnodinium sp.
Prorocentrum minimum
Scrippsiella tricoidea
Unknown Chlorophyte
Eutreptia lanowii
Calycomonas ovalis
Pyramimonas sp.

Cluster 2 - Mid-River

Actinoptychus senarius
Cylindrotheca closterium
Leptocylindrus minimus
Nitzschia delicatissima
Plagiogramma staurophorum
Skeletonema costatum
Unknown centrales (<20 μm)
Unknown pennales #2 (>20 μm)
Amphidinium acutum
Gymnodinium nelsonii
Scrippsiella tricoidea
Unknown Chlorophyte
Calycomonas ovalis
Calycomonas wulfii
Pyramimonas sp.

Cluster 3 - Southern Branch

Actinoptychus senarius
Cylindrotheca closterium
Leptocylindrus minimus
Skeletonema costatum
Unknown centrales (<20 μm)
Unknown pennales #5 (>20 μm)
Amphidinium acutum
Gymnodinium nelsonii
Gymnodinium sp.
Prorocentrum minimum
Scrippsiella tricoidea
Eutreptia lanowii
Calycomonas ovalis
Pyramimonas sp.

Cluster 4 - Northern Branch

Acanthes sp.
Cylindrotheca closterium
Leptocylindrus minimus
Plagiogramma staurophorum
Pleurosigma sp.
Skeletonema costatum
Amphidinium acutum
Gymnodinium nelsonii
Gymnodinium sp.
Prorocentrum minimum
Scrippsiella tricoidea
Unknown Chlorophyte
Calycomonas ovalis
Calycomonas wulfii
Pyramimonas sp.

Table 37. Comparison of environmental and biological clusters for Stations 1, 4, 9, and 13.

Cruise Date	Station	Environmental Cluster	Biological Cluster
17 August 1981	1	1	1
	4	2	2
	9	4	2
	13	3	3
24 August 1981	13	3	3
31 August 1981	1	1	1
	4	2	2
	9	4	4
	13	3	3
7 September 1981	1	1	1
	4	1	1
	13	3	3
14 September 1981	1	1	1
	4	2	1
	9	4	2
	13	3	3
21 September 1981	1	1	1
	13	3	3
28 September 1981	4	3	1
	9	4	2
	13	2	2
5 October 1981	1	1	1
	9	2	3
	13	2	2
12 October 1981	4	2	1
	9	4	4
	13	4	4
19 October 1981	13	3	4
26 October 1981	1	1	1
	4	2	2
	9	4	4
	13	4	4

Table 38. Summary of cluster classifications for both environmental and biological data sets, indicating percentages belonging to each category. Underlined values indicate correctly classified collections.

Environmental Cluster	Biological Cluster			
	1	2	3	4
1	<u>100.0</u>	0.0	0.0	0.0
2	25.0	<u>62.5</u>	12.5	0.0
3	12.5	0.0	<u>75.0</u>	12.5
4	0.0	37.5	0.0	<u>62.5</u>

FIGURES

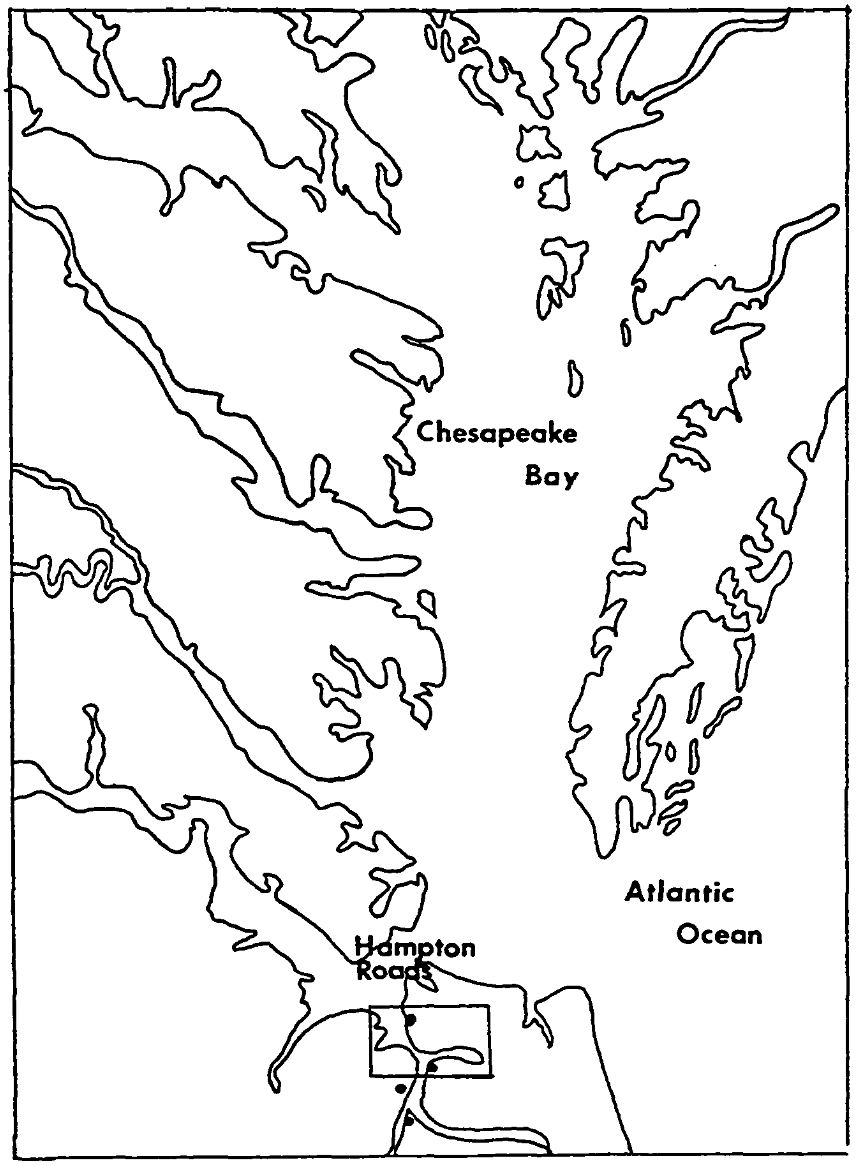

Figure 1. Chesapeake Bay area showing the Lafayette River. Circles indicate locations of sewage treatment plants.

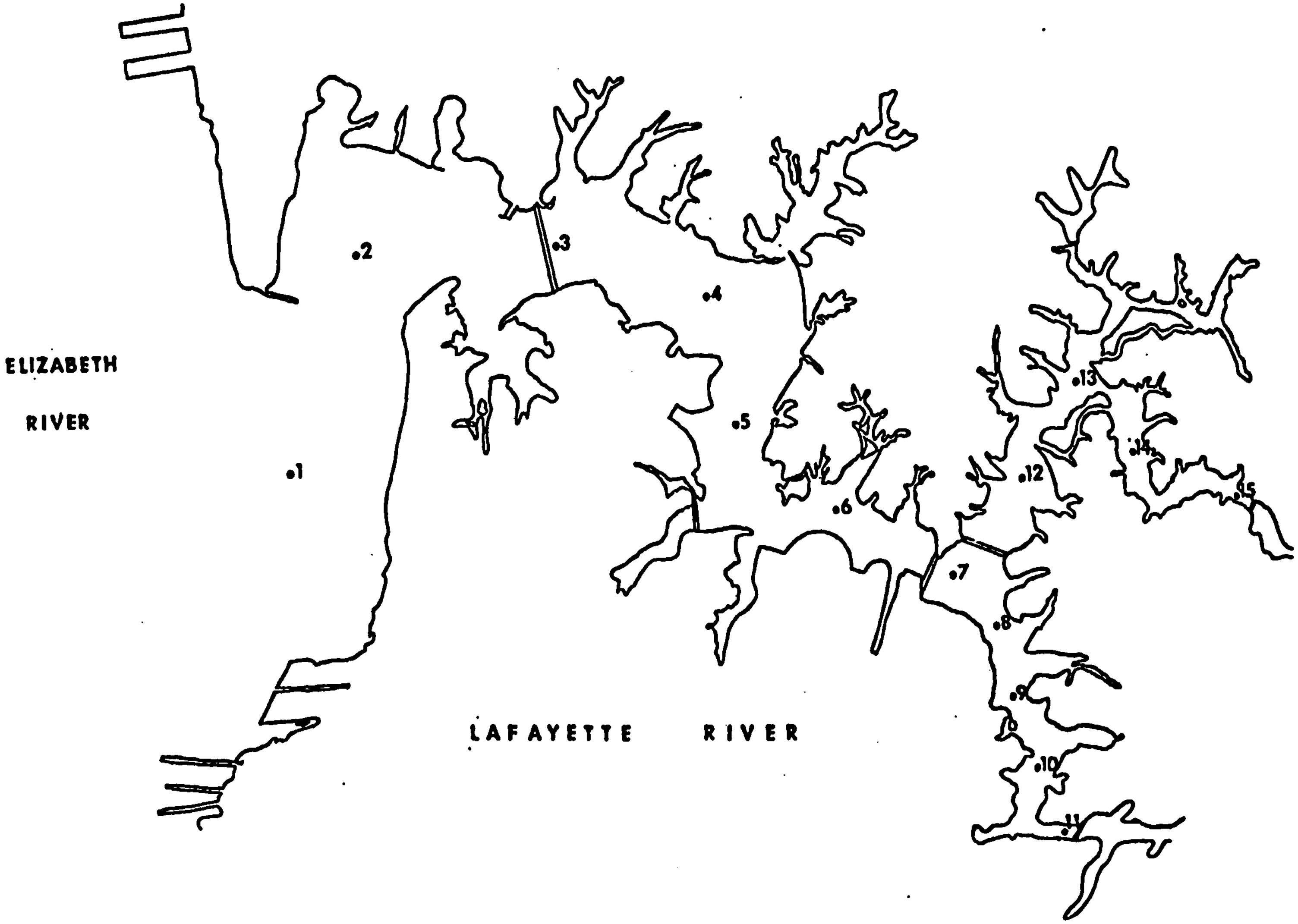

Figure 2. The Lafayette River showing station locations.

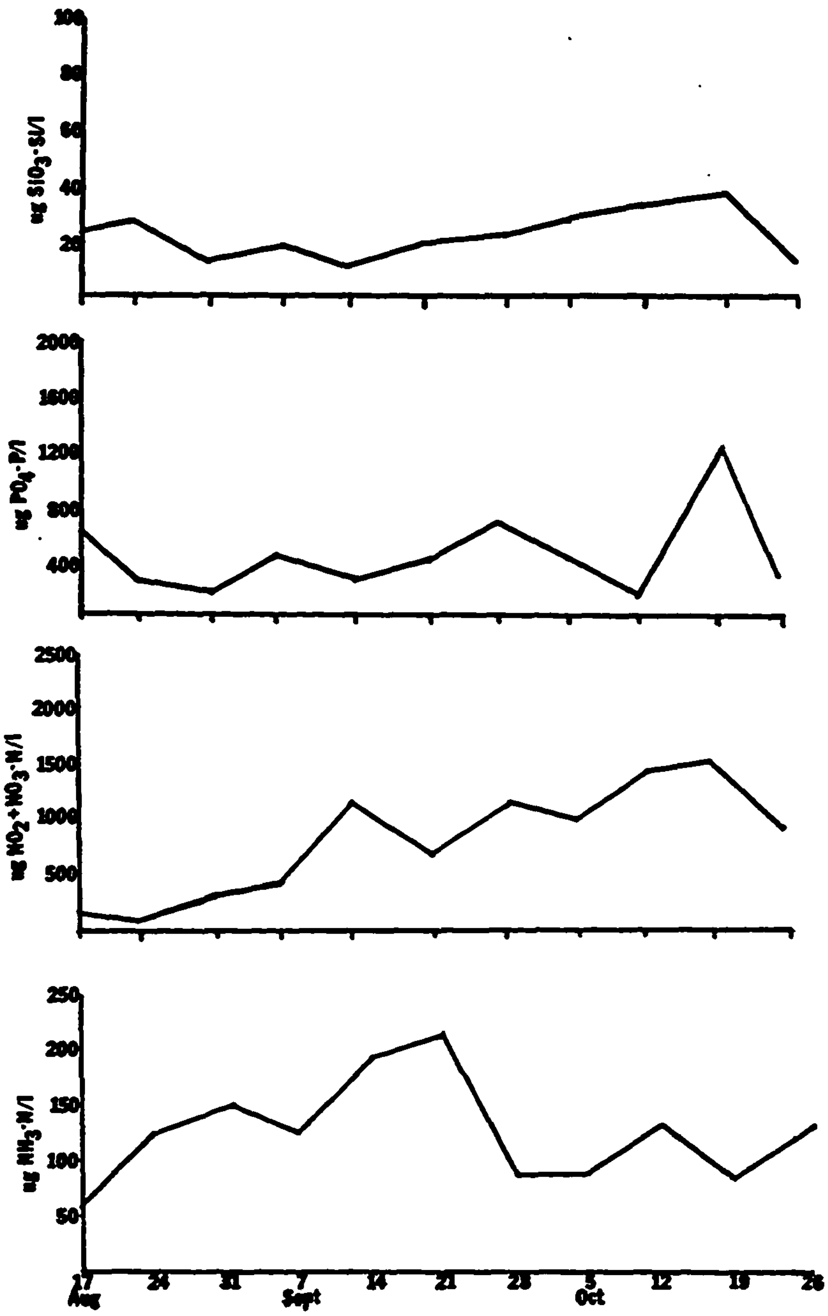

Figure 3. Nutrient concentrations for Station 1 over the collection period.

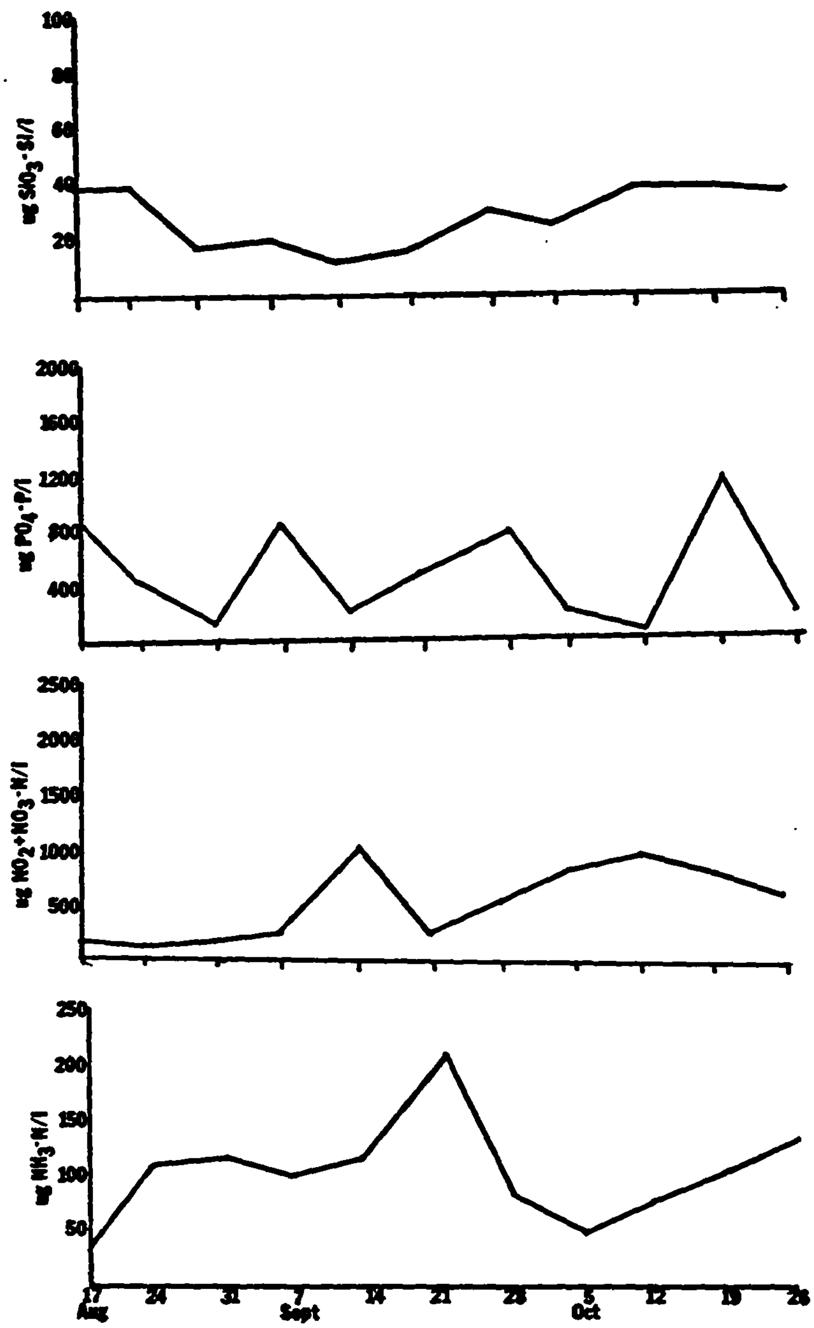

Figure 4. Nutrient concentrations for Station 4 over the collection period.

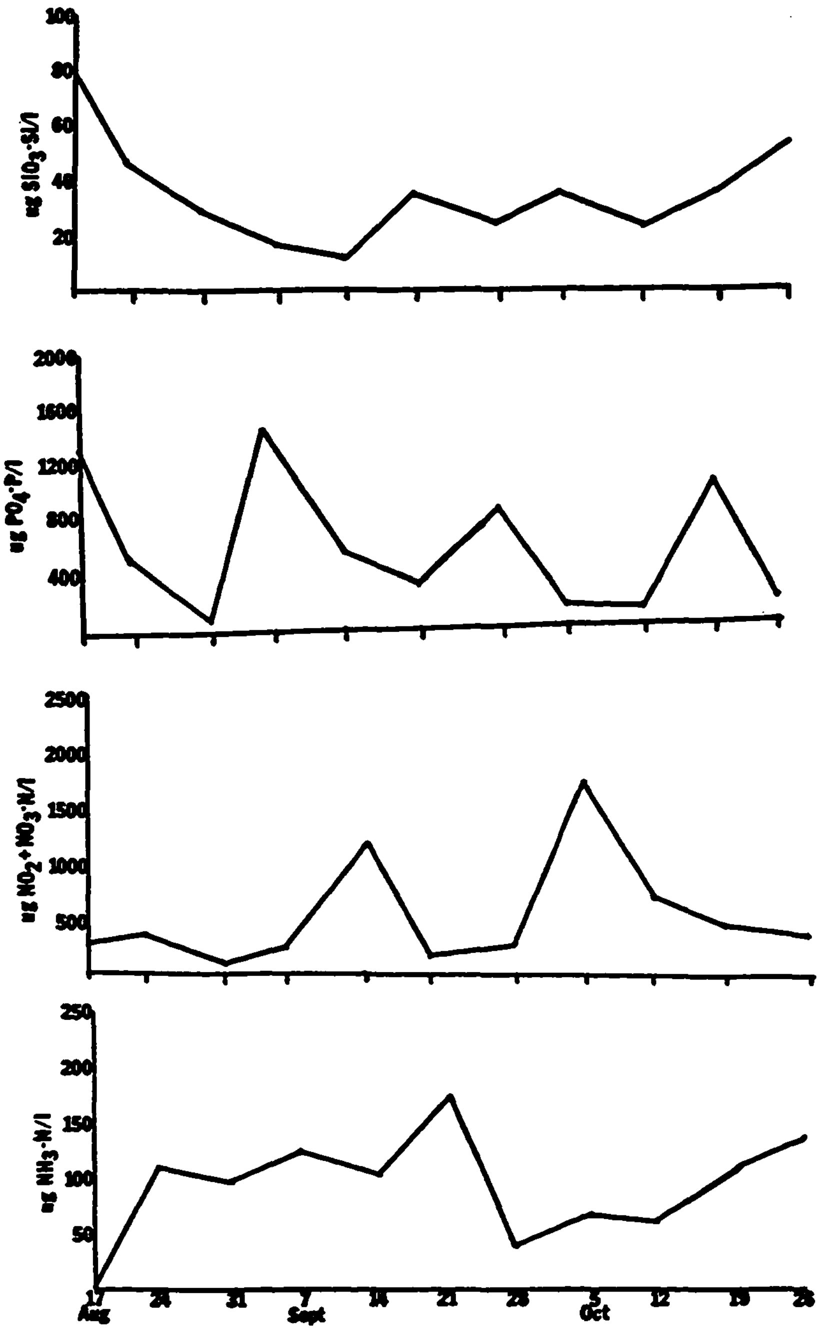

Figure 5. Nutrient concentrations for Station 9 over the collection period.

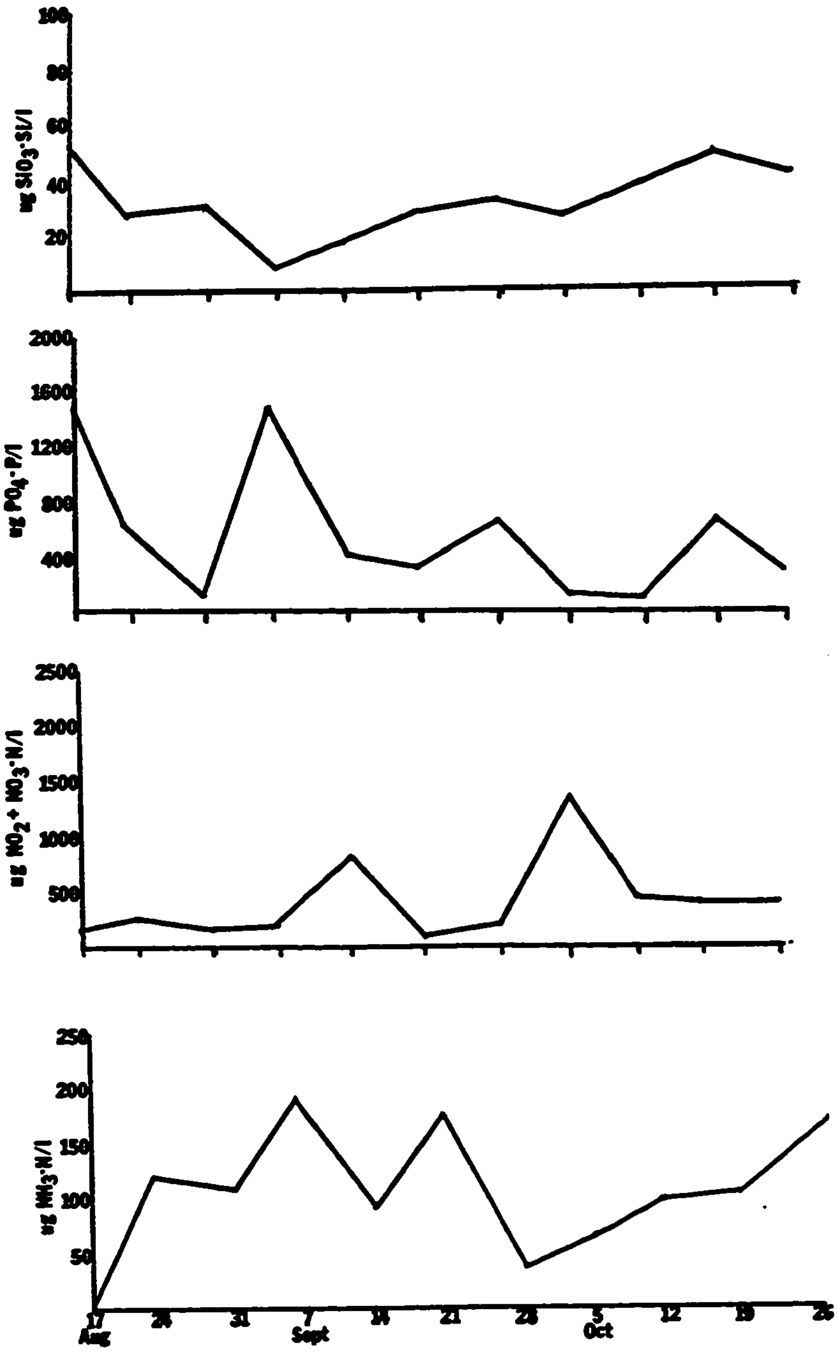

Figure 6. Nutrient concentrations for Station 13 over the collection period.

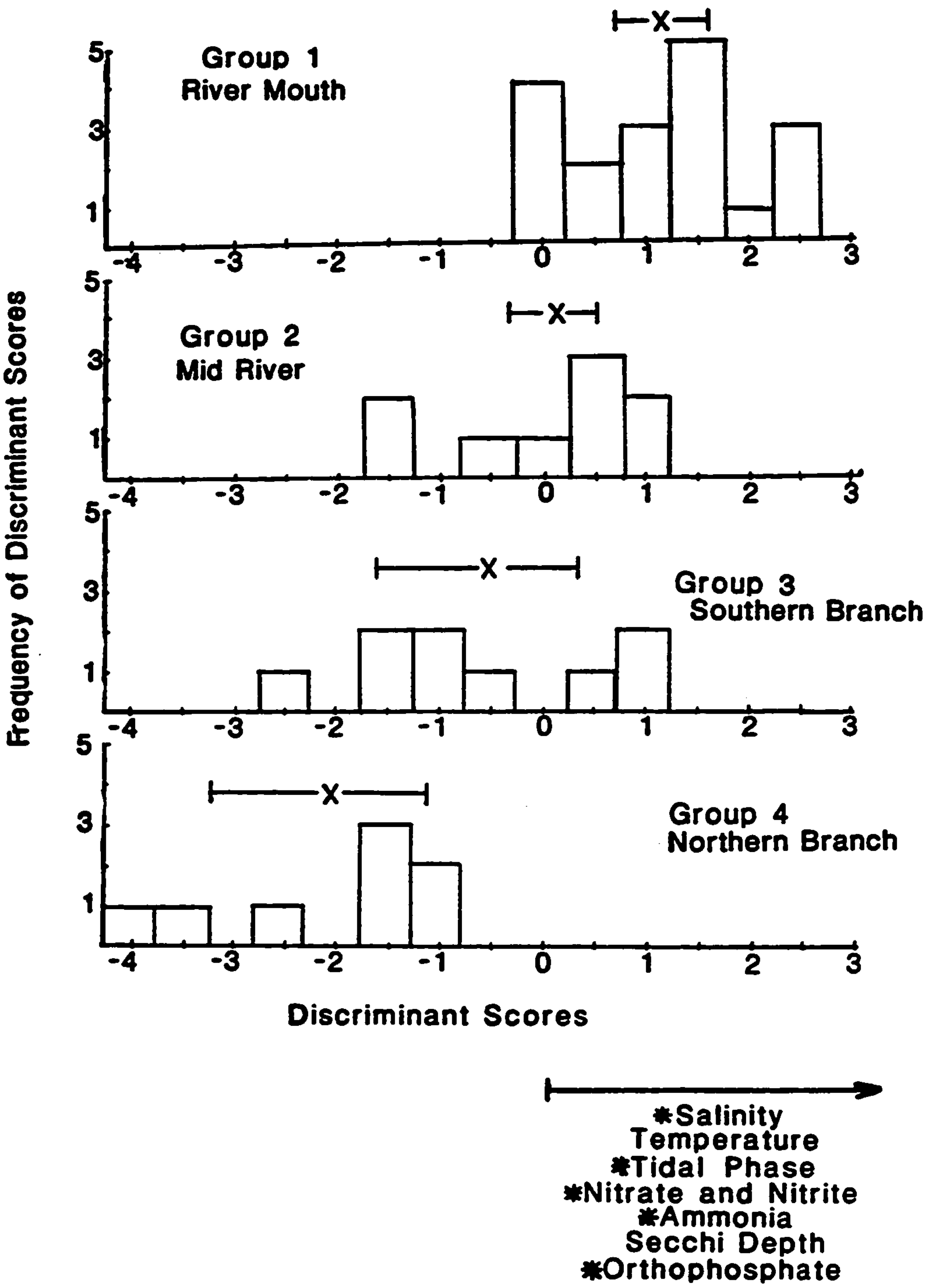

Figure 7. Results of Discriminant Function and Pearson Correlation Analyses on Environmental data. Arrow indicates a positive relationship between discriminant function scores and original variables.

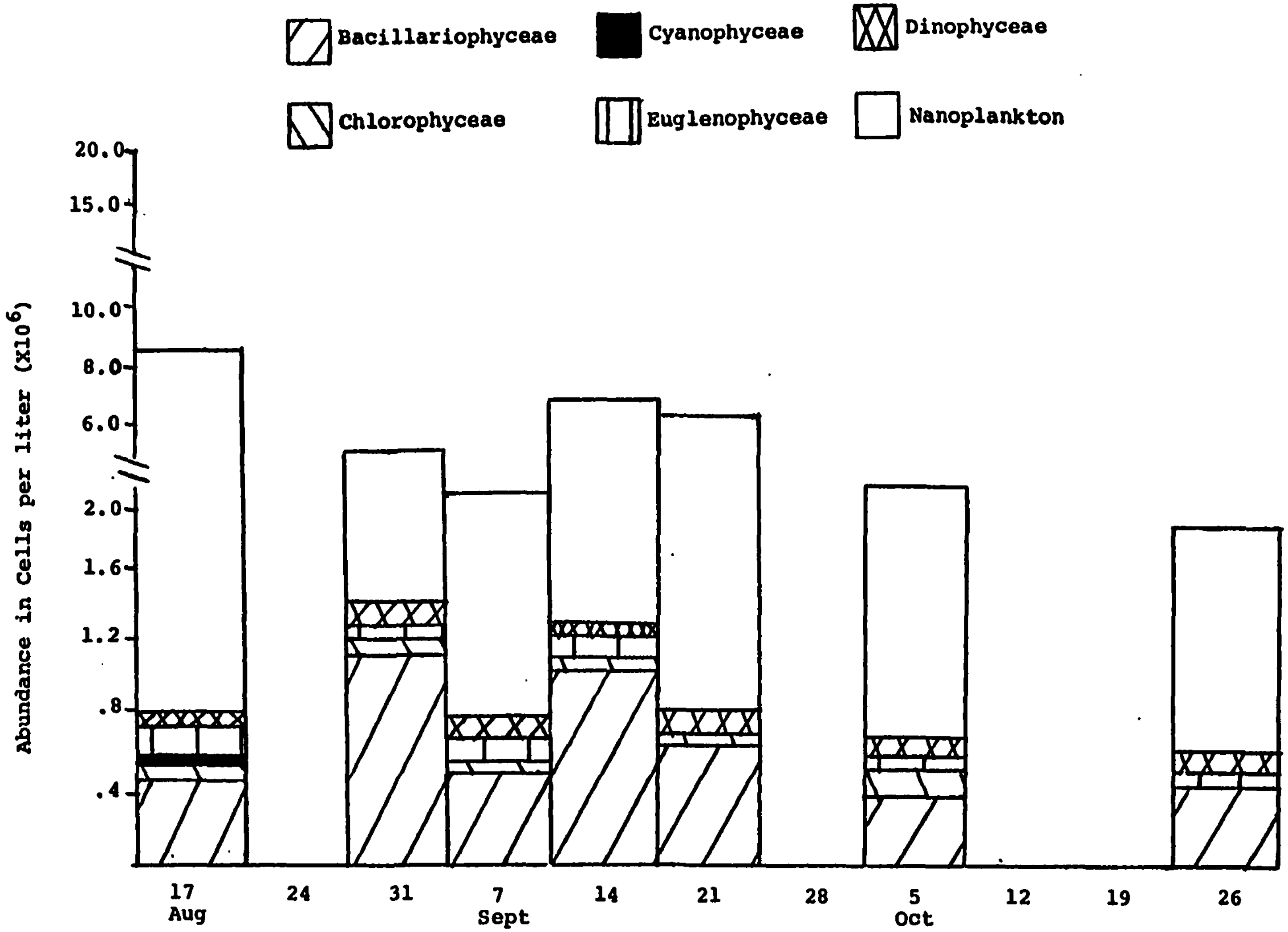

Figure 8. Cell abundances over time for Station 1. Divisions indicate phylogenetic groups.

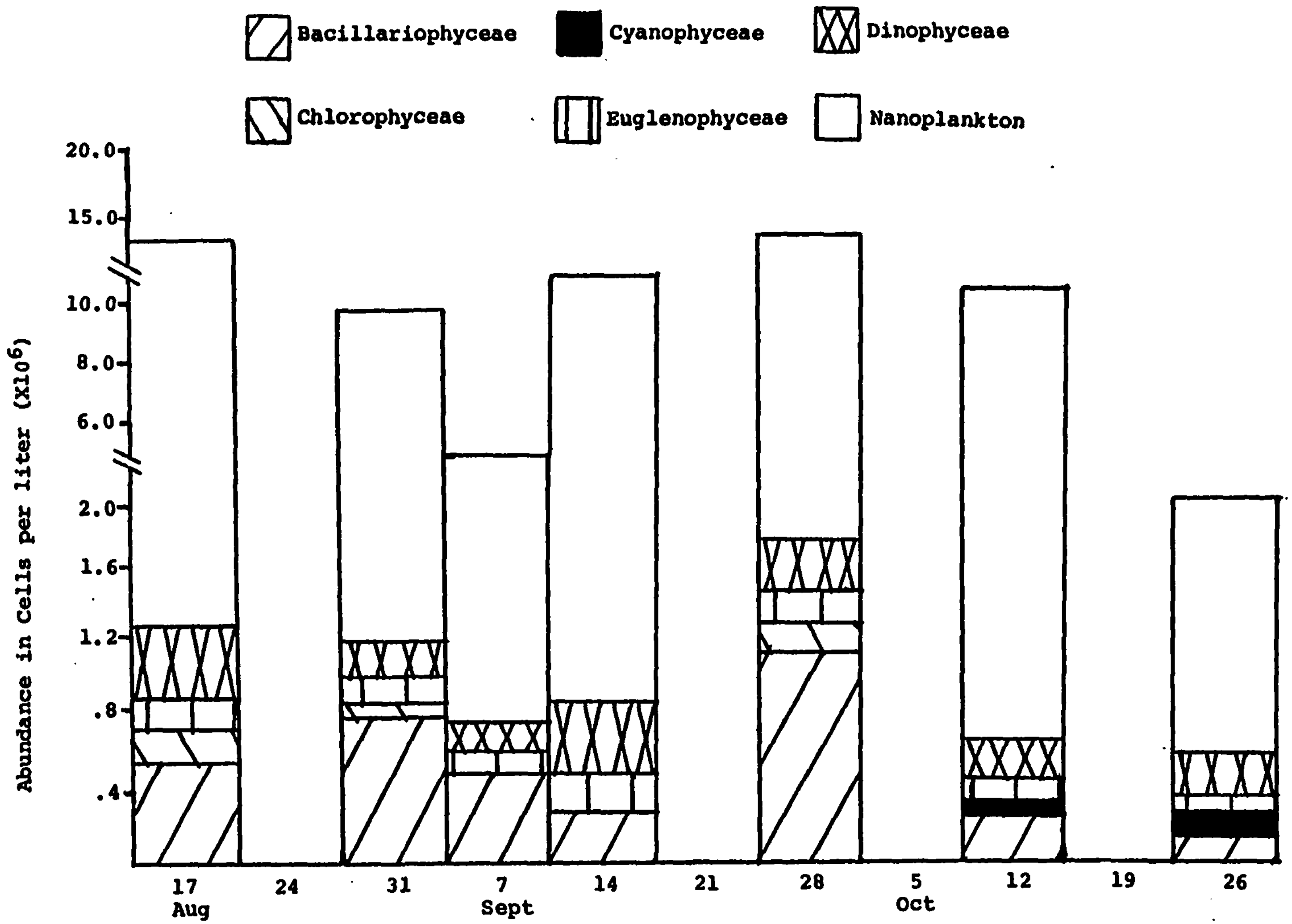

Figure 9. Cell abundances over time for Station 4. Divisions indicate phylogenetic groups.

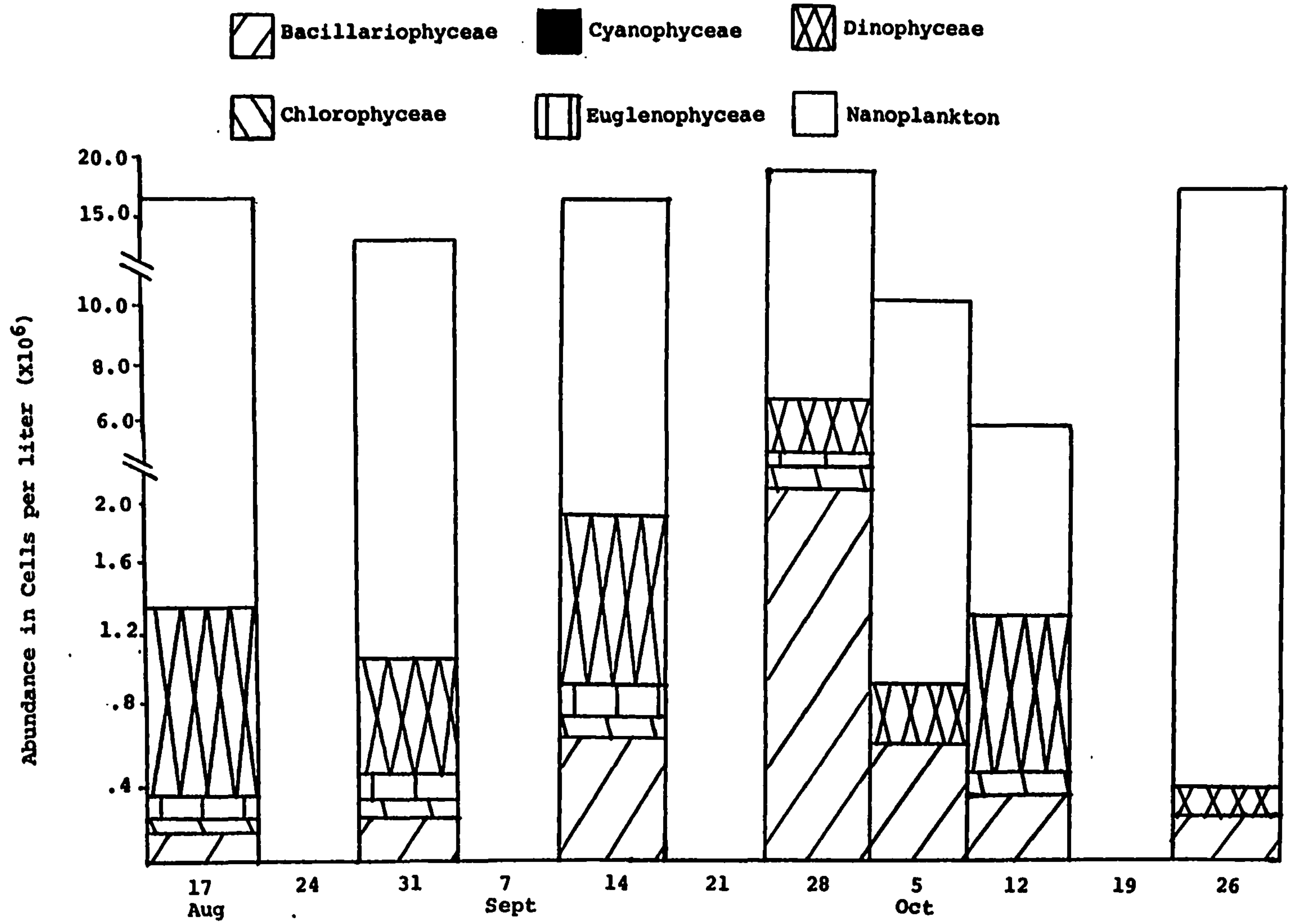

Figure 10. Cell abundances over time for Station 9. Divisions indicate phylogenetic groups.

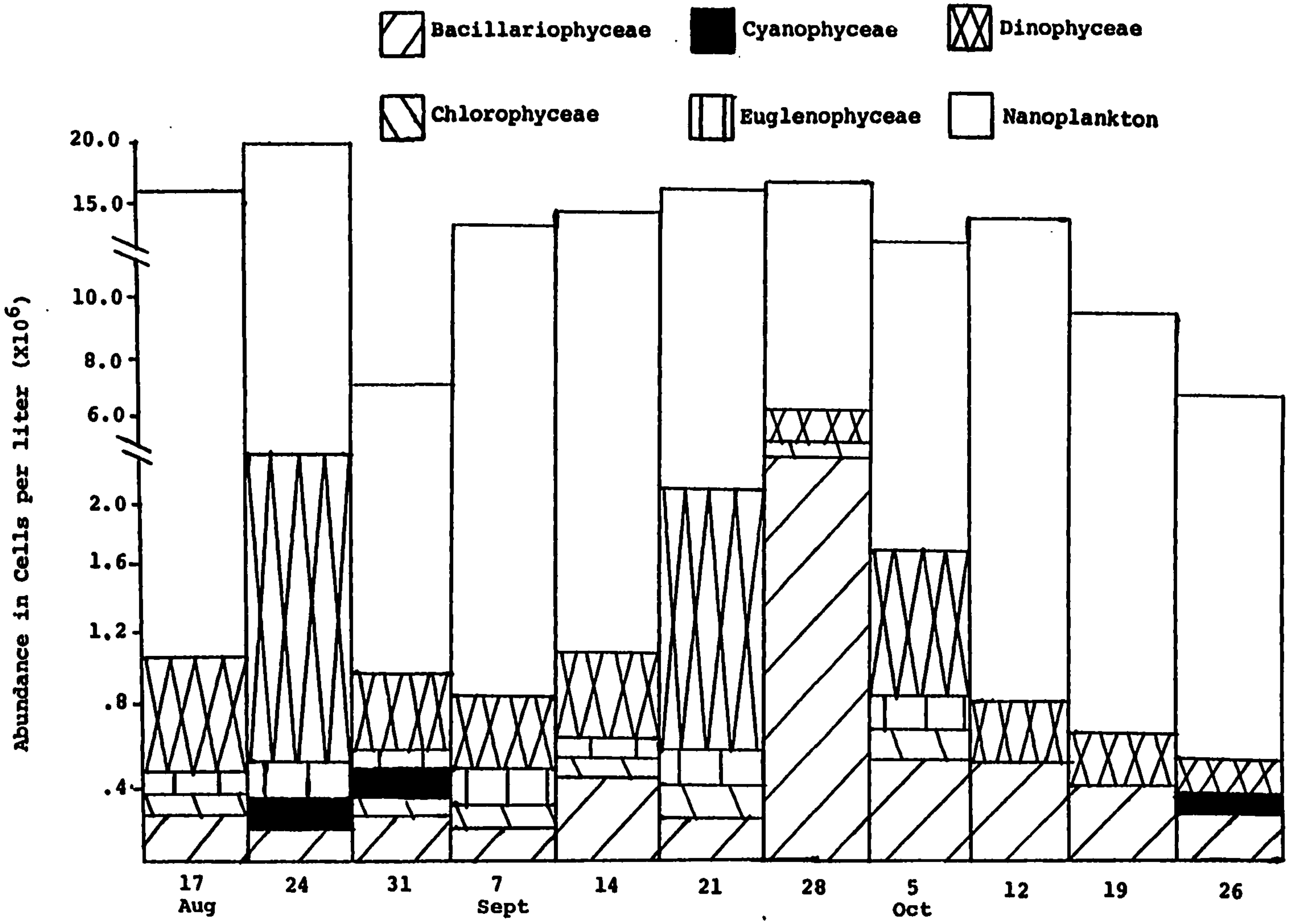

Figure 11. Cell abundances over time for Station 13. Divisions indicate phylogenetic groups.

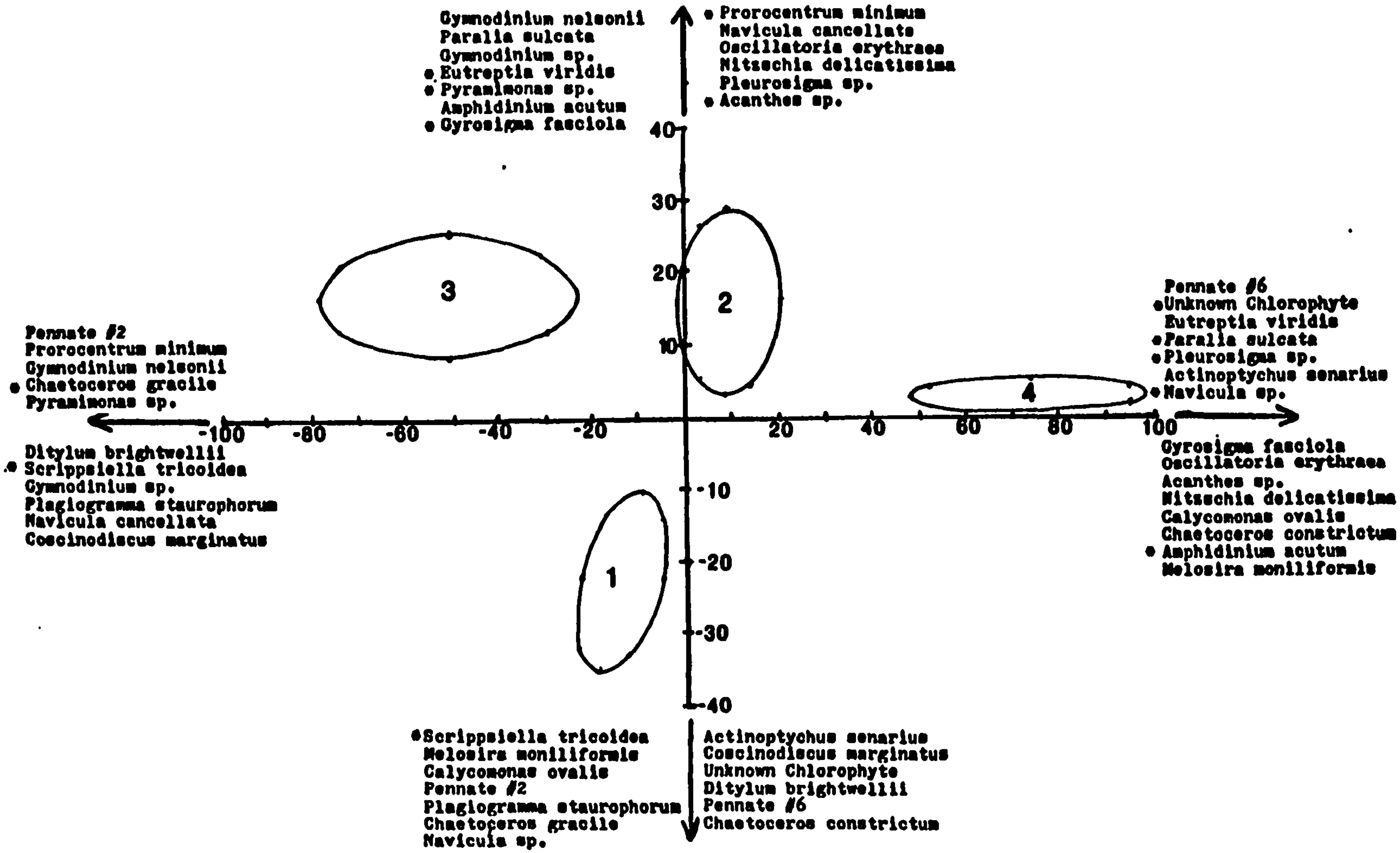

Figure 12. Results of Discriminant Function and Pearson Correlation Analyses on Phytoplankton data. X-axis is the first Discriminant function. Y-axis is the second. Ellipses indicate 95% confidence intervals around group centroids. Arrows indicate phytoplankton populations correlated in the direction of the axes.

APPENDICES

Appendix A. Supportive physical data for all stations, surface and bottom.

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (°/oo)	Temperature (°C)
17 August 1981	Storm	1S	1.5	0.46	22.85	26.84
	Spring	2S	1.0	0.46	22.85	26.80
	High	3S	5.0	0.61	22.07	27.12
		3B	---	----	23.03	26.53
		4S	0.5	0.30	21.96	27.22
		5S	2.0	0.30	21.65	27.49
		5B	---	----	21.84	27.31
		6S	3.0	0.30	21.39	27.69
		6B	---	----	21.65	27.25
		7S	3.0	0.46	20.85	27.92
		7B	---	----	21.12	27.68
		8S	2.0	0.30	21.20	27.26
		9S	2.0	0.30	20.89	27.58
		10S	2.0	0.30	20.54	27.74
		11S	0.8	0.15	20.15	27.72
		12S	3.0	0.46	21.18	27.80
		13S	1.0	0.46	21.12	27.31
		14S	1.0	0.30	20.65	26.25
		15S	1.0	0.30	20.71	27.19
24 August 1981	Storm	1S	4.0	1.22	22.12	23.40
	Neap	1B	---	----	22.20	23.42
	Low	2S	3.0	0.91	22.00	23.29
		2B	---	----	21.85	23.24
		3S	3.5	0.91	21.02	23.20
		3B	---	----	21.28	23.10
		4S	1.5	0.76	19.30	23.05
		5S	2.0	0.61	17.64	23.62
		5B	---	----	20.84	22.84
		6S	3.5	0.46	17.30	22.85

Appendix A. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity ($^{o}/_{oo}$)	Temperature (^{o}C)
24 August 1981 (continued)		6B	---	----	20.18	22.82
		7S	1.5	0.46	17.07	22.88
		8S	1.0	0.30	13.98	23.36
		9S	1.0	0.15	14.23	23.14
		10S	1.0	0.30	14.66	23.23
		12S	0.5	0.30	14.70	23.23
		13S	0.5	0.30	14.42	23.14
		14S	0.5	0.30	12.61	23.35
31 August 1981	Lower Spring High	1S	1.5	1.21	22.13	25.38
		2S	1.0	1.00	22.00	25.50
		3S	1.5	0.91	21.76	26.98
		3B	---	----	22.24	25.18
		4S	1.5	0.76	21.58	26.80
		4B	---	----	22.18	25.46
		5S	3.0	0.76	21.33	27.19
		5B	---	----	21.66	26.10
		6S	4.0	0.61	21.13	27.03
		6B	---	----	21.50	26.34
		7S	2.0	0.61	21.01	26.26
		7B	---	----	21.08	26.13
		8S	1.0	0.61	21.10	26.83
		9S	1.0	0.61	21.01	26.83
		10S	1.0	0.61	20.76	26.85
		11S	1.0	0.46	20.15	27.35
		12S	0.8	0.61	20.72	27.09
		13S	0.8	0.61	20.42	27.30
		14S	0.5	0.46	20.28	27.45
		15S	0.5	0.46	20.42	27.45

Appendix A. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (°/oo)	Temperature (°C)
7 September 1981	Higher	1S	2.5	0.91	22.35	25.48
	Neap	1B	---	----	22.39	25.16
	Low	2S	1.0	0.76	22.26	25.67
		3S	4.5	0.76	22.24	25.60
		3B	---	----	22.09	25.27
		4S	1.0	0.61	22.00	25.57
		5S	1.5	0.46	21.87	26.04
		5B	---	----	21.86	25.55
		6S	3.5	0.46	21.61	26.19
		6B	---	----	21.56	25.58
		7S	2.5	0.46	21.51	26.34
		7B	---	----	21.52	25.92
		8S	1.0	0.46	21.26	26.16
		9S	2.0	0.30	21.02	25.95
		10S	1.0	0.30	20.94	26.35
		11S	1.0	0.30	20.60	26.47
		12S	0.5	0.46	21.58	26.09
		13S	0.5	0.30	21.30	26.45
		14S	0.5	0.46	21.17	26.66
		15S	0.5	0.30	20.98	26.63
14 September 1981	Higher	1S	3.0	0.76	21.35	26.19
	Spring	1B	---	----	21.20	25.79
	High	2S	1.5	0.91	21.37	26.30
		3S	3.0	1.07	20.54	26.99
		3B	---	----	21.58	25.48
		4S	1.5	1.07	20.92	26.19
		5S	2.5	1.07	19.91	27.06
		5B	---	----	20.31	25.95

Appendix A. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity ($^{o}/oo$)	Temperature (^{o}C)
14 September 1981 (continued)		6S	2.5	1.07	19.45	27.59
		6B	---	----	18.07	27.09
		7S	2.5	0.91	19.27	27.73
		7B	---	----	18.52	26.60
		8S	1.0	0.61	19.23	26.49
		9S	2.0	0.91	17.52	27.20
		10S	2.0	0.91	18.44	27.20
		11S	1.0	0.61	17.64	26.90
		12S	1.5	0.61	19.27	26.55
		13S	1.0	0.46	18.63	26.78
		14S	0.5	0.46	18.52	26.89
		15S	0.5	0.46	17.91	26.92
21 September 1981	Storm	1S	2.5	1.22	21.04	21.62
	Neap	1B	---	----	19.13	23.05
	Low	2S	2.5	1.22	21.17	21.64
		2B	---	----	16.38	23.02
		3S	4.0	1.07	20.50	22.04
		3B	---	----	20.15	22.39
		4S	1.0	0.91	20.54	21.54
		5S	1.5	0.91	20.08	21.37
		6S	3.0	0.76	19.75	22.38
		6B	---	----	18.28	21.83
		7S	3.5	0.76	19.53	22.17
		7B	---	----	16.43	21.83
		8S	1.0	0.61	19.14	21.36
		9S	2.0	0.46	18.58	21.08
		10S	1.0	0.46	18.56	20.94
		11S	1.0	0.30	17.60	21.60

Appendix A. (Continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (o/oo)	Temperature (oC)
21 September 1981		12S	0.8	0.46	19.45	21.92
(continued)		13S	1.0	0.46	19.20	21.47
		14S	1.0	0.30	19.02	22.00
		15S	1.0	0.30	18.63	22.00
28 September 1981	Lower	1S	3.0	1.22	21.55	21.55
	Spring	1B	---	----	21.55	21.55
	High	2S	2.5	0.91	21.55	21.55
		2B	---	----	21.55	21.55
		3S	5.5	1.22	21.55	21.55
		3B	---	----	21.55	21.55
		4S	1.0	0.91	21.48	21.88
		5S	3.0	1.22	21.32	22.12
		5B	---	----	21.32	21.32
		6S	4.5	0.91	21.07	22.12
		6B	---	----	18.34	21.67
		7S	2.5	0.91	20.92	22.34
		7B	---	----	21.20	21.70
		8S	1.5	0.76	20.91	21.95
		9S	1.5	0.61	20.41	22.21
		10S	2.0	0.46	20.67	21.85
		11S	1.5	0.46	20.03	22.02
		12S	1.0	0.76	20.79	22.03
		13S	1.5	0.61	20.55	21.89
		14S	1.0	0.61	20.28	22.52
		15S	1.5	0.46	20.44	22.46
5 October 1981	Higher	1S	2.5	0.91	21.41	17.58
	Neap	1B	---	----	20.00	18.28

Appendix A. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (°/oo)	Temperature (°C)
5 October 1981 (continued)	Low	2S	1.0	0.76	21.58	17.55
		3S	4.5	0.91	21.29	17.44
		3B	---	----	20.76	18.02
		4S	1.0	0.76	21.10	17.50
		5S	2.0	0.76	20.96	17.55
		5B	---	----	20.86	17.35
		6S	2.5	0.61	20.84	18.04
		6B	---	----	18.16	17.66
		7S	3.5	0.61	20.45	17.74
		7B	---	----	20.62	17.82
		8S	1.0	0.46	20.10	17.74
		9S	2.0	0.46	19.64	17.53
		10S	1.0	0.46	19.47	17.67
		11S	0.5	0.46	18.37	18.37
		12S	1.0	0.61	20.24	17.69
		13S	1.0	0.61	19.99	18.10
		14S	1.0	0.46	19.82	18.40
		15S	0.5	0.46	19.39	18.29
12 October 1981	Storm Spring High	1S	3.5	1.52	23.20	16.51
		1B	---	----	23.41	16.95
		2S	1.0	0.91	23.13	16.46
		3S	5.0	1.52	22.84	16.04
		3B	---	----	23.41	16.76
		4S	1.5	1.37	22.78	16.10
		5S	3.0	1.37	22.38	16.28
		5B	---	----	22.29	16.28
		6S	4.5	1.22	21.99	16.50
		6B	---	----	22.13	16.24

Appendix A. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity ($^{o}/oo$)	Temperature (^{o}C)
12 October 1981		7S	3.5	0.91	21.62	16.12
(continued)		7B	---	----	21.80	16.00
		8S	2.0	0.76	20.81	15.65
		9S	3.0	0.61	20.75	15.58
		10S	2.5	0.46	20.75	15.60
		11S	2.0	0.46	20.82	15.82
		12S	2.0	0.61	21.31	15.87
		13S	1.5	0.46	20.89	15.38
		14S	1.0	0.46	20.97	15.62
		15S	1.0	0.46	20.52	15.18
19 October 1981	Lower	1S	4.5	1.52	23.40	15.85
	Neap	1B	---	----	23.37	15.85
	Low	2S	3.0	1.37	23.52	15.94
		2B	---	----	23.55	15.94
		3S	4.5	1.07	23.45	15.71
		3B	---	----	23.45	15.80
		4S	1.5	0.76	23.08	16.00
		5S	2.5	0.76	22.70	15.92
		5B	---	----	22.87	16.12
		6S	4.5	0.91	22.68	15.98
		6B	---	----	22.69	15.98
		7S	3.5	0.61	22.39	16.07
		7B	---	----	22.55	15.91
		8S	1.5	0.76	22.26	16.19
		9S	2.0	0.76	22.17	16.37
		10S	1.5	0.46	22.00	16.50
		11S	1.5	0.46	21.89	16.56
		12S	1.5	0.76	22.32	16.08

Appendix A. (continued)

Cruise Date	Tidal Phase	Station	Water Depth (m)	Secchi Depth (m)	Salinity (°/oo)	Temperature (°C)
19 October 1981		13S	1.0	0.61	22.29	16.35
(continued)		14S	1.0	0.61	22.06	16.42
		15S	1.0	0.46	21.94	16.31
26 October 1981	Lower	1S	3.5	1.22	22.39	15.27
	Spring	1B	---	----	22.48	15.18
	High	2S	3.0	1.22	22.31	15.50
		2B	---	----	22.58	15.43
		3S	4.5	1.22	21.56	15.34
		3B	---	----	22.52	14.98
		4S	1.5	0.76	21.42	15.35
		5S	2.0	0.61	19.31	15.95
		5B	---	----	20.76	15.24
		6S	3.0	0.61	17.91	15.85
		6B	---	----	20.21	15.25
		7S	2.5	0.76	16.83	15.98
		7B	---	----	18.80	15.46
		8S	1.0	0.46	16.40	15.58
		9S	1.5	0.46	14.84	16.30
		10S	1.5	0.46	13.33	16.56
		11S	1.5	0.30	9.88	16.73
		12S	0.3	0.30	16.40	16.55
		13S	0.5	0.46	12.38	17.15
		14S	0.5	0.30	10.95	17.27
		15S	0.3	0.30	9.21	17.27

Appendix B. Supportive chemical data from all stations, surface and bottom.

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
17 August 1981	1S	1	117.01	210.00	508.34
		2	51.94	210.00	728.59
		3	32.82	190.00	636.74
	2S	1	27.08	240.00	555.52
		2	9.84	240.00	846.86
		3	19.40	240.00	683.43
	3S	1	23.24	280.00	730.14
		2	42.38	280.00	741.83
		3	13.66	280.00	800.17
	3B	1	27.08	260.00	566.71
		2	40.46	280.00	648.43
		3	17.50	240.00	683.46
	4S	1	32.82	240.00	718.46
		2	28.98	310.00	741.83
		3	32.94	310.00	940.26
	5S	1	28.98	280.00	963.60
		2	19.42	240.00	893.58
		3	21.34	240.00	788.52
	5B	1	32.82	260.00	846.89
		2	17.50	240.00	963.60
		3	15.60	220.00	858.58

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
17 August 1981 (continued)	6S	1	30.90	210.00	1220.44
		2	21.32	190.00	1267.16
		3	25.16	180.00	1313.84
	6B	1	21.34	210.00	1173.75
		2	17.50	210.00	1173.75
		3	19.40	170.00	1115.38
	7S	1	28.98	190.00	1430.59
		2	11.76	180.00	1360.53
		3	19.40	180.00	1395.56
	7B	1	30.90	170.00	1407.21
		2	21.34	180.00	1383.87
		3	17.50	210.00	1453.93
	8S	1	6.97	170.00	1389.70
		2	3.14	220.00	1407.21
		3	8.89	190.00	1407.21
	9S	1	1.23	170.00	1308.01
		2	0.35	170.00	1453.93
		3	0.28	170.00	1430.59
	10S	1	3.15	170.00	1488.93
		2	4.10	170.00	1518.13
		3	4.10	170.00	1506.44
	11S	1	4.10	170.00	1734.11
		2	4.10	170.00	1722.42
		3	4.10	170.00	1722.42

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
17 August 1981 (continued)	12S	1	4.10	170.00	1407.21
		2	4.10	170.00	1442.24
		3	4.10	170.00	1395.50
	13S	1	0.28	160.00	1465.62
		2	0.28	170.00	1453.93
		3	0.28	140.00	1395.56
	14S	1	0.28	190.00	1488.93
		2	0.28	170.00	1850.82
		3	0.28	160.00	1757.45
	15S	1	0.28	160.00	1757.45
		2	0.28	190.00	1909.23
		3	0.28	170.00	1909.23
24 August 1981	1S	1	126.94	540.00	318.49
		2	120.85	540.00	389.52
		3	116.28	620.00	346.89
	1B	1	110.21	510.00	403.71
		2	111.72	540.00	488.93
		3	107.16	560.00	446.34
	2S	1	108.68	540.00	460.54
		2	111.72	610.00	488.93
		3	114.77	510.00	460.54

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
24 August 1981 (continued)	2B	1	113.25	520.00	432.14
		2	122.36	440.00	460.54
		3	113.25	510.00	446.34
	3S	1	110.21	460.00	531.56
		2	114.77	440.00	531.56
		3	111.72	420.00	559.98
	3B	1	113.25	370.00	517.36
		2	120.85	420.00	574.18
		3	102.56	380.00	545.79
	4S	1	111.72	320.00	375.32
		2	102.59	360.00	432.14
		3	111.72	320.00	460.50
	5S	1	119.34	240.00	446.34
		2	119.34	260.00	375.29
		3	113.25	280.00	446.34
	5B	1	105.64	310.00	460.54
		2	107.16	300.00	517.36
		3	107.16	300.00	517.36
	6S	1	110.21	300.00	559.98
		2	119.34	310.00	517.36
		3	116.28	320.00	488.93

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/1	Nitrates and Nitrites µg N/1	Ortho-phosphate µg P/1
24 August 1981 (continued)	6B	1	107.16	320.00	446.34
		2	105.64	320.00	503.13
		3	113.25	300.00	517.36
	7S	1	111.72	240.00	460.54
		2	119.34	260.00	488.93
		3	101.08	240.00	474.73
	8S	1	116.28	220.00	488.93
		2	116.28	210.00	545.75
		3	122.37	210.00	503.13
	9S	1	111.72	210.00	460.54
		2	113.25	240.00	417.94
		3	105.64	220.00	460.54
	10S	1	110.21	210.00	403.71
		2	114.77	220.00	389.51
		3	111.72	220.00	432.14
	12S	1	119.34	210.00	403.71
		2	116.28	220.00	531.56
		3	113.25	190.00	531.56
	13S	1	126.94	190.00	659.37
		2	120.85	190.00	630.97
		3	113.25	210.00	630.97

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
24 August 1981 (continued)	14S	1	113.25	190.00	716.22
		2	114.77	210.00	702.03
		3	108.68	210.00	616.78
31 August 1981	1S	1	162.29	360.00	178.37
		2	136.72	260.00	240.31
		3	141.85	220.00	260.99
	2S	1	126.50	330.00	178.37
		2	136.72	220.00	178.37
		3	138.43	240.00	157.73
	3S	1	150.36	200.00	219.67
		2	131.60	320.00	157.73
		3	128.20	220.00	199.02
	3B	1	128.20	270.00	157.73
		2	136.72	180.00	219.67
		3	129.91	180.00	199.02
	4S	1	119.67	240.00	240.31
		2	114.56	160.00	116.37
		3	124.80	180.00	199.02
	4B	1	123.09	200.00	178.37
		2	114.56	180.00	219.67
		3	124.80	150.00	157.73

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
31 August 1981 (continued)	5S	1	117.96	180.00	178.37
		2	117.96	200.00	178.37
		3	109.45	180.00	157.70
	5B	1	95.82	180.00	137.05
		2	99.22	120.00	178.37
		3	100.91	150.00	178.37
	6S	1	102.62	180.00	116.37
		2	106.04	180.00	116.37
		3	95.82	180.00	95.73
	6B	1	107.74	120.00	199.33
		2	102.62	120.00	219.67
		3	111.15	120.00	219.67
	7S	1	107.74	120.00	219.67
		2	104.33	120.00	178.37
		3	100.93	120.00	178.37
	7B	1	109.45	120.00	260.99
		2	102.62	120.00	178.44
		3	94.17	120.00	178.44
	8S	1	104.33	120.00	137.05
		2	100.93	120.00	157.73
		3	100.91	120.00	178.37

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µµg N/l	Ortho-phosphate µg P/l
31 August 1981 (continued)	9S	1	92.40	120.00	116.37
		2	97.51	120.00	95.73
		3	95.82	120.00	95.73
	10S	1	87.28	120.00	95.73
		2	97.51	120.00	95.73
		3	100.93	120.00	137.05
	11S	1	119.67	120.00	75.08
		2	116.27	120.00	75.08
		3	107.74	120.00	54.44
	12S	1	104.33	120.00	157.73
		2	95.82	120.00	95.73
		3	97.51	120.00	95.73
	13S	1	99.22	120.00	137.05
		2	107.74	120.00	116.37
		3	100.91	120.00	137.05
	14S	1	114.56	120.00	302.31
		2	114.56	120.00	302.31
		3	128.20	120.00	343.60
	15S	1	114.56	120.00	219.67
		2	121.38	120.00	178.37
		3	117.96	120.00	199.02

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
7 September 1981	1S	1	126.92	440.00	511.44
		2	115.43	300.00	589.81
		3	122.33	400.00	623.38
	1B	1	117.74	350.00	679.36
		2	117.74	350.00	690.56
		3	113.13	400.00	668.17
	2S	1	101.64	400.00	656.98
		2	110.84	350.00	724.13
		3	106.23	350.00	724.13
	3S	1	115.43	350.00	724.13
		2	124.63	400.00	768.92
		3	106.23	350.00	780.08
	3B	1	94.75	400.00	813.69
		2	115.44	350.00	858.45
		3	106.23	260.00	858.45
	4S	1	97.03	300.00	802.50
		2	101.64	300.00	802.50
		3	80.95	260.00	813.69
	5S	1	87.84	440.00	970.39
		2	87.84	260.00	959.20
		3	92.44	260.00	981.58

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
7 September 1981 (continued)	5B	1	110.84	220.00	1048.73
		2	106.23	260.00	1104.72
		3	106.23	170.00	1071.11
	6S	1	99.34	260.00	1048.73
		2	108.53	220.00	1071.14
		3	99.34	260.00	1127.10
	6B	1	101.64	220.00	1149.48
		2	92.44	170.00	1194.27
		3	97.03	120.00	1194.24
	7S	1	108.53	170.00	1160.67
		2	110.84	170.00	1194.27
		3	110.84	170.00	1205.47
	7B	1	113.13	220.00	1306.22
		2	113.13	260.00	1283.83
		3	110.82	170.00	1283.80
	8S	1	115.43	220.00	1339.76
		2	113.12	260.00	1373.36
		3	120.04	170.00	1339.76
	9S	1	122.33	260.00	1418.13
		2	126.92	260.00	1406.97
		3	120.04	170.00	1440.51

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
7 September 1981 (continued)	10S	1	133.83	260.00	1541.26
		2	133.83	120.00	1552.48
		3	143.02	120.00	1518.88
	11S	1	129.22	170.00	1563.64
		2	143.02	80.00	1563.64
		3	136.12	80.00	1563.64
	12S	1	124.63	80.00	1642.01
		2	124.63	80.00	1630.82
		3	126.92	80.00	1642.01
	13S	1	170.60	120.00	1686.77
		2	189.00	170.00	1697.96
		3	189.00	120.00	1686.77
	14S	1	267.16	80.00	1776.33
		2	267.16	80.00	1776.33
		3	269.47	80.00	1731.54
	15S	1	271.77	80.00	1440.51
		2	278.66	80.00	1451.73
		3	271.77	80.00	1440.51
14 September 1981	1S	1	196.62	1270.00	280.39
		2	186.76	1160.00	335.88
		3	191.69	1160.00	280.39
	1B	1	167.02	1270.00	354.39
		2	142.63	1380.00	280.39
		3	147.28	1270.00	354.39

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
14 September 1981 (continued)	2S	1	152.21	1380.00	280.39
		2	147.28	1380.00	354.39
		3	132.48	1380.00	354.39
	3S	1	107.81	1160.00	280.39
		2	68.35	1270.00	354.39
		3	93.02	1160.00	280.39
	3B	1	122.61	1160.00	317.38
		2	152.21	1160.00	335.88
		3	152.22	930.00	372.87
	4S	1	107.81	1160.00	280.39
		2	122.61	1040.00	280.39
		3	102.89	1270.00	280.[illegible]
	5S	1	122.61	1160.00	317.38
		2	122.61	1270.00	280.39
		3	117.68	1270.00	335.88
	5B	1	122.61	1160.00	372.87
		2	142.35	1270.00	354.39
		3	132.48	1270.00	391.37
	6S	1	102.89	1160.00	372.87
		2	93.02	1040.00	354.39
		3	93.02	930.00	354.39

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
14 September 1981 (continued)	6B	1	122.61	1160.00	391.37
		2	122.61	1040.00	317.38
		3	137.42	1270.00	391.37
	7S	1	112.76	1270.00	317.38
		2	132.48	1270.00	391.37
		3	112.76	1160.00	391.37
	7B	1	112.76	1040.00	317.38
		2	122.61	1040.00	391.37
		3	93.02	820.00	317.38
	8S	1	112.76	1270.00	428.36
		2	122.61	1270.00	465.34
		3	122.61	1270.00	446.83
	9S	1	117.68	1380.00	502.35
		2	97.94	1040.00	502.35
		3	88.09	930.00	465.34
	10S	1	132.48	930.00	428.36
		2	142.35	930.00	465.34
		3	132.48	1040.00	465.34
	11S	1	147.28	930.00	502.35
		2	142.35	820.00	465.34
		3	132.48	930.00	465.34

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
14 September 1981 (continued)	12S	1	132.48	930.00	483.85
		2	122.61	820.00	502.35
		3	122.61	930.00	502.35
	13S	1	83.15	930.00	502.35
		2	102.89	930.00	483.85
		3	93.02	710.00	502.35
	14S	1	78.20	820.00	539.34
		2	83.16	1040.00	557.81
		3	83.15	820.00	576.32
	15S	1	191.69	710.00	557.81
		2	191.69	600.00	557.81
		3	176.88	710.00	576.32
21 September 1981	1S	1	226.81	630.00	518.16
		2	208.84	630.00	480.19
		3	199.85	720.00	461.19
	1B	1	187.88	540.00	480.19
		2	193.86	450.00	480.19
		3	190.86	450.00	499.16
	2S	1	193.86	280.00	537.17
		2	184.87	190.00	499.16
		3	169.90	280.00	480.19

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
21 September 1981 (continued)	2B	1	181.87	280.00	442.18
		2	160.90	450.00	423.21
		3	160.92	360.00	423.21
	3S	1	154.92	450.00	404.21
		2	160.92	450.00	404.21
		3	151.93	280.00	442.18
	3B	1	166.91	360.00	461.19
		2	172.89	360.00	480.19
		3	160.92	450.00	461.19
	4S	1	208.84	190.00	423.21
		2	202.85	360.00	461.19
		3	208.84	190.00	461.19
	5S	1	178.89	100.00	423.21
		2	160.92	190.00	442.18
		3	157.92	190.00	423.21
	6S	1	172.89	100.00	423.21
		2	169.90	100.00	423.21
		3	172.89	100.00	423.21
	6B	1	142.92	100.00	385.21
		2	148.93	100.00	385.21
		3	130.96	100.00	423.21

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
21 September 1981 (continued)	7S	1	148.93	360.00	366.23
		2	148.93	450.00	347.23
		3	148.93	630.00	347.23
	7B	1	160.90	720.00	404.21
		2	160.90	720.00	366.23
		3	160.90	630.00	385.21
	8S	1	172.89	540.00	385.21
		2	172.89	450.00	423.21
		3	172.89	280.00	347.23
	9S	1	178.88	280.00	347.23
		2	172.89	190.00	309.26
		3	175.88	100.00	309.26
	10S	1	184.87	190.00	252.28
		2	184.87	100.00	214.27
		3	184.87	280.00	233.27
	11S	1	181.87	100.00	214.27
		2	193.86	100.00	233.27
		3	184.87	100.00	233.27
	12S	1	181.87	100.00	385.21
		2	172.89	100.00	385.21
		3	166.89	100.00	366.23

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
21 September 1981 (continued)	13S	1	190.86	100.00	347.23
		2	193.86	100.00	309.26
		3	178.88	100.00	309.26
	14S	1	196.85	100.00	309.26
		2	196.85	100.00	271.25
		3	190.86	100.00	271.25
	15S	1	208.84	100.00	271.25
		2	202.85	100.00	309.26
		3	208.84	100.00	309.26
28 September 1981	1S	1	98.84	1160.00	767.00
		2	89.38	1260.00	767.00
		3	89.38	1160.00	767.00
	1B	1	84.64	1160.00	932.88
		2	87.02	950.00	932.88
		3	79.93	1060.00	849.96
	2S	1	53.91	950.00	932.88
		2	42.08	1160.00	932.88
		3	42.08	950.00	767.00
	2B	1	51.55	950.00	849.90
		2	39.72	830.00	849.90
		3	51.55	740.00	932.88

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
28 September 1981 (continued)	3S	1	49.18	830.00	849.90
		2	51.55	740.00	849.90
		3	51.55	740.00	932.88
	3B	1	56.28	830.00	849.90
		2	56.28	530.00	1015.81
		3	44.45	530.00	932.88
	4S	1	94.11	640.00	767.00
		2	84.66	530.00	767.00
		3	79.93	530.00	767.00
	5S	1	37.35	420.00	684.05
		2	37.35	530.00	684.05
		3	32.62	530.00	849.90
	5B	1	51.55	530.00	767.00
		2	42.08	640.00	849.90
		3	51.55	640.00	767.00
	6S	1	13.71	530.00	684.05
		2	18.42	530.00	684.05
		3	13.71	530.00	684.05
	6B	1	27.89	420.00	767.00
		2	18.42	420.00	684.05
		3	13.69	530.00	767.00

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
28 September 1981 (continued)	7S	1	23.17	530.00	684.05
		2	25.54	420.00	601.09
		3	27.89	420.00	601.09
	7B	1	27.89	530.00	684.05
		2	27.89	420.00	601.09
		3	27.89	320.00	601.09
	8S	1	8.97	320.00	601.09
		2	8.97	420.00	684.05
		3	8.97	530.00	601.09
	9S	1	30.27	320.00	932.88
		2	27.89	320.00	767.00
		3	32.62	220.00	767.00
	10S	1	23.16	120.00	601.09
		2	23.16	120.00	601.09
		3	30.24	320.00	601.09
	11S	1	30.25	220.00	767.00
		2	23.16	120.00	767.00
		3	23.16	320.00	849.90
	12S	1	35.00	420.00	849.90
		2	35.00	320.00	767.00
		3	35.00	320.00	767.00

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
28 September 1981 (continued)	13S	1	27.89	120.00	601.09
		2	25.54	320.00	767.00
		3	32.62	220.00	767.00
	14S	1	25.54	120.00	767.00
		2	25.54	220.00	767.00
		3	27.89	320.00	767.00
	15S	1	25.54	220.00	932.88
		2	27.90	320.00	932.88
		3	27.90	120.00	932.88
5 October 1981	1S	1	92.06	1060.00	404.05
		2	92.06	1060.00	438.28
		3	95.91	950.00	438.28
	1B	1	47.73	950.00	358.42
		2	41.94	950.00	392.65
		3	41.94	740.00	381.34
	2S	1	61.22	640.00	426.87
		2	61.22	840.00	438.28
		3	61.22	840.00	438.28
	3S	1	61.22	740.00	267.16
		2	55.44	740.00	301.38
		3	49.66	740.00	278.57

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
5 October 1981 (continued)	3B	1	40.01	740.00	301.38
		2	45.81	740.00	267.16
		3	40.01	740.00	244.34
	4S	1	40.01	640.00	221.53
		2	40.01	740.00	221.53
		3	41.94	840.00	221.53
	5S	1	49.66	950.00	175.86
		2	51.58	1060.00	175.86
		3	43.88	1060.00	175.86
	5B	1	41.94	740.00	210.12
		2	45.81	840.00	221.53
		3	45.79	950.00	232.93
	6S	1	38.08	950.00	175.86
		2	41.94	1160.00	187.27
		3	41.94	950.00	187.27
	6B	1	41.94	1060.00	198.68
		2	40.01	1160.00	221.53
		3	41.94	950.00	221.53
	7S	1	45.79	1060.00	198.68
		2	40.01	1160.00	175.86
		3	41.94	1260.00	187.27

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/1	Nitrates and Nitrites µg N/1	Ortho-phosphate µg P/1
5 October 1981 (continued)	7B	1	40.01	1060.00	198.68
		2	43.88	1060.00	198.68
		3	43.88	1160.00	198.68
	8S	1	47.73	1260.00	175.86
		2	47.73	1260.00	187.27
		3	47.73	1160.00	187.27
	9S	1	55.44	1900.00	164.45
		2	57.36	1370.00	164.45
		3	51.58	1680.00	153.05
	10S	1	59.29	1580.00	130.23
		2	59.29	1580.00	153.06
		3	57.37	1580.00	130.23
	11S	1	59.29	1580.00	118.82
		2	55.44	1580.00	118.82
		3	61.22	1580.00	118.82
	12S	1	47.73	1160.00	175.86
		2	45.81	1260.00	175.86
		3	43.88	1370.00	153.05
	13S	1	55.44	1480.00	118.82
		2	51.58	1370.00	118.82
		3	57.36	1480.00	118.82

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
5 October 1981 (continued)	14S	1	59.29	1680.00	73.19
		2	61.22	1790.00	73.19
		3	57.36	1580.00	73.19
	15S	1	63.14	1580.00	61.78
		2	69.29	1580.00	61.78
		3	61.22	1580.00	61.78
12 October 1981	1S	1	130.06	1280.00	196.97
		2	130.06	1380.00	196.97
		3	130.06	1480.00	196.97
	1B	1	132.89	1280.00	196.97
		2	115.86	1380.00	174.84
		3	110.19	1380.00	152.67
	2S	1	115.86	1380.00	152.67
		2	117.29	1280.00	152.67
		3	112.62	1280.00	108.38
	3S	1	97.43	1000.00	64.08
		2	98.84	1000.00	64.08
		3	104.52	1000.00	108.38
	3B	1	107.35	1100.00	64.08
		2	107.35	1000.00	64.08
		3	107.35	800.00	64.08

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
12 October 1981 (continued)	4S	1	70.46	900.00	108.38
		2	73.30	800.00	108.38
		3	77.56	800.00	64.08
	5S	1	50.60	710.00	108.38
		2	64.79	900.00	108.38
		3	77.36	800.00	64.08
	5B	1	50.60	800.00	108.38
		2	64.79	800.00	86.24
		3	64.79	800.00	108.38
	6S	1	61.95	800.00	108.38
		2	81.82	800.00	86.24
		3	61.95	900.00	108.38
	6B	1	50.60	610.00	108.38
		2	39.27	700.00	130.51
		3	44.91	700.00	130.51
	7S	1	80.39	700.00	108.38
		2	84.66	610.00	108.38
		3	76.15	520.00	108.38
	7B	1	50.60	610.00	108.38
		2	43.51	700.00	108.38
		3	44.93	700.00	108.38

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
12 October 1981 (continued)	8S	1	35.00	520.00	108.38
		2	54.85	520.00	108.38
		3	50.60	610.00	108.38
	9S	1	47.77	610.00	108.38
		2	50.60	700.00	108.38
		3	49.18	520.00	108.38
	10S	1	76.13	610.00	130.51
		2	73.30	420.00	130.51
		3	70.46	420.00	108.38
	11S	1	67.62	420.00	108.38
		2	70.46	420.00	130.51
		3	64.79	520.00	130.51
	12S	1	93.17	320.00	130.51
		2	96.01	320.00	130.51
		3	93.16	520.00	130.51
	13S	1	78.99	520.00	108.38
		2	76.13	520.00	86.24
		3	67.62	420.00	108.38
	14S	1	76.13	520.00	108.38
		2	78.97	420.00	108.38
		3	80.39	420.00	108.38

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
12 October 1981 (continued)	15S	1	64.79	520.00	108.38
		2	67.62	420.00	108.38
		3	61.95	320.00	108.38
19 October 1981	1S	1	109.34	1460.00	1126.66
		2	90.19	1380.00	1116.15
		3	97.85	1460.00	1116.15
	1B	1	78.71	1380.00	1105.65
		2	78.71	1230.00	1095.14
		3	86.37	1080.00	1095.14
	2S	1	55.72	1080.00	1084.63
		2	59.56	1000.00	1063.61
		3	74.87	1000.00	1063.61
	2B	1	59.56	920.00	1053.10
		2	76.78	840.00	1063.61
		3	59.56	1000.00	1053.10
	3S	1	69.13	920.00	1063.61
		2	55.72	840.00	1063.61
		3	49.98	920.00	1074.12
	3B	1	120.82	840.00	1063.61
		2	136.14	840.00	1042.59
		3	113.16	770.00	1053.10

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
19 October 1981 (continued)	4S	1	90.19	770.00	1032.08
		2	90.19	840.00	1042.59
		3	90.19	770.00	1032.08
	5S	1	53.82	770.00	1053.10
		2	44.24	700.00	1053.10
		3	51.90	700.00	1063.61
	5B	1	65.30	620.00	1042.59
		2	65.30	620.00	1042.59
		3	65.30	620.00	1032.08
	6S	1	44.24	620.00	1042.59
		2	44.24	620.00	1042.59
		3	36.58	770.00	1053.10
	6B	1	28.92	460.00	1042.59
		2	42.32	460.00	1032.08
		3	28.92	460.00	1032.08
	7S	1	113.16	620.00	1032.08
		2	120.82	460.00	1021.57
		3	113.16	620.00	1021.57
	7B	1	84.45	460.00	1032.08
		2	78.71	460.00	1021.57
		3	78.71	620.00	1021.57

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
19 October 1981 (continued)	8S	1	48.06	380.00	979.54
		2	51.88	310.00	969.03
		3	51.88	460.00	1000.56
	9S	1	97.86	460.00	858.52
		2	97.85	380.00	858.52
		3	97.86	460.00	948.01
	10S	1	76.78	380.00	979.54
		2	86.35	380.00	1000.56
		3	84.45	380.00	979.54
	11S	1	32.75	310.00	842.92
		2	55.72	310.00	853.43
		3	55.72	310.00	863.94
	12S	1	132.31	310.00	842.92
		2	132.31	310.00	821.90
		3	132.31	310.00	790.38
	13S	1	74.87	310.00	727.32
		2	86.37	310.00	716.81
		3	74.87	310.00	727.32
	14S	1	120.82	310.00	706.30
		2	117.00	310.00	706.30
		3	120.82	310.00	685.29

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
19 October 1981 (continued)	15S	1	92.11	310.00	622.23
		2	94.02	230.00	622.23
		3	90.19	230.00	622.23
26 October 1981	1S	1	147.81	850.00	352.04
		2	143.84	850.00	352.04
		3	118.01	850.00	374.17
	1B	1	139.86	850.00	329.87
		2	118.01	850.00	352.04
		3	139.86	850.00	363.10
	2S	1	108.07	670.00	329.87
		2	100.13	670.00	340.94
		3	86.21	670.00	307.74
	2B	1	96.15	670.00	285.57
		2	100.13	670.00	285.57
		3	104.09	670.00	318.80
	3S	1	118.01	670.00	296.67
		2	110.05	670.00	285.57
		3	112.04	670.00	285.57
	3B	1	102.10	670.00	296.67
		2	90.19	670.00	307.74
		3	90.19	670.00	296.67

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
26 October 1981 (continued)	4S	1	121.97	670.00	263.44
		2	121.97	670.00	241.30
		3	119.99	670.00	241.30
	5S	1	133.90	480.00	241.27
		2	121.97	480.00	241.27
		3	112.04	480.00	241.27
	5B	1	133.90	480.00	241.27
		2	137.87	480.00	230.21
		3	127.93	480.00	219.14
	6S	1	125.94	480.00	174.84
		2	121.98	480.00	174.84
		3	127.93	480.00	174.84
	6B	1	133.90	480.00	196.97
		2	137.87	480.00	196.97
		3	137.87	480.00	196.97
	7S	1	133.90	480.00	230.21
		2	125.94	480.00	196.97
		3	133.90	480.00	196.97
	7B	1	133.90	480.00	196.97
		2	133.90	480.00	196.97
		3	129.92	480.00	196.97

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
26 October 1981 (continued)	8S	1	129.92	300.00	219.14
		2	145.82	300.00	208.07
		3	133.90	300.00	219.11
	9S	1	145.82	300.00	185.91
		2	139.86	300.00	208.07
		3	139.86	300.00	230.21
	10S	1	149.80	300.00	208.07
		2	149.80	300.00	230.21
		3	149.80	300.00	208.07
	11S	1	177.60	300.00	296.67
		2	177.60	300.00	307.74
		3	181.58	300.00	329.87
	12S	1	163.70	300.00	196.97
		2	159.73	300.00	208.07
		3	171.65	300.00	196.97
	13S	1	181.58	300.00	329.90
		2	175.62	300.00	385.27
		3	175.62	300.00	407.40
	14S	1	179.59	300.00	440.63
		2	187.54	300.00	462.80
		3	185.56	300.00	462.80

Appendix B. (continued)

Cruise Date	Station	Replicate	Ammonia µg N/l	Nitrates and Nitrites µg N/l	Ortho-phosphate µg P/l
26 October 1981	15S	1	171.64	300.00	484.93
		2	185.56	300.00	462.80
		3	175.62	300.00	462.80