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Biological and Chemical Evaluation of the Aquatic Environment of Selected Undeveloped Kentucky Lake Embayments

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ABSTRACT

This report describes research involving biological and chemical analysis of two undeveloped embayments on Kentucky Lake, namely Anderson and Vickers Bays. Field and laboratory studies were made to assess current biotic standing crops, limnological conditions, levels of inorganic and organic pollutants in the embayments.

Keywords: *Plankton, *Benthos, *Fishes, *Organic Pollutants limnological conditions, productivity

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The report is dedicated to the memory of our colleague Dr. Morgan E. Sisk, co-investigator and friend whose initial leadership and endeavors were instrumental in the success of this study.

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CHAPTER I

INTRODUCTION

The initial decision to examine the waters of Kentucky Lake was prompted by a lack of information on water quality and biological entities of this largest lake in the T.V.A. system. Some biological and chemical data had been generated from a previous study (Ky. Dept. of Fish & Wildlife Research, Project No. 4-48-R) below Kentucky Dam, but knowledge of these parameters in the lake are limited. The main objective of this research was to provide such information from two large undeveloped embayments (Anderson and Vicker's creeks) of Kentucky Lake.

Kentucky Lake, a reservoir constructed in 1944, is the largest of the Tennessee River impoundments which was developed for a variety of coordinated uses. Kentucky Lake, the last mainstream reservoir on the Tennessee River system, has the capability of controlling the flow of the Tennessee into the Ohio. The Tennessee River flows generally along the eastern edge of the unconsolidated Cretaceous deposits, but its valley is, for the most part, cut into underlying Middle and Lower Mississippi rock. This rock, predominately composed of limestone, has been exposed to the Tennessee River and contributes carbonates to the system (T.V.A., 1974). The headwaters of the Tennessee River are in eastern Tennessee, western Virginia, western North Carolina, and northern Georgia. The main river rises just below Knoxville, Tennessee and flows southwesterly through Tennessee, across northern Alabama, northeastern Mississippi, and then north through western Tennessee and western Kentucky to its confluence with the Ohio River at Paducah, Kentucky.

Anderson Creek, a third order stream (Kuehne, 1962), is a tributary to the Tennessee River. The stream and all of its headwater tributaries are located in Calloway County, Kentucky. The headwaters of Anderson Creek lie at approximately 500 feet mean sea level whereas the mouth is at 355 feet mean sea level. The area drained by the creek is woodland with very little agricultural activity. The stream channel below 355 feet mean sea level has been inundated by the impoundment of the Tennessee River and the formation of Kentucky Lake. Anderson Creek is located on the west shore of the reservoir at Tennessee River Mile (TRM) 45.4. The long axis of the bay runs in an east to west direction perpendicular to the main stream of the Tennessee River.

The morphometric data of Anderson Creek embayment was made available by a class project; however, the data varies seasonally due to water level fluctuations. For this reason, pool stages are designated winter pool and summer pool, elevation 354 feet above sea level and 359 feet above sea level respectively. Figure 1, shows a map of the embayment and the various bottom contours. The maximum length of the embayment ranges from 1.06 mi. (1.71 km.) to 1.18 mi. (1.90 km.). Maximum width is 0.39 mi. (0.63 km.) to 0.41 mi. (0.66 km.). The cove has a shoreline length ranging from 2.44 mi. (3.93 km.) to 3.22 mi. (5.18 km.). Areal extent is 177 acres (0.71 sq. km.) at summer pool and 142 acres (0.57 sq. km.) at winter pool. Maximum depths and mean depths are 23.3 ft. (7.1m.) to 28.3 ft. (8.6m.) and 12.6 ft. (3.8m.) to 15.6 ft. (4.8m.), respectively. At summer pool, the volume is 2,216 acre-feet (2.733,414 cubic m.) while at winter pool, 1,421 acre-feet (1,752,789 cubic m.) are impounded in the embayment.

Vickers Bay, Figure 2, is located at Tennessee River mile 40 in Land Between the Lakes, Trigg County, Kentucky. The bay lies in an almost east to west fashion, with the mouth of the embayment opening almost directly toward the west. Prevailing winds plus an inswing of the main lake channel toward the mouth of the cove effect the embayment in that wave actions and currents disturb the strata and bottom sediment, thus causing a constant mixing of the existing biota and chemical characteristics.

The embayment is approximately 1.25 miles long and 0.25 miles wide, with an area of about 160 acres. Maximum depths range from 23 to 28 feet with a mean depth of 13.6 feet and a volume of about 3,808 acre feet at summer pool.

The shoreline of the embayment is characteristic of the area in that it is composed of chert gravel. The bottom type of the embayment is varied depending upon the depth, with the creek channel made up of thick clay mud and more shallow areas having sand, fine gravel, or as in the extreme upper, shallow section, large coarse allocthanous materials such as leaves, twigs and bark. On the whole, total allocthanous material in the embayment is minimal in that the inflowing creeks have insignificant flow and are of short length. This is unlike Anderson Creek embayment which has a significant feeder stream and rich bottom sediments.

Aquatic research on the Tennessee River has been predominantly fisheries oriented. Fisheries of Kentucky Lake has been well documented by the Tennessee Valley Authority and the Tennessee and Kentucky Fish and Game Departments. Several published reports specifically on pre- and

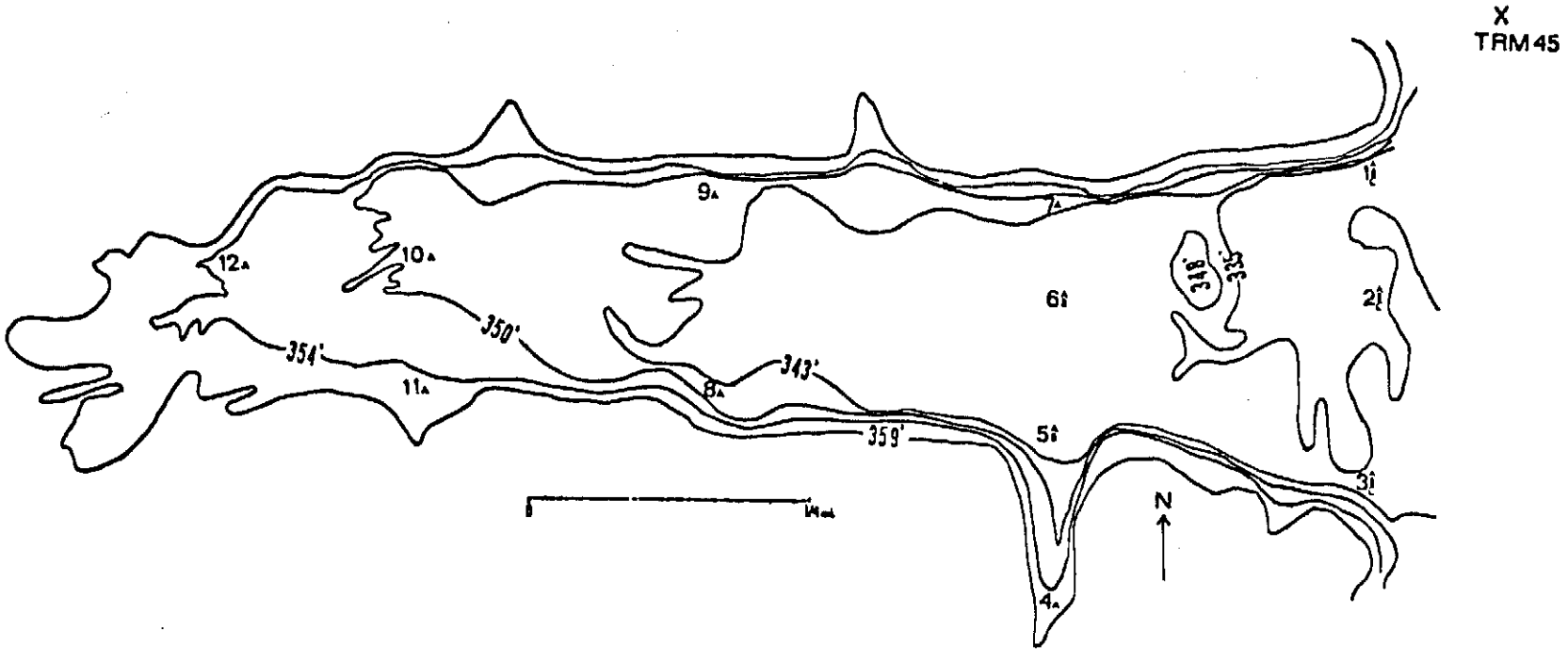

Figure 1. Contour Map of Anderson Creek and Sampling Station Locations.

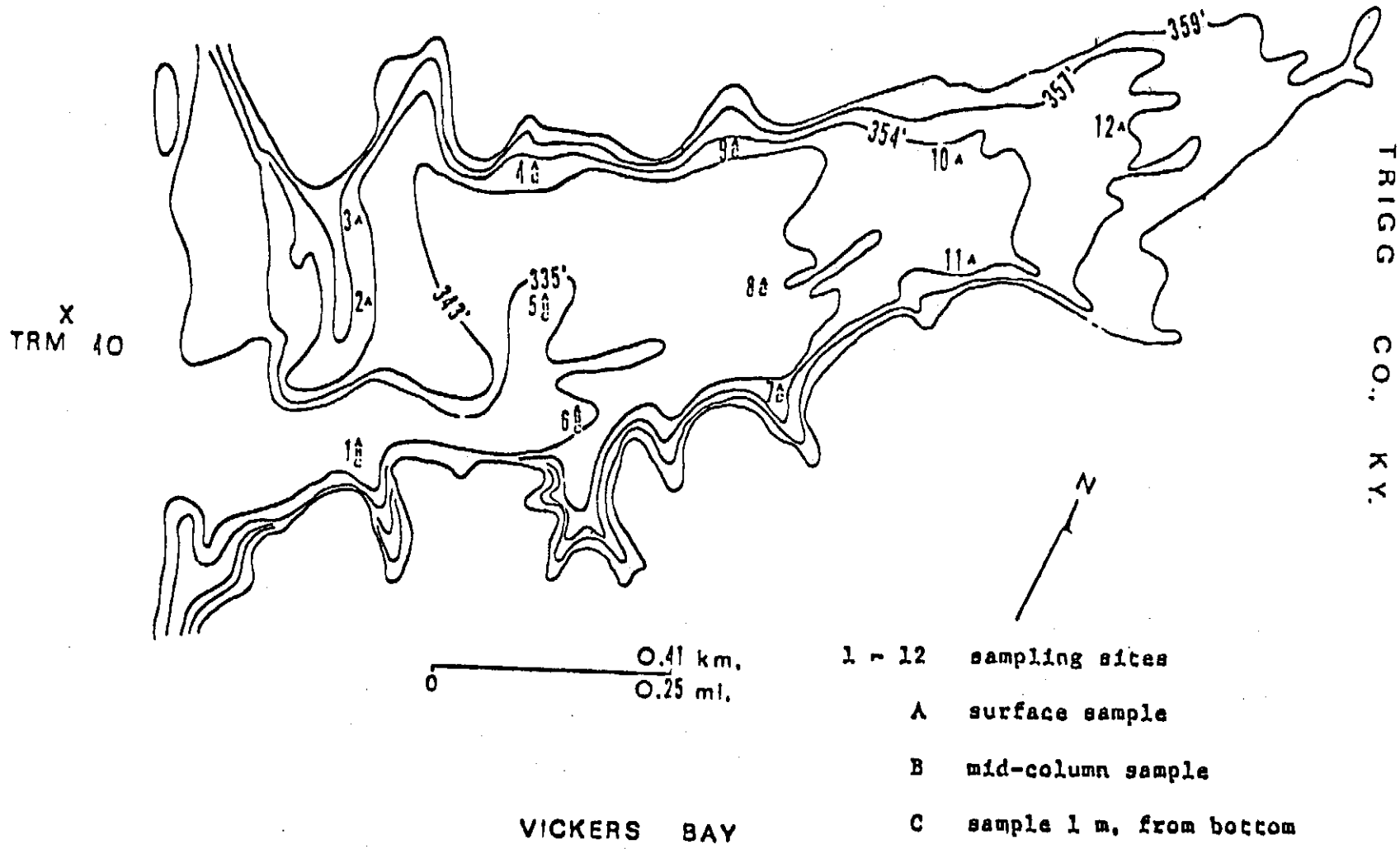

Figure 2. Contour Map of Vickers Bay and Sampling Station Locations.

post-impoundment bottom fauna of the Tennessee River appear in the literature. Pre-impoundment studies include: Ortman (1924) on the upper east portion of the Tennessee River Basin, and Lyman (1943) on the Watts Bar area. Wiebe (1938) on Norris reservoir and Sinclair and Ingram (1961) on Pickwick reservoir are references to post-impoundment studies. Bates (1962) compared the pre-impoundment and post-impoundment mussel fauna of Kentucky Lake. Limnological studies of Kentucky Lake are uncommon in the literature. The Tennessee Valley Authority Water Quality Branch reported in 1974 on the quality of water in Kentucky Lake. This was part of a series of special studies involving main stem reservoirs and all sampling was conducted within the main channel of the river. Taylor (1971) included Kentucky Lake in a report of six Tennessee Valley Authority reservoirs in which phytoplankton productivity and nutrient availability were studied in relation to certain environmental factors.

No published report was found involving any type of limnological work of Kentucky Lake embayments. Nationwide river monitoring programs have included the Tennessee River since it is the fifth largest river in the United States. Scott and Williams (1962) reported on the principal diatoms. Williams (1964) reported dominant planktonic rotifers of major waterways of the United States. Weber (1971) published a guide to the common diatoms of Water Pollution Surveillance System Stations that included the Tennessee River. Silva (1951) reported on the algae of the Tennessee Valley Region. His study constituted a systematic treatment of the algae and is an excellent reference to the identification of species. Effects of impoundment on physical and chemical qualities of water in the Tennessee Valley have been documented in several reports: Wiebe, 1938,

1939, 1940; Churchill, 1958; Dendy, 1946; and Eschmeyer, 1939, 1950. The Tennessee Stream Pollution Board (1960) reported on surface water quality at selected stream sampling stations on portions of the Tennessee River within the state of Tennessee. Annual reports by the United States Geological Survey in cooperation with the Kentucky Geological Survey, supply data on chemical quality, water temperature, and sediments on all surface waters of Kentucky. This includes that portion of the Tennessee River which flows through Kentucky.

CHAPTER II

RESEARCH PROCEDURES

Sampling Stations. Monthly samples were taken from the embayments at selected sampling sites shown in Figure 1 and 2. Sampling was initiated on Anderson Creek during late July and early August, 1974. Work on Vicker's Creek was delayed until late September and early October, 1974, due to man-power problems. All stations were marked with floating buoys and by landmarks. Tables 1 and 2 give bottom elevations and depths of each sampling station in Anderson Creek and Vickers Creek embayments, respectively. At each station, plankton and benthos were collected and selected water quality measurements were made. Stations located in the shallow protions of each cove, ex. numbers 4, 7, 8, 9, 10, 11, and 12 in Figure 1, were sampled for water quality at the surface only. Also, using Figure 1 as an example, stations 3, 5, and 6 were sampled at the surface and one meter from the bottom; station 1 and 2 maintained sufficient depth throughout the year to obtain samples from the surface, mid-column, and one meter from the bottom.

Plankton Determinations. Plankton was sampled by submerging a Juday plankton trap in the euphotic zone at all sampling stations. At deeper stations, bottom and mid-column samples were obtained. Generally, half of the stations were sampled one week and the other half the following week. This was done in order to examine the samples while they were still fresh. A Juday trap was used to obtain a five liter sample with minimal disturbance to the water. The sample was concentrated to 40 milliliters in the field, and all samples were transported to Murray State University

Table 1. Bottom Elevations And Depth Of Each Sampling Station in Anderson Creek.

Station	Bottom elevation in feet above Mean Sea Level*	Depth at seasonal pool elevations	
		winter	summer
1	331.7	23.3 ft. (7.1m)	28.3 ft. (8.6m)
2	335.7	19.3 ft. (5.9m)	24.3 ft. (7.4m)
3	338.7	15.3 ft. (4.7m)	20.3 ft. (6.2m)
4	352.2	1.8 ft. (0.5m)	6.8 ft. (2.1m)
5	341.7	12.3 ft. (3.7m)	17.3 ft. (5.3m)
6	337.7	14.1 ft. (4.3m)	19.6 ft. (6.3m)
7	348.7	5.3 ft. (1.6m)	10.3 ft. (3.1m)
8	347.7	6.3 ft. (1.9m)	11.3 ft. (3.4m)
9	344.7	9.3 ft. (2.8m)	14.3 ft. (4.4m)
10	350.7	3.3 ft. (1.0m)	8.3 ft. (2.5m)
11	352.7	1.3 ft. (0.4m)	6.3 ft. (1.9m)
12	352.7	1.3 ft. (0.4m)	6.3 ft. (1.9m)

* Bottom elevations from which depths were determined are approximations accurate within one foot.

Table 2. Bottom Elevations and Depths of Each Sampling Station in Vickers Bay.

Station	Bottom elevation in feet above Mean Sea Level	Depth at seasonal pool elevations winter	summer
1	351.7	23.3 ft. (7.1m)	28.3 ft. (8.6m)
2	352.5	1.5 ft. (0.5m)	6.5 ft. (2.0m)
3	353	1.3 ft. (0.4m)	6.0 ft. (1.8m)
4	345.7	8.3 ft. (2.5m)	13.3 ft. (4.0m)
5	332.7	21.3 ft. (6.5m)	26.3 ft. (8.0m)
6	333	21.0 ft. (6.4m)	26.0 ft. (7.9m)
7	346.5	7.5 ft. (2.3m)	12.5 ft. (3.8m)
8	338.7	15.3 ft. (4.6m)	20.3 ft. (6.2m)
9	346.7	7.3 ft. (2.2m)	12.3 ft. (3.7m)
10	350.7	3.3 ft. (1.0m)	8.3 ft. (2.5m)
11	348.7	5.3 ft. (1.6m)	10.3 ft. (3.1m)
12	355.7	inaccessable	3.3 ft. (1.0m)

* Bottom elevations from which depths were determined are approximations accurate within one foot.

Biological Station. Upon arrival to the lab, all samples were immediately enumerated as to total phytoplankters per liter and total zooplankters per liter. Enumeration was obtained from a one milliliter aliquot of the sample by making strips on a Sedwick-Rafter slide under 200x magnification using a Whipple micrometer disc. Individual phytoplankters and colonies and zooplankters were included in the count if the forms totally or partially covered the image of the Whipple grid. When making the strip count, 2-4 strips the length of the cell were made, depending on the density of the cell. The same enumeration was used on zooplankters for the first three collecting months. After that a total count of the entire cell was made. Identification of plankton was made when possible in the counting chamber; however, most organisms were identified subsequent to enumeration. The general procedure used in identification was to allow the sample bottle to settle for at least 24 hours and then pipette a subsample from the bottom of the bottle. Drops of these subsamples were placed on slides and covered with 50 X 20 mm glass coverslips. Organisms were examined under 400x and identified to genus whenever possible. Most samples were refrigerated and examined while still fresh except for the August collection and miscellaneous samples. Refrigeration of the samples with covers removed allowed for examination of live organisms up to seven days. August samples were preserved with five percent formalin; however, subsequent samples were preserved with a Merthiolate solution (Weber, 1968). Both preservations appeared to be adequate. Identification of the various taxa was made following Prescott (1962) for phytoplankton and Pennak (1953) and Ward and Whipple (1965) for zooplankton. Total phytoplankters and total zooplankters per liter were recorded for each station taxa listed.

Benthos Determination. Benthic sampling was conducted at every station. Qualitative and quantitative samples of the substrate were collected at each station with an Ekman dredge. The known area, 524 sq. cm., of the Ekman dredge provided a quantitative estimate of the macrobenthic population. The dredge was an excellent sampling device at most stations. Stations located near the mouths of tributary streams to the embayments, ex. numbers 4 and 11, Figure 1, accumulated considerable detritus from the terrestrial environment. Other stations, ex. numbers 8 and 12, Figure 1, had gravel and sand mixed with the substrate. The gravel, sand, and detritus on occasion prevented the jaws of the dredge from closing properly. Most stations had sufficient sediment and clay to obtain adequate samples. After the bottom sample was collected, it was brought to the surface and placed in a large pail. The sample was then passed through a U. S. Standard No. 30 mesh sieve while the sieve was rotated in the water. The washing operation was repeated until fine material was washed out leaving benthic organisms in the sieve. The organisms and coarser debris were removed from the sieve and placed in wide mouth jars. The samples were returned to the laboratory and organisms were sorted while still alive. A white enamel pan was used in the hand picking operation. The pan was half filled with water, and material from the sample jar was placed in the center of the pan. Macroinvertebrates were removed with forceps after sorting through the sample. In difficult samples containing detritus, a sugar flotation method was used (Anderson, 1959). A sugar solution of specific gravity 1.12 was added to the washed sample to float the organisms. This process, with an intermediary washing, was performed twice on each sample. Once sorted, all macroinvertebrates were preserved in 35 percent isopropyl and placed in

vials containing the date and station number. At a later date, the contents of each sample was separated under a dissecting scope and organisms were sorted and respective taxa counted. The organisms were identified to genus when possible according to Pennak (1953) and expressed as numbers per square meter. To compliment sampling the benthic population, artificial substrates were employed at three different time periods during the collection year. Multiple-plate samplers constructed of tempered hardboard (Hester and Dendy, 1962) were placed on bottom at each of the twelve sampling stations and attached to a buoy line. The three time periods were approximately two, four week intervals and one, five week interval. A total of 36 samplers were set of which only 20 were recovered, the loss presumably due to vandalism. Samplers were pulled from the water and placed in plastic bags and returned to the lab. Here they were thoroughly washed out over a U. S. Standard No. 30 sieve and organisms recovered and place in 35 percent isopropyl for later identification. Density of organisms was also expressed as number per square meter.

Water Quality Determinations. Selected physical parameters including turbidity, water temperature, conductivity, total dissolved solids, dissolved oxygen, and Secchi-disc readings were obtained at each station using accepted procedures. Temperature readings were taken with a Yellow Spring Instrument Company Telethermometer, Model 43TD. Conductivity measurements were made with a Beckman, Model RA-2A Conductivity Meter. Dissolved oxygen measurements were made with a Hach Meter, Model 1962. Other tests were made by collection of water samples using a Kemmerer Water Sampler, 1200 ml, and use of a Hach Kit.

Chemical tests including free carbon dioxide total alkalinity, and pH were made using the Hach Kit and a Hellige meter. Other chemical

parameters, nitrates and phosphates, were determined in the chemistry laboratories using procedures outlined in Standard Methods on freshly collected samples.

Organic Compound Determinations. The initial sampling for organics was performed by taking "grab" samples (approximately 1 quart in glass jars with Teflon-lined caps) at each station in both embayments. The grab samples were treated in the following ways:

1. headspace analysis - this technique is best suited for volatile organics which are not appreciably water soluble. A 1 ml portion of the water sample was sealed in a small vial and warmed slightly and the headspace sampled with a 1 ml gas-tight syringe. The vapor was analyzed by GC and GC/MS/COM.

2. distillation - water soluble volatile organics may be concentrated by distillation of a portion of the collected water sample. Because the compounds analyzed by this method are steam volatile, the distillate was enriched in organics and injected directly into the GC. The presence of water soluble non-volatiles was checked for by analysis of the water sample left in the distillation pot.

3. separation by pH adjustment - water insoluble organics were extracted by liquid-liquid extraction using hexane if pH is 5-14 or methylene chloride if pH is 1-<5.

Earlier identification procedures required large amounts of sample. Therefore, a portable carbon adsorption water sampler was designed and constructed, Figure 3. This procedure developed by EPA, has proved to be very good for obtaining sufficient quantities of extract for GC and GC/MS/COM analysis. The portable sampler was placed in a boat and anchored at the spot to be sampled. After pumping a pre-determined amount

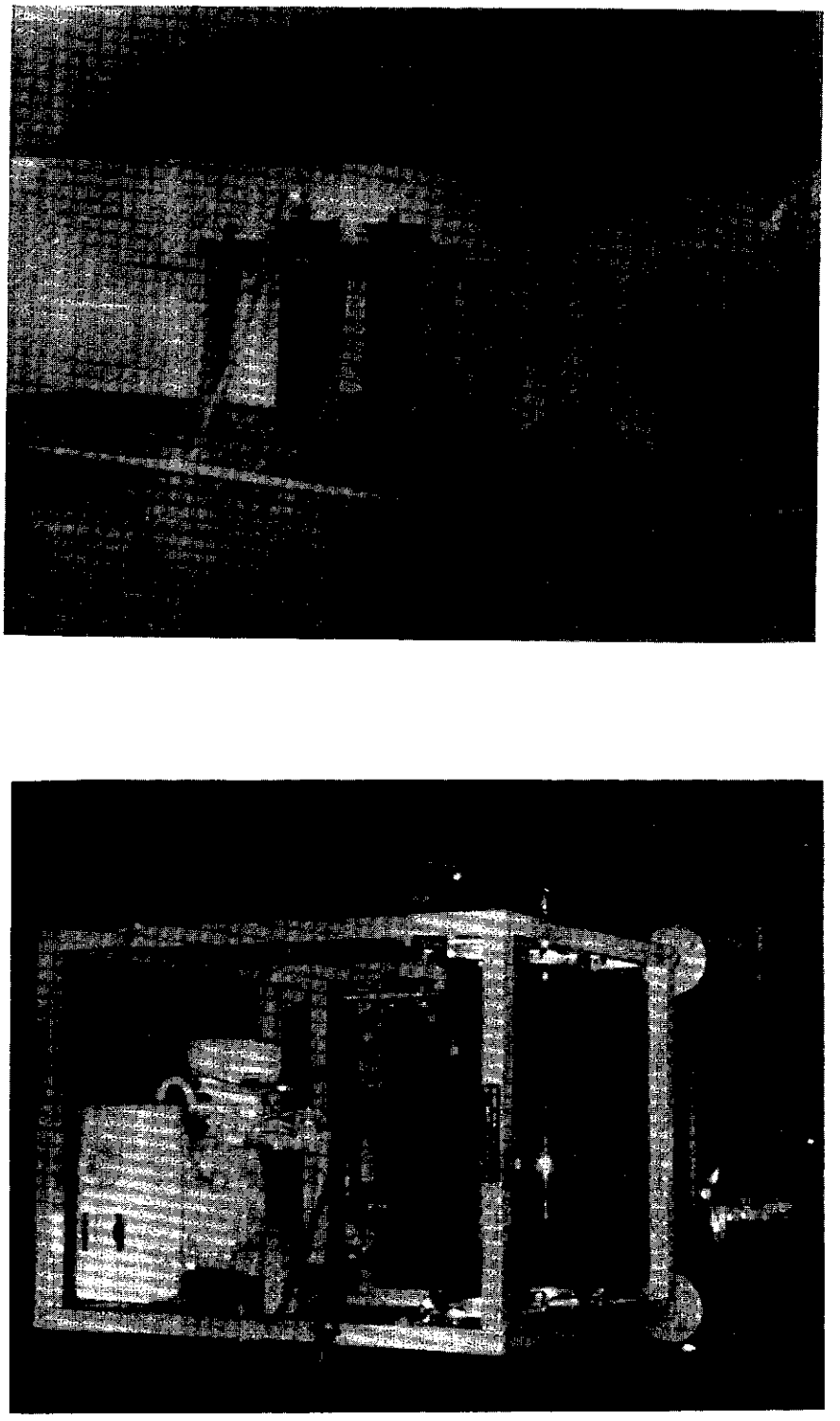

Figure 3. Portable Organic Water Sampler

of water through the filter, the contents (carbon containing adsorbed organics) were dried and extracted (soxhlet) using Burdick/Jackson distilled-in-glass solvents. Blank runs were made with tap water and care was taken not to introduce artifacts. The extracts were concentrated using Kuderna-Danish evaporators to approximately 10 ml. Further concentration (to approximately 1 ml) of the extract was accomplished using a stream of pre-purified organic-free nitrogen. The concentrated extract was sealed in crimp top vials sealed with Teflon lined septa. The concentrated extract in vials was analyzed by GC. More efficient identification techniques utilizing better transfer of organic in water to GC column and from it to the mass spectrometer permitted small "grab" samples to be used once again, thereby rendering the portable organic sampler with carbon filter obsolete.

One of the most effective techniques currently available in our laboratories for the removal of volatile organics from water samples involves the use of an organic-free water-insoluble gas to entrain the organic compounds from the water sample to be trapped onto a suitable absorbent. Typically samples were sparged for 1 hour at room temperature or up to 70°C with organic-free helium and the volatile organics collected onto Tenax (a polymer of 2,6-diphenyl-*p*-phenyleneoxide). All-glass sparging equipment constructed by a glassblower with sizes from 10 ml to 5 liters has been used, Figure 4. Helium gas passed through a molecular sieve trap cooled by liquid nitrogen to remove organics from the sparging has entered the bottom of the sparging apparatus through a medium porosity glass fritted wafer. At the top of the sparging apparatus, a condenser with 19/22 standard taper joints was placed to prevent water vapors from getting into the Tenax trap. Glass tubes (typically 3 mm X 110 mm) containing

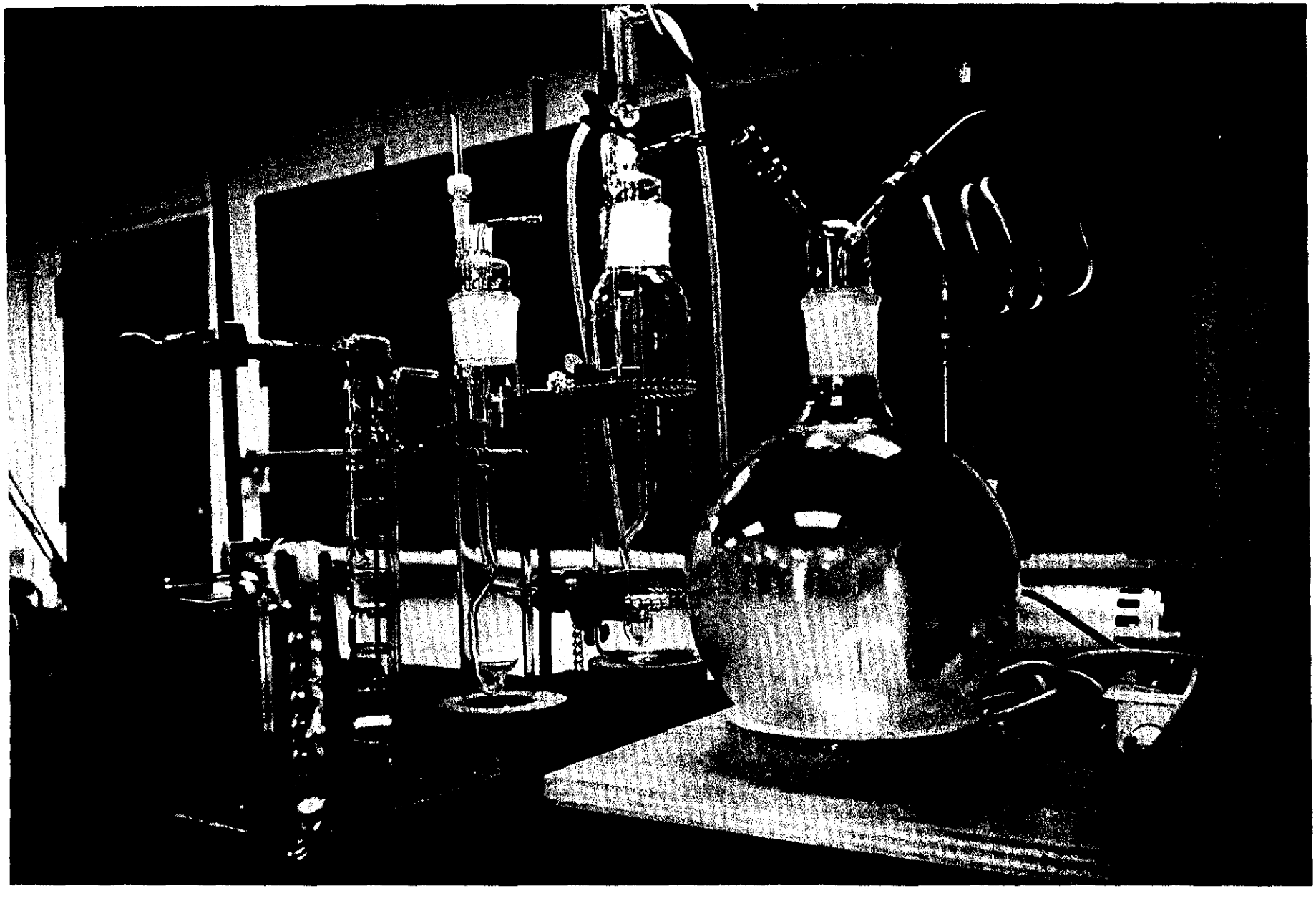

Figure 4. Volatile Organics Removal Apparatus

approximately 50 mg of conditioned Tenax was placed in holes of Teflon plug which sits atop of the condenser. Because of sample size and concentration of organics it sometimes was necessary to use more than one tube in sequence and to mix the contents of more concentrated tubes with conditioned Tenax to obtain desirable concentrations for use with the GC/MS/COM system. Tenax absorbed a number of different classes of organic compounds and because of its high temperature stability was an excellent choice for heat desorption of organics. Its low specific surface area (approx. $19M^2/g$) has not presented problems in our studies. We have used tubes of Tenax for concentrating liquid-liquid extracts. Normally, after the sparging process, the mixture was extracted according to published procedures by EPA workers with distilled-in-glass solvents. The extract was concentrated using Kuderna/Danish evaporators and further concentrated using a stream of pure nitrogen. Additional solvent was removed from this extract by injection of 10μℓ of extract into the Tenax tube and subsequent flushing of the tube with helium. This procedure can be repeated to build up the desirable concentration of organics on Tenax. Tenax is soluble in some solvents, for example, methylenechloride. In this case we have used with some success tubes containing silanized glass wool for further concentration of the extract. After the sparging process, the glass tubes containing Tenax with absorbed organics are placed directly into the GC injector port for subsequent GC analysis. When using the Tenax tubes, a typical GC procedure is as follows: The oven is cooled to approximately 0°C (depending on liquid phase used in glass capillary), and the desorbed organics (from the heat of the injector port) collected in a "loop" made in the glass capillary which is immersed in liquid nitrogen. Approximately 15 minutes is required for desorption and on-column trapping. Temperature programming of the oven

produces the normal GC profile. By spiking the water sample with known compounds and with prior knowledge of the sparging efficiency, one can gain quantitative information using the digital integrator.

Separation and identification of organics from the water samples was achieved by GC/MS/COM technique. The system used in our laboratories is in a constant state of change in an effort to achieve the best results with the smallest amount of samples. A picture of the system currently being used is shown in Figure 5. Very simply, the current state of GC/MS/COM instrumentation in our laboratory can be summed up as follows:

1. Gas Chromatography - use of high resolution glass capillary columns (made in our lab) in which part of the effluent flows directly into the mass spectrometer, the remainder, to the FID.

2. Mass Spectrometer - a Finnigan quadrupole mass filter capable of mass range 0-420 amu.

3. Computer - an IBM Model 1130 with tape and disc capabilities. Spectra can be obtained manually or automatically with background subtract, spectral enhancement, RGC, and LMRC features. The need for high resolution mass spectra is met by use of a Perkin Elmer RMU-7 double focusing mass spectrometer, Figure 6.

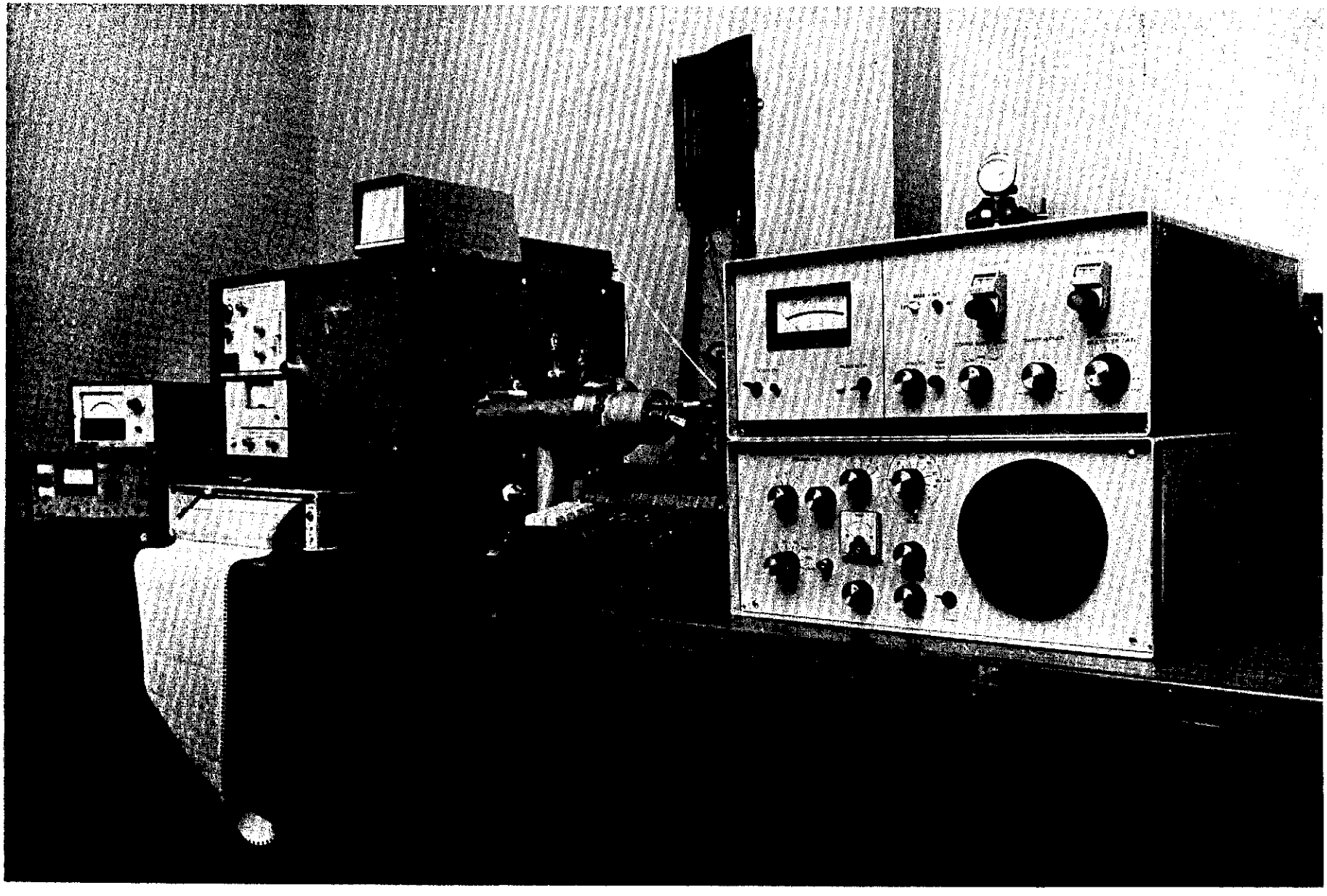

Figure 5. Murray State University GC/MS/COM System

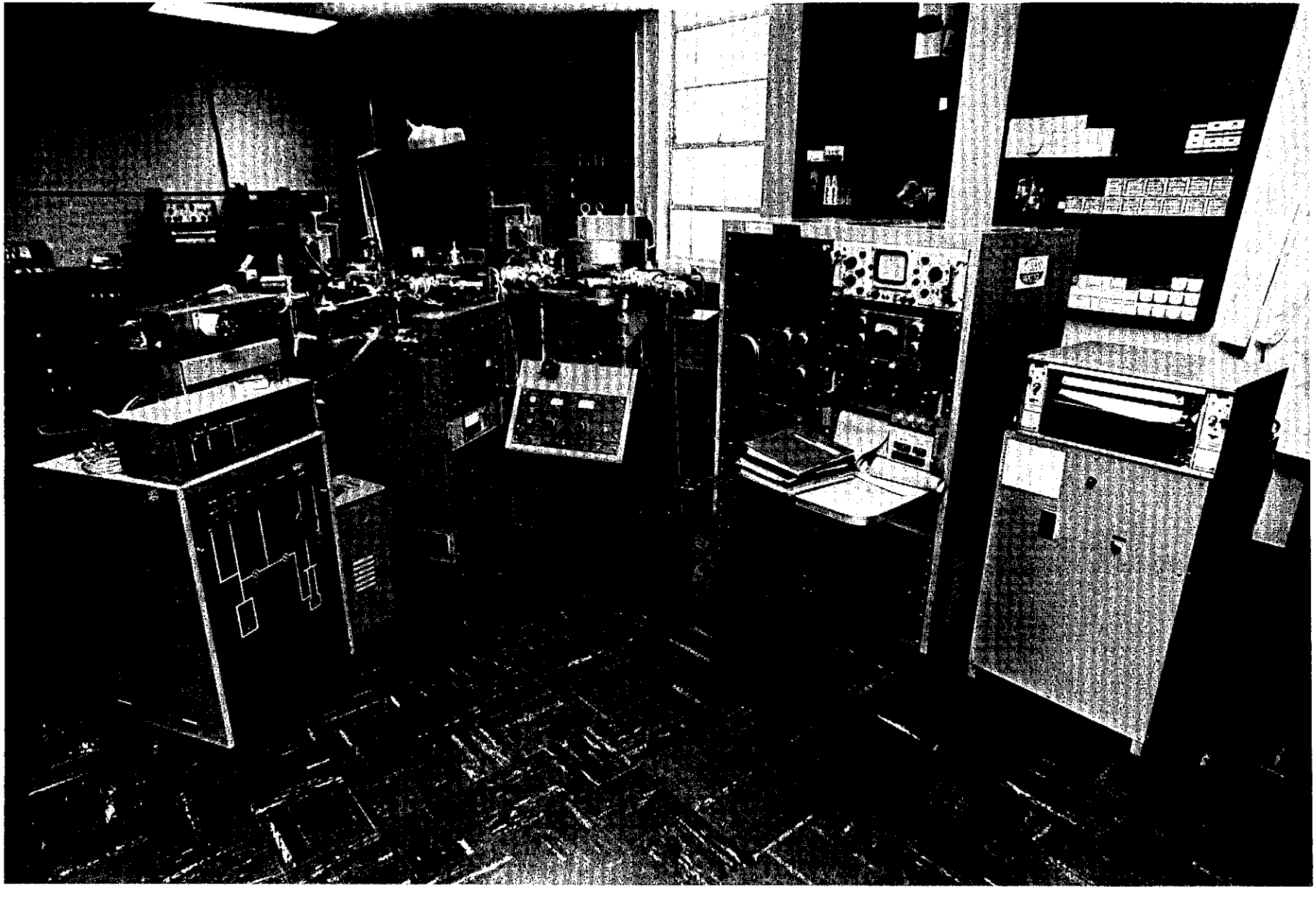

Figure 6. Perkin-Elmer RMU-7 Double Focusing Mass Spectrometer

CHAPTER III

DATA AND RESULTS

Because of the manner in which the study was executed, i.e. the biological component was shared among two graduate students (Mr. Kinman's responsibility was Anderson Creek and Mr. Prather's Vickers Bay) and the chemical component by primarily one undergraduate (Mr. Dobroth responsible for sampling and nitrate phosphate determinations, others helped with the analysis of organics), it will be necessary to treat each embayment separately when presenting data and results.

A. Anderson Creek. The sampling period for this embayment was from August, 1974, through October, 1975.

1. Plankton Results.

a. Phytoplankton. Phytoplankton of Anderson Creek embayment consisted of 98 genera representing five phyla. The genera were identified as members of the following phyla: Chlorophyta (49), Chrysophyta (30), Pyrrhophyta (3), Euglenophyta (3), and Cyanophyta (12), and the total number of genera per phylum appear in parenthesis. Although the largest number of genera belonged to the phylum Chlorophyta, Chrysophyta was quantitatively more abundant throughout the study. Diatoms dominated the flora for the entire study period except for August in which the embayment approached stagnant conditions and blue-green algae (Cyanophyta) then became prevalent. Since only a total count of phytoplanktonic cells was recorded and no individual phylum counts made, all comments in reference to numbers of individual phyla are based on personal observations.

Table 3 is a list of the genera identified with respect to phylum and the percent frequency of occurrence for each month and a total for

Table 3. Percent Frequency of Occurrence by Collecting Stations of All Phytoplankters Collected from Anderson Creek Embayment.

	1974					1975									
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Chrysophyta															
Asterionella sp.				5%	11%	63%	95%	95%	100%	100%	5%				11%
Achnanthes sp.				5%											
Amphipleura sp.								5%							
Cyclotella sp.	57%	57%	63%	63%	84%	47%	53%	84%	84%	26%	89%	100%	84%	53%	63%
Cymbella sp.	5%	10%	53%	5%		21%	11%	53%	11%	21%	26%	16%	11%	5%	
Cocconeis sp.			5%	5%	5%						16%		5%	11%	
Diatoma sp.			11%	11%	21%	84%	89%	100%		11%	5%	5%	11%		5%
Diploneis sp.			11%												
Eunotia sp.	5%														
Fragilaria sp.	10%	29%	68%	32%	37%	32%	16%	53%	53%	68%	21%	5%	11%		32%
Frustulia sp.										32%	21%	5%			
Gomphonema sp.	5%		21%	11%	5%	5%	5%		11%	21%	16%	21%	16%	5%	
Gyrosigma sp.	10%	14%	11%		16%	58%	47%	37%	32%	37%	79%	32%	16%		16%
Melosira sp.	86%	100%	89%	100%	100%	95%	95%	95%	100%	95%	84%	100%	100%	95%	100%
Navicula sp.	14%	52%	68%	53%	53%	80%	53%	74%	63%	37%	63%	53%	63%	21%	53%
Nitzschia sp.		10%	16%	5%	5%	26%	26%	47%	47%	53%	11%	11%	16%		
Opephora sp.		5%													
Pinnularia sp.		5%						5%							
Rhoicosphenia sp.										5%					
Synedra sp.	95%	90%	84%	89%	89%	95%	74%	100%	100%	84%	84%	95%	81%	79%	63%
Surirella sp.	10%	19%		16%	16%	37%	26%	58%	32%	16%	37%	16%	63%	47%	11%
Stephanodiscus sp.		29%	26%	26%	53%	74%	95%	79%	26%						
Tabellaria sp.			5%			5%			5%						
Dinobryon sp.						5%		26%	42%	11%					5%
Chrysococcus sp.	5%														
Mallomonas sp.		5%				5%	5%		5%		11%				
Ophiocytium sp.	14%										37%				
Synura sp.						5%		11%	16%			5%			

Table 3. (Continued)

	1974					1975									
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Tribonema sp.					5%							5%			
Vaucheria sp.									5%						
Meridion sp.													5%		
Pyrrhophyta															
Glenodinium sp.	81%	43%	11%	11%	5%				42%	16%	68%	95%	68%	79%	16%
Peridinium sp.		10%						5%		11%					
Ceratium sp.	10%	10%									79%	89%	57%		57%
Euglenophyta															
Trachelomonas sp.	38%	24%	5%			11%	26%	42%	89%	11%	58%	79%	68%	42%	37%
Phacus sp.	5%	43%	26%	5%	21%	5%	11%	21%	42%		37%	47%	37%	11%	16%
Euglena sp.	10%	14%		26%	47%	47%	26%	37%	53%	11%	11%	37%	26%	47%	81%
Cyanophyta															
Chroococcus sp.	62%	33%	42%	11%	5%	5%			5%	95%	47%	89%	81%	16%	5%
Aphanocapsa sp.	10%	11%				11%			5%		11%		11%	11%	5%
Microcystis sp.	33%	33%	16%	11%	11%	11%		5%			53%	63%	63%	26%	42%
Merismopedia sp.	24%	29%		11%							84%	58%	57%	5%	5%
Aphanothece sp.		10%	5%	5%		16%					11%	32%	26%	11%	16%
Spirulina sp.	24%	10%					5%		5%		5%	68%	74%		5%
Oscillatoria sp.							5%	5%	10%	10%	21%	5%	63%	26%	32%
Lyngbya sp.	81%	71%			21%	95%	42%	63%	53%	16%	58%	95%	81%	47%	68%
Anabaena sp.	90%	38%	11%			5%		5%	16%	5%	42%	95%	100%	11%	21%
Nostoc sp.		24%													
Gloeocapsa sp.							5%								
Unidentified procaryotic filament	14%								5%					37%	

Table 3. (Continued)

	1974					1975									
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Chlorophyta															
Chlamydomonas sp.		19%	5%	16%	53%	26%	32%	26%	95%		26%	26%	53%	95%	79%
like						5%	32%	68%	53%					11%	11%
Lobomonas sp.	10%								36%	5%	21%	53%	5%		
Carteria sp.								37%	47%						
Gonium sp.		5%	5%						16%						
Platydorina sp.	52%	38%	11%						11%		47%	79%	16%		
Pandorina sp.	86%	29%	11%	5%				5%	89%		89%	89%	81%	16%	5%
Eudorina sp.		5%				5%			42%	16%	53%	21%		5%	
Pleodorina sp.									16%		5%				
Volvox sp.					5%		5%		5%						
Gloeocystis sp.		5%	5%			32%		5%			16%		5%		
Tetraspora sp.		5%													
Ulothrix sp.	5%	10%		5%		5%			68%		5%				
Stichococcus sp.									11%						
Cylindrocapsa sp.	5%														
Microspora		5%		16%		5%				5%				5%	
Stigeoclonium sp.								11%							
Oedogonium sp.		10%													5%
Golenkinia sp.	14%	38%	5%		11%		11%	21%	21%		26%	47%	32%	11%	11%
Characium sp.	5%										5%		74%	21%	11%
Pediastrum sp.	95%	90%	42%	63%	21%	16%	11%	11%	5%	26%	89%	95%	95%	81%	57%
Coelastrum sp.	33%	10%	5%								47%	60%	42%	26%	5%
Botryococcus sp.											11%				
Dictyosphaerium sp.	10%		5%			11%	16%	16%	47%	5%	32%	11%	79%	42%	84%
Chlorella sp.	29%	86%	79%	81%	79%	74%	53%	53%	63%	11%	37%	58%	16%		
Treubaria sp.	24%	29%									58%	74%	11%	16%	
Oocystis sp.	5%	5%									5%			5%	11%
Lagerheimia sp.	5%	14%				21%	5%	11%			5%	5%	5%		
Franceia sp.		11%											5%		
Ankistrodesmus sp.	52%	71%	53%	53%	68%	100%	74%	79%	79%	21%	74%	89%	47%	11%	53%

Table 3. (Continued)

	1974					1975									
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Schroederia sp.	33%	10%	11%					5%			57%	74%			
Closteriopsis sp.		14%	5%	5%	5%										
Chodatella sp.				5%											
Selenastrum sp.						5%									
Tetrastrum sp.									5%	5%		11%			5%
Tetraedron sp.	29%	14%	32%	26%	21%	5%	5%	16%	10%	26%	26%	42%	63%	26%	5%
Scenedesmus sp.	86%	86%	47%	42%	5%	58%	16%	53%	26%	89%	95%	95%	81%	74%	95%
Actinastrum sp.	19%	90%	47%		5%	26%		5%	32%		74%	89%	95%	47%	81%
Crucigenia sp.						5%	5%	11%		26%	21%			21%	11%
Micractinium sp.		5%			11%	58%	42%	21%	53%	5%	26%	26%			11%
Cosmarium sp.	10%	5%								16%	53%	32%	42%		5%
Euastrum sp.		19%	5%								16%		63%	16%	16%
Staurastrum sp.	14%	14%	5%	11%		5%					53%	58%	26%		5%
Micrasterias sp.	38%					5%		5%			37%	47%	16%		
Closterium sp.	5%		5%	11%		5%	5%	5%		5%	16%	16%			11%
Mougeotia sp.			5%	26%	37%		11%	37%			47%	37%	26%	11%	
Spirogyra sp.			5%	5%	11%	11%						5%	11%	11%	32%
Gloeothece sp.											5%		5%		
Marssoniella sp.	33%	10%	11%			5%		5%			37%	68%	21%	5%	
Kirchneriella sp.													21%		
Polyedriopsis sp.													5%		

the entire study. Monthly percent frequency of occurrence was calculated by totaling the number of samples in which each genus was found and expressing that as a percent of the total number of samples collected for that particular month. Yearly percent frequency of occurrence was calculated in the same manner except the occurrence of each genus throughout the year was totaled and expressed as a percent of the total number of samples taken during the yearly study. By frequency of occurrence the genera of Chlorophyta collected in more than 50% of the samples were Chlorella sp. (59%), Ankistrodesmus sp. (68%), and Scenedesmus sp. (59%). These genera were identified in every collecting month and usually in relatively high frequencies of occurrence. Other genera of green algae occurring in high percentages were Pediastrum sp. (48%), Pandorina sp. (34%), and Actinastrum sp. (33%).

Green algae were seasonally most abundant during the spring and summer. There was a marked increase in the numbers of flagellated green algae in the spring with the genus Pandorina becoming common in April. There was a general increase in diversity of green algae in June which continued through August.

Diatoms (Chrysophyta) dominated the flora, as in most river systems, and the most frequently occurring forms were species of Melosira (95%), Synedra (90%), Cyclotella (67%), and Navicula (55%). Williams (1964) reported species of Melosira, Stephanodiscus, and Cyclotella to be the dominant diatoms from the Tennessee River Basin. Other common planktonic diatoms collected were Fragilaria sp., Diatoma sp., Stephanodiscus sp., Gyrosigma sp., Nitzschia sp., and Surirella sp. Seasonally, there was an increase in diatoms beginning in August and continuing through the

following spring. The genus Melosira dominated this increase and formed the bulk of the phytoplankton in the winter. In May, the genus Asterionella was first observed in large numbers and steadily decreased throughout the summer.

Blue-greens (Cyanophyta) made up the bulk of the plankton in late summer. Dominate genera were Anabaena sp., Lyngbya sp., Chroococcus sp., Merismopedia sp., Microcystis sp., and Spirulina sp. with Anabaena sp. and Lyngbya sp. being the most numerous genera observed. Blue-greens were not abundant in total numbers or in diversity of genera present at any time other than summer months. Lyngbya sp. (50%) and Chroococcus sp. (33%) were the only frequent genera in high percentages. Dinoflagellates (Pyrrhophyta) were not commonly collected, Glenodinium sp. being most frequent, and their numbers were seldom large. Ceratium sp. was found in 16% of the samples but appeared in only four different months of sampling (June through August, inclusive). Euglenophyta was represented by three genera Trachelomonas sp., Phacus sp., and Euglena sp.; all of which were rather uniformly distributed during the collecting year.

Marked seasonal fluctuations were seen in the total phytoplankton standcrop (Figure 7). Phytoplankton cell counts ranged from a low of 6000 cells per liter in May to a yearly high of 118,000 cells per liter in June. Following the yearly high cell counts in June there was a gradual decline in numbers until September. Then in October a definite increase in numbers was observed. Winter standing crops remained rather stable with no pronounced fluctuation. Again in April a "semi" spring pulse was approached with higher phytoplankton counts. Prior to the summer bloom in June, there was a drastic decrease in numbers in May that will be discussed later.

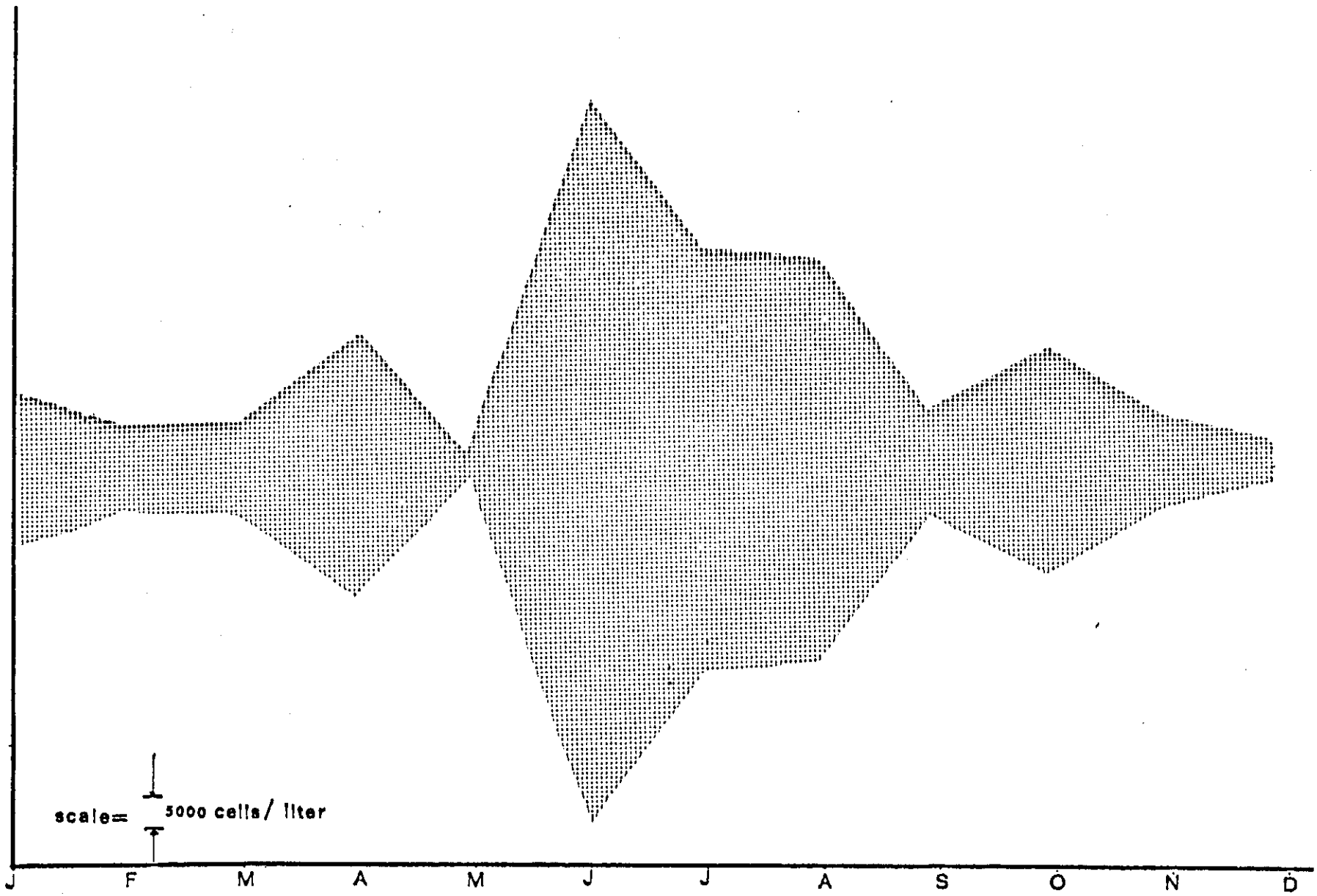

Figure 7. Monthly Variation in Total Phytoplankton Cell per Liter in Anderson Creek Embayment.

b. Zooplankton. General features of monthly frequency of occurrence and relative abundance of zooplankton are shown in Table 4 and Figure 8, respectively. Zooplankton numbers were treated in the same manner as phytoplankton. Each taxa identified was recorded as a percent frequency of occurrence at the collecting stations by month and by an annual percentage.

Amoeboid and ciliate Protozoa were important components of Anderson Creek embayment fauna during most of the collecting year, but comprised little of the total number of zooplankters. The rhizopod, Difflugia sp. (Sarcodina) was consistently the most frequent occurring form. Ciliates were not as important quantitatively as Sarcodina, although Codonella sp. occasionally approached such a position. The genus Vorticella was collected rather frequently, many times attached to a Melosira filament. Most ciliated were only identified to class due to the difficulty in identification.

Rotifers (Rotifera) consistently made up the bulk of the zooplankton encountered in all monthly samples except May. A total of 20 genera of Rotifera were identified. Rotifers that could not be identified were merely listed under Rotifera (Table 4). Branchionus sp., Polyarthra sp., Keratella sp., Synchaeta sp. and Asplanchia sp. were the dominant genera identified and occurred in the following frequencies: 63%, 47%, 30%, 29%, and 27%, respectively. Polyartha sp., Synchaeta sp. and Branchionus sp. were collected in every month of the year, while Keratella sp. and Asplanchia sp. were taken 8 out of 12 months. Other genera of rotifers occurred sporadically. Cyclopoid copepods were common during the sampling but never in large numbers. They occurred in 34% of the total number of samples collected. Copepod naupli were taken in every month, again never in large

Table 4. Percent Frequency of Occurrence by Collecting Stations of All Zooplankters Collected from Anderson Creek Embayment.

	1974					1975									
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Protozoa															
Sarcodina															
Actinosphaerium sp.		14%	26%		26%	26%	13%	21%	10%						
Acanthocystis sp.		21%		5%	5%					37%					
Actinophrys sp.				5%	5%	5%									
Difflugia sp.	10%	14%	10%	16%			5%			10%	77%	77%	100%		
Ciliata	10%	24%	10%	5%	32%	32%	10%	5%	47%	10%	53%	47%	5%		53%
Codonella sp.			16%	10%			21%	32%	21%	63%	26%	58%	57%	68%	16%
Vorticella sp.						68%		16%	10%		5%	16%	5%	5%	11%
Strombidium sp.					5%										
Staurophyra sp.					5%										
Spirostomum sp.						5%									
Podophyra sp.											11%				
Rotifera unidentified	43%	19%	21%	5%	42%		10%	16%	58%	32%	37%		37%	5%	16%
Trichocera sp.	48%	29%	16%	5%		5%				10%	80%	84%	74%	5%	57%
Ploesoma sp.	48%	19%	16%								32%	58%	32%	47%	11%
Asplanchia sp.	29%	5%	10%			47%			16%	52%	80%	84%	32%	68%	42%
Branchionus sp.	62%	95%	84%	100%	80%	80%	16%	47%	68%	42%	21%	53%	84%	11%	16%
Cephalodella sp.		10%		5%											
Synchaeta sp.	5%	27%	16%	5%	52%	37%	5%	21%	63%	32%	42%	42%		26%	11%
Pompholyx sp.		5%													
Polyartha sp.	53%	14%	26%	26%	26%	80%	32%	26%	52%	68%	87%	84%	81%	84%	79%
Colletheca sp.		5%													

Table 4. (Continued)

	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Euchlanis sp.		10%													
Notommata sp.		5%		5%		5%									
Keratella sp.			16%	26%	26%			16%	52%	74%	89%	68%	42%	21%	26%
Monostyla sp.			5%										5%		
Gastropus sp.			5%												
Kellicottia sp.						63%	32%	5%	10%						
Conochilius sp.						11%		5%					11%		
Aelosoma sp.						5%									
Sinantherina sp.											5%		5%	5%	
Filinia sp.	16%											21%	11%		
Hexartha sp.											21%	68%	57%	5%	
Platyias sp.													47%	16%	5%
Limnias sp.													5%		
Gastrochia												11%			
Nematoda		5%		10%					5%						5%
Hydra sp.		5%													
Tardigrada				10%		5%	5%		5%	5%					
Oligochaeta															
Chaetogaster sp.					16%										
Copepoda (nauplius)	14%	38%	21%	26%	58%	95%	74%	53%	58%	95%	74%	80%	100%	63%	42%
Cyclopoida	10%	10%		16%	16%	52%	42%	58%	47%	68%	47%	42%	47%	32%	16%

Table 4. (Continued)

	1974					1975									
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Cladocera	14%	10%		5%				5%	21%	95%	47%	32%			
Diaphanosoma sp.													74%	5%	
Bosmina sp.													74%	63%	16%

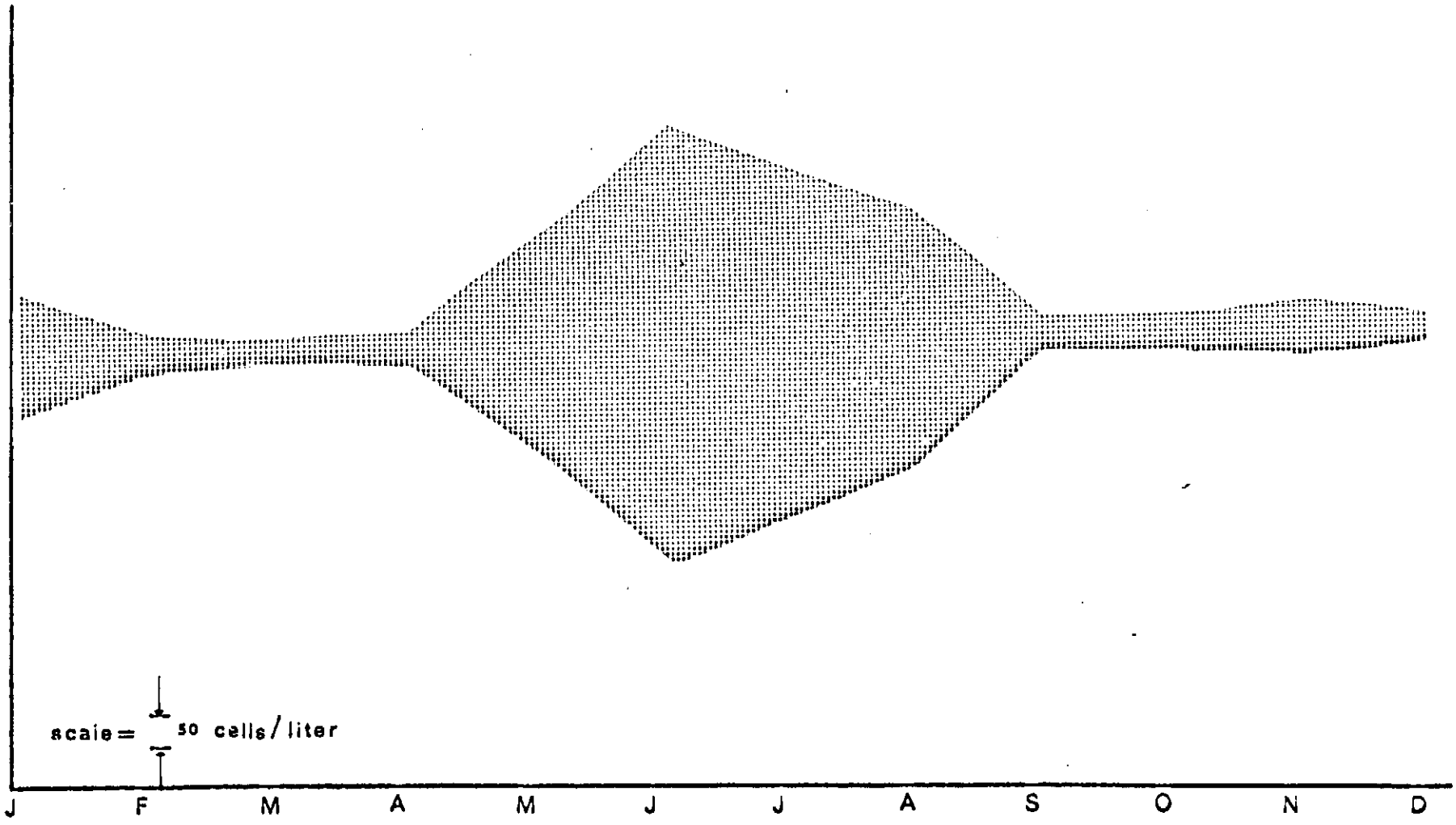

Figure 8. Monthly Variation in Total Zooplankton Cells per Liter in Anderson Creek Embayment

numbers.

The only other taxon collected in large quantity during the study was Cladocera. The largest numbers of Cladocera were collected in the summer months. In May there was a definite bloom of Bosmina sp., that was responsible for the large number of total zooplankters. This bloom will be discussed in relation to the low phytoplankton numbers in May. Other zooplankton collected less frequently were Oligochaeta, Nematoda, Tardigrada, Gastrochia, and Hydra. Variation among cell counts between various stations occurred sporadically. To avoid confusion, only average values of zooplankters from all collecting stations were plotted in Figure 8. The peak in zooplankton density occurred in June, when counts reached 687 organisms per liter. Following this peak there was a gradual decrease in numbers with minimum cell counts recorded during the winter months. Numbers did not increase until the following May, preceding the June peak.

2. Benthos Results. The benthic fauna collected from Anderson Creek embayment consisted of 34 taxa representing 15 orders. Table 5 shows a list of the various benthic organisms identified during the study and the average monthly numbers per square meter in the embayment. Seasonal variation in total numbers of all benthic organisms is shown in Figure 9.

The dominant macroinvertebrates by total numbers collected included representatives of Oligochaeta, Pelecypoda, and Insecta. Quantitatively, 95% of the total number of organisms per square meter were representatives of the following taxa: Oligochaeta, Pelecypoda, Emphemeroptera, Diptera. Monthly differences between these groups are illustrated in Figure 10. Oligochaetes represented 7% of the total number of organisms per

Table 5. Benthic Macroinvertebrates from Anderson Creek Embayment

List of benthic macroinvertebrates collected in Anderson Creek embayment, average monthly numbers per meter square, months in which they were collected (abbreviated), and method of collection.

E= Ekman dredge
D= Hester-Dendy sampler

Bryozoa
- Pectinatella magnifica statoblasts E

Turbellaria
- Tricladidia E (1.6/m^2-Dec.)

Annelida
- Oligochaeta
  - Tubificidae
    - Branchiura sp. E (19/m^2-J,F,M,A,J,J,S); D (1.4/m^2-April)
    - Unidentified oligochaetes E (40/m^2-J,F,M,A,M,J,J,A,S,O,N,D)
      D (26.1/m^2-March, April, July)
- Hirudinea
  - Helobdella sp. E (1.6/m^2-Jan.)

Mollusca
- Pelecypoda
  - Sphaeriidae
    - Musculium sp. E (11.7/m^2-J,F,M,A,S)
    - Sphaerium sp E (42.3/m^2-J,F,M,A,M,J,J,A.S,O,N,D)
  - Unionidae
    - Quadrula quadrula E (1.6/m^2-F)
- Gastropoda
  - Physidae
    - Physa sp. E (1.6/m^2-F); D (1.5/m^2-April, July)

Crustacea
- Copepoda
  - Cyclops sp. E (1.6/m^2-June); D (2.9/m^2-March)
- Amphipoda
  - Hyalella azteca E(9.6/m^2-Feb., May, July)
- Hydracarina E (23.4/m^2-J,F,M,A,M,J,J,S,O,D); D (1.4/m^2-March)
- Insecta
  - Collembola
    - Isotoma sp. E (1.6/m^2-July)
  - Ephemeroptera
    - Ephemeridae
      - Hexagenia sp. E (146/m^2-J,F,M,A,M,J,J,A,S,O,N,D)
      - Oreianthus sp. E (1.6/m^2-F); D (9.2/m^2-March, July)

Table 5. (Continued)

Heptageniidae
Stenonema sp. E (5.6/m^2-Feb., July); D (38.6/m^2-March, April)

Odonata
Anisoptera
Lanthus sp. E (1.6/m^2-N)

Zygoptera
Enallagma sp. E (3.2/m^2-S); D (8.3/m^2-July)
Argia sp. D (3.3/m^2-July)
unidentified E (1.6/m^2-S)

Megaloptera
Sialidae
Sialis sp. D (5.0/m^2-July)

Tricoptera
Psychomyia sp. E (1.6/m^2-F)
Polycentropus sp. E (3.2/m^2-March); D (26/m^2-July)
unidentified E (1.6/m^2-Feb., March)

Coleoptera
Elmidae E (1.6/m^2-Jan, April)
Hydrophilidae
Berosus sp. E (3.2/m^2-Sept.)

Diptera
Chironomidae
Tendipes sp. E (28.6/m^2-J,F,M,A,M,J,J)
Pentaneura sp. E (17/m^2-J,F,M,M,J,J); D (1.4/m^2-April)
unidentified chironomids E (278/m^2-J,F,M,A,M,J,J,A.S,O,N,D)
D (108.4/m^2-M,A,July)

Ceratopogonidae
Probezzia sp. E (128.6/m^2-J,F,M,A,M,J,J,A,S,O,N,D)
D (12.4/m^2-March, July)

Culicidae
Chaoborus sp. E (99/m^2-J,F,M,A,M,J,J,A,S,O,N,D)

Dixidae
Dixa sp. E (1.6/m^2-March, May)

Tipulidae
Tipula sp. E (1.6/m^2-April)
Hexatoma sp. E (1.6/m^2-March)

Tabanidae
Chrysops sp. E (4.8/m^2-May, June)
Tabanus sp. E (1.6/m^2-May)

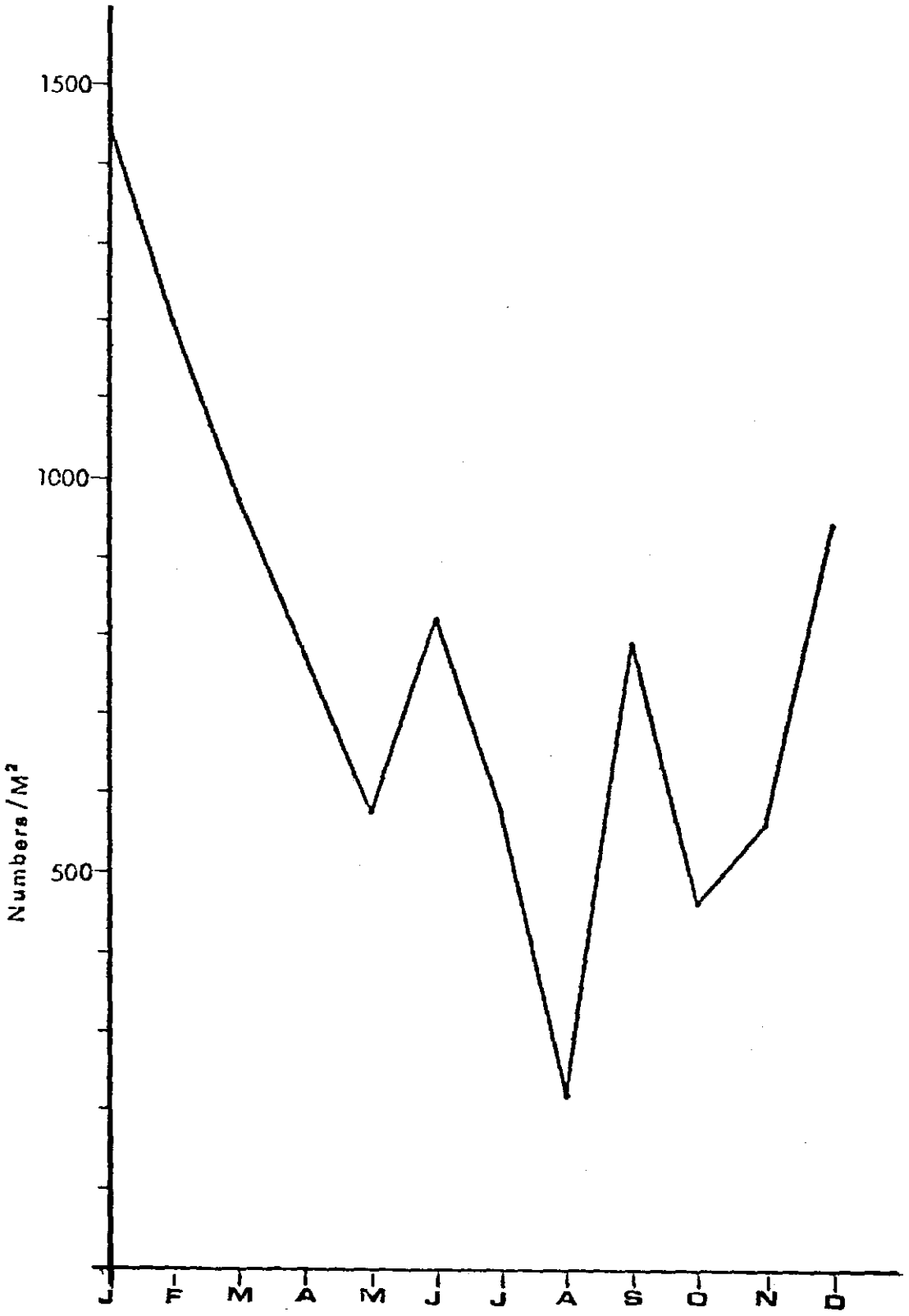

Figure 9. Monthly Mean Variation in Total Macroinvertebrates Collected with the Ekman Dredge in Anderson Creek Embayment

Figure 10. Monthly Mean Variation of Dominant Macroinvertebrate Taxa Collected in Anderson Creek Embayment

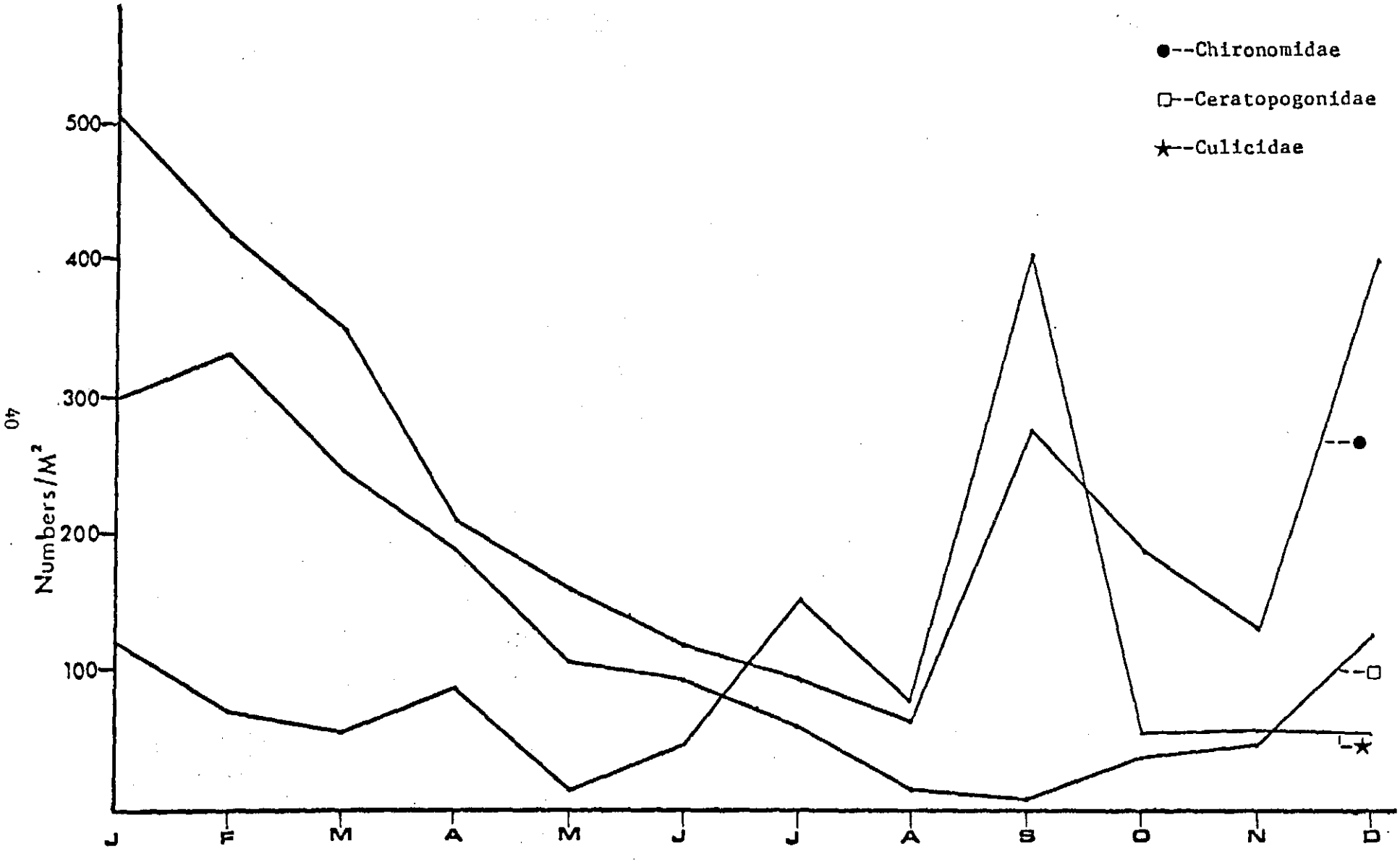

Figure 11. Monthly Mean Variation of Dominant Dipteran Families Collected in Anderson Creek Embayment

square meter collected in benthic dredges. Many were of the genus Branchiura, a member of the Tubificidae family. Other genera of Oligochaetes were not identified due to the difficulty in identification.

The class Pelecypoda was dominated by members of the family Sphaeridae. The genera Musculium and Sphaerium were identified and monthly averages were 140 and 507 individuals per square meter, respectively. Only one specimen of Quadrula quadrula was collected representing the family Unionidae. As a class, Pelecypoda, comprised 6% of the total numbers of benthic organisms collected.

The order Diptera consisted mainly of members of the families Chironomidae (52%), Ceratopogonidae (27%), and Culididae (20%) and collectively they formed 64% of the total macroinvertebrate numbers. Graphic representation of these families is shown in Figure 11. Other dipterous families collected in insignificant numbers were Dixidae, Tipulidae, and Tabanidae. Identified generic members of these families are uncommon inhabitants of the embayment benthic fauna.

The following genera of mayflies were collected in Ekman dredge samples: Hexagenia, Oreianthus, and Stenonema. The mayfly fauna was divided into two components; the mud-burrowing forms (Ephemeridae) and aufwuchs forms (Heptageniidae). The mayfly fauna formed 19% of the total number of macroinvertebrates collected.

Members of the insect orders Collembola, Odonata, and Coleoptera were also collected, however, the paucity of their numbers was such that they were not graphed. Al insects collected were either larval or pupal forms. On single occasions representatives of Numatoda, Turbellaria, Hirudinea, Copepoda, and Tricoptera were collected.

Two other taxa of minor importance quantitatively were Amphipoda and Hydracarina. The amphipod Hyalella aztecta was collected in three of the collecting months and averaged 9.5 organisms per square meter. Hydracarinids were collected in nine of the 12 months, but were not identified to genus. Statoblasts of Pectinatella magnifica were frequently observed in benthic samples, but no accurate record of their occurrence was maintained.

The total number of organisms collected from Hester-Dendy samplers and the Ekman dredge samples were not compared quantitatively since so few Hester-Dendy samplers were recovered. All of the above quantitative data on benthic organisms were collected with the Ekman dredge. Table 5 designates the means by which various invertebrates were collected. The total taxa collected with artificial substrates included Oligochaeta, Gastropoda, Copepoda, Hydracarina, Metaloptera, Ephemeroptera, Odonata, and Diptera.

3. Water Quality Results. Water quality results were recorded each month to augment the biological studies. Physical and chemical parameters for the entire collecting year are graphed as they are presented in the text.

Water level fluctuated throughout the study period. The reservoir is held near full-pool level, elevation 359.0, from May 1 down to elevation 354.0 by December 1. Between this low-level stage and the top of the gates at elevation 375.0, the maximum storage space for flood control is available. The reservoir is allowed to refill during April to full-pool level as winter flood threats pass. Figure 12 shows reservoir levels during the collecting period.

Monthly variation and average water temperature are shown in Figure 13. The yearly maximum water temperature was recorded at the surface in

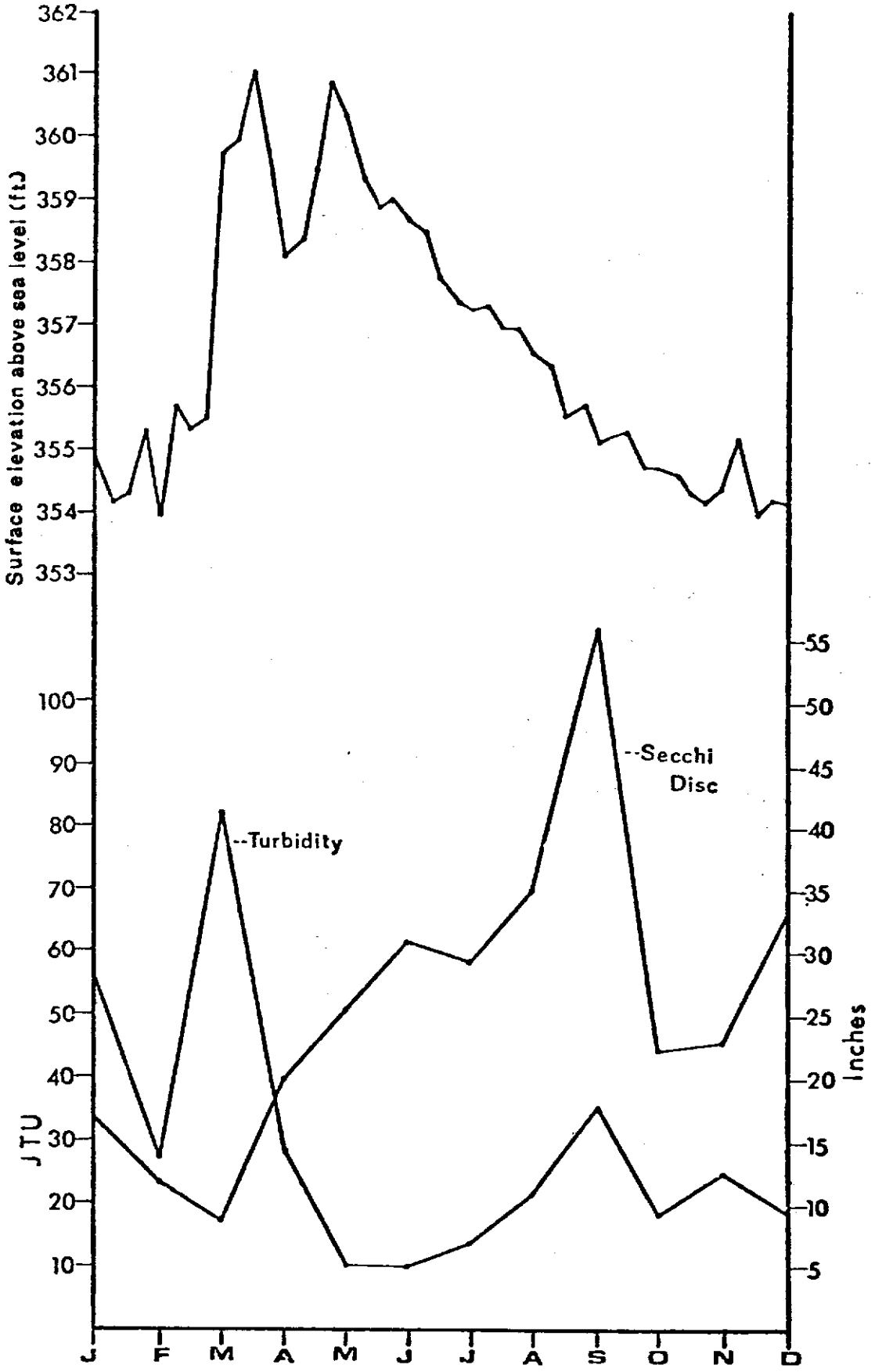

Figure 12. Monthly Mean Variation of Turbidity and Secchi-Disc Transparency in Anderson Creek Embayment and Surface Elevation Fluctuations of Kentucky Lake during the Study Period

June, 31.5°C, and the yearly minimum water temperature was in December, 6.2°C. Yearly variation in water temperature followed a generalized seasonal pattern of changes in air temperature. During colder months of the year there was sufficient water flow and mixing to give fairly uniform temperatures throughout the water column. Warmer temperatures varied slightly with depth at the onset of warmer weather. The greatest temperature variation with depth was recorded in August at station 1, a variation of 3°C.

Monthly ranges and average values of dissolved oxygen in ppm are shown in Figure 14. The yearly maximum of 15 ppm was detected in April and the minimum (7 ppm) occurred in August and June. This low value of 7 ppm was recorded at several stations in August following high temperatures in this month and the two previous months.

The pH and the free carbon dioxide are plotted on the same graph (Figure 15). Values of pH range from 6.3 to 9.1 with most values falling between 7.0 and 9.0. There was a general increase in the average pH values in the following time periods: March through April, May through July, and again in September through October.

Yearly ranges for free carbon dioxide were 12 ppm to 0; the same range was also exhibited in August. Generally low values were recorded at the surface stations and higher values lower in the water column.

Alkalinity values in Anderson Creek embayment ranged from 20 to 85 ppm throughout the collecting year (Figure 16). Alkalinity represents the content of bicarbonates, carbonates, and hydroxides present in the water. In the pH range 6.5 to 8.5, the alkalinity is primarily bicarbonate (Reid, 1961).

Average values for conductance ranged from 55 micromhos per cm. to

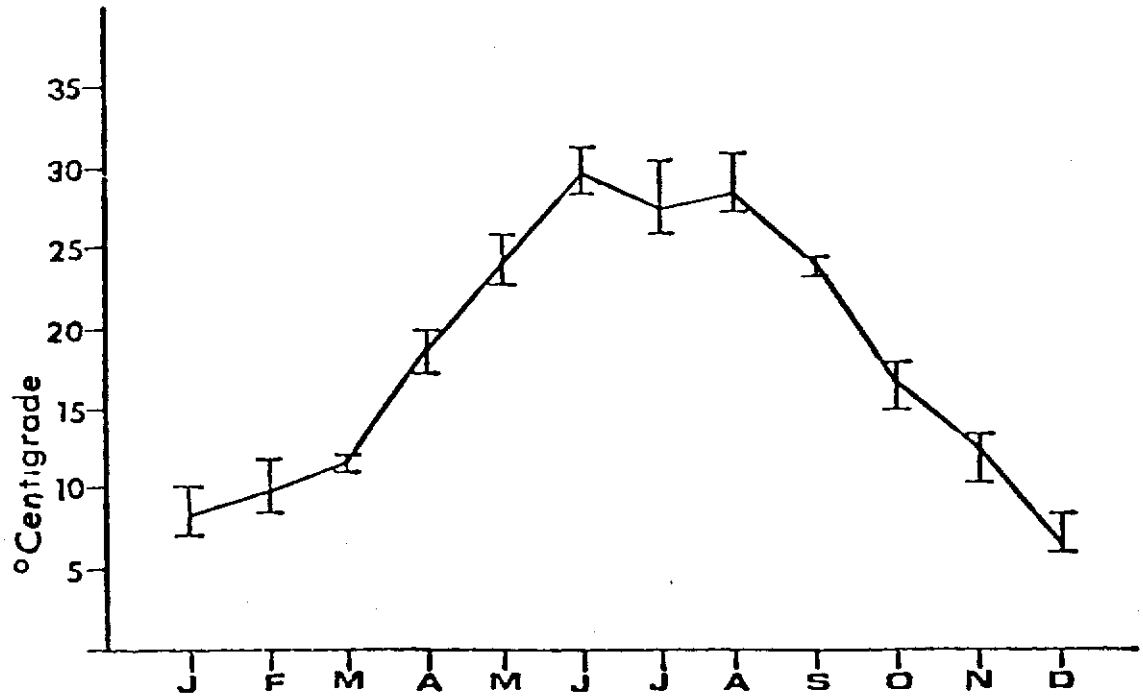

Figure 13. Monthly Range and Mean Variation of Water Temperature in Anderson Creek Embayment

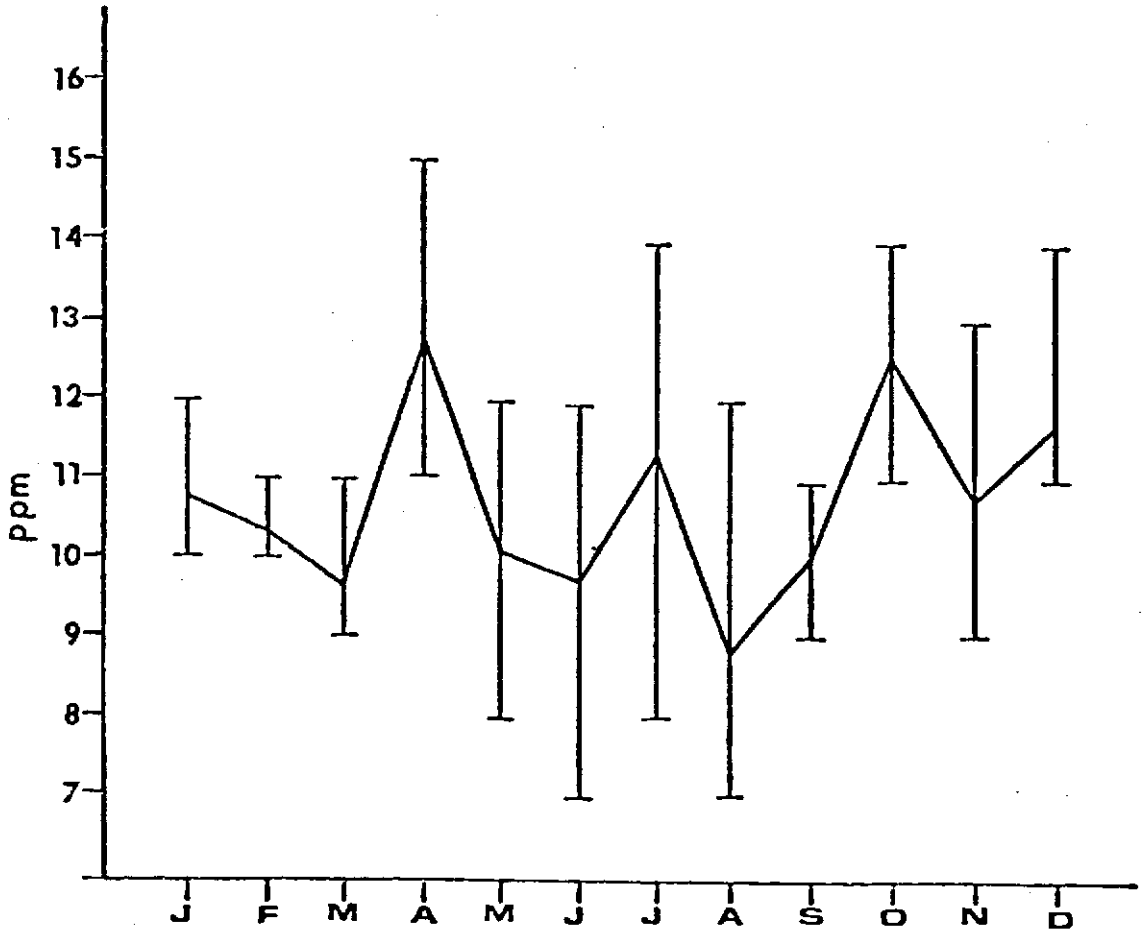

Figure 14. Monthly Range and Mean Variation of Dissolved Oxygen in Anderson Creek Embayment

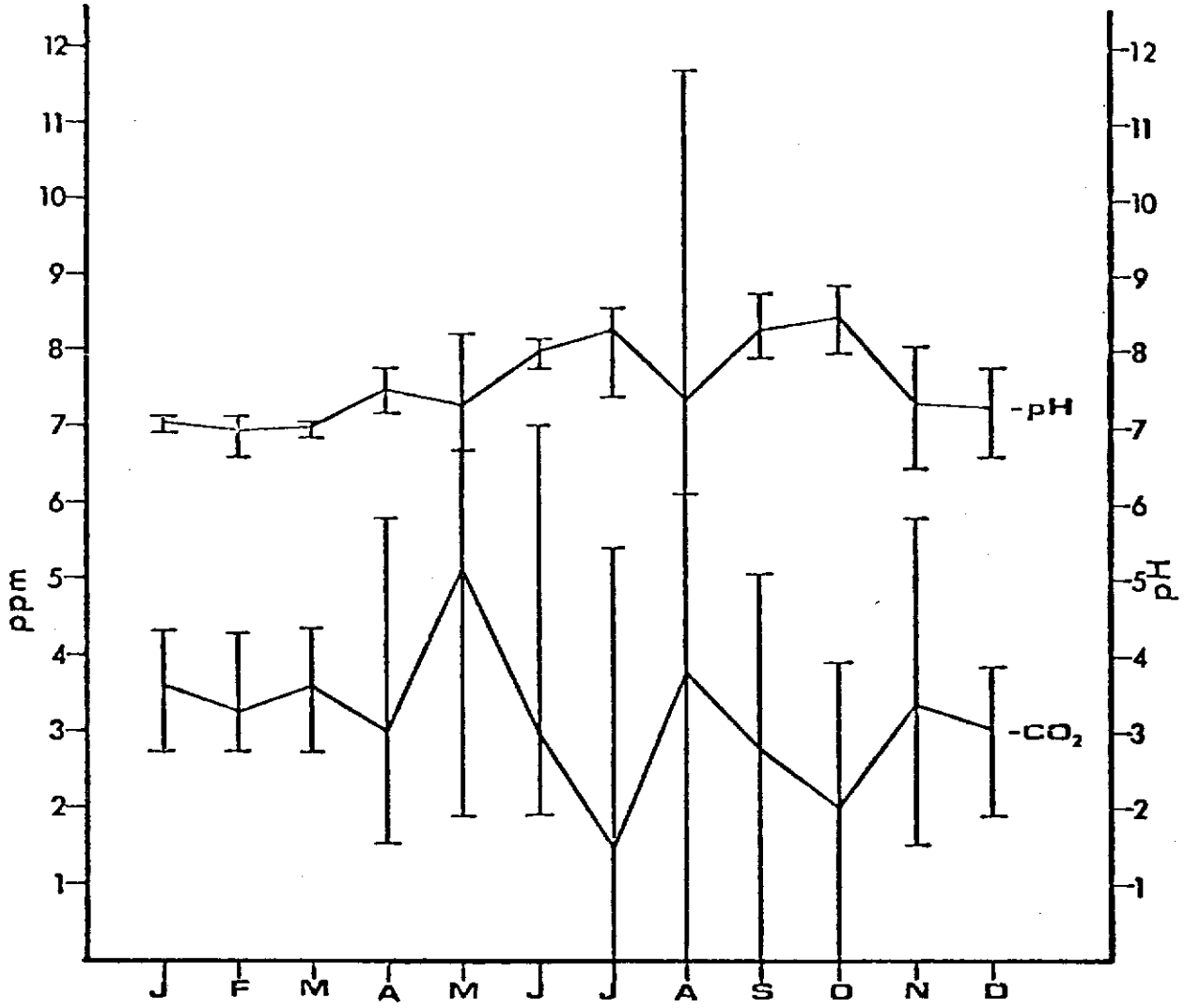

Figure 15. Monthly Range and Mean Variation of pH and Free Carbon Dioxide in Anderson Creek Embayment

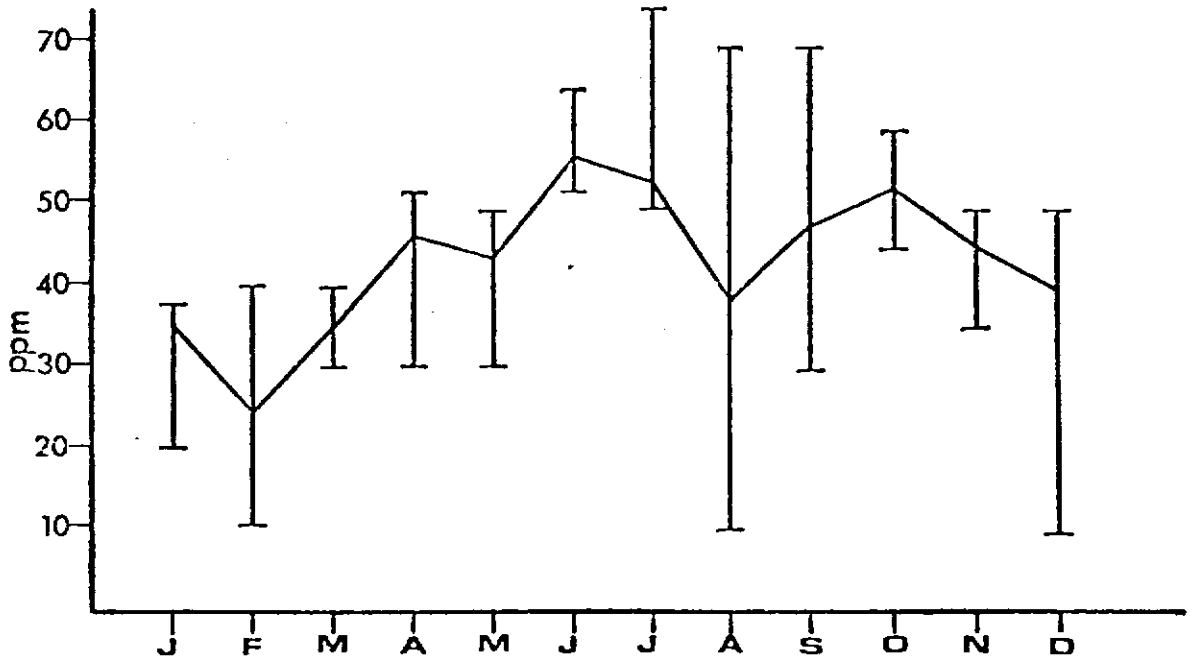

Figure 16. Monthly Range and Mean Variation of Total Alkalinity in Anderson Creek Embayment

175 micromhos per cm., which represented approximate average dissolved solid concentrations of 64 ppm to 131 ppm, respectively. The monthly average dissolved solid concentrations are plotted on Figure 17.

Average Secchi disc readings ranged from 71 inches (180 cm.) in September to 8.2 inches (20 cm.) in March (Figure 12). Turbidity values follow the general pattern of Secchi disc readings (Figure 12). The maximum average turbidity value (83 JTU) was recorded in March and the minimum (10 JTU) was recorded in May and June.

During oxidation, nitrogen can exist in several forms including ammonia, nitrites, and nitrates. Values for nitrite nitrogen were found to be negligible since nitrogen in this form is in the transition between ammonia and nitrate. Monthly values, Table 6, for nitrate nitrogen ranged from 0 to 0.90, with monthly averages, Figure 18, ranging from 0.014 ppm to 0.31 ppm.

Average phosphate values range from 0.04 ppm in December to 0.13 ppm in October and November (Table 7). Average monthly values are shown in Figure 19.

4. Organic Results. The state-of-the-art of organic analyses is constantly changing. Our laboratory has attempted to keep pace with these changes. Therefore, results of this study will reflect changes in instrumentation design and usage which makes it difficult to make accurate quantitative measurements of individual organics that may be present in the lake samples. Because our early instrumentation used GC's water packed columns, glass "jet" separators between the GC and MS, it simply was not as sensitive as more recent versions of the same instrumentation. Early GC/Total Ion Monitor scans are shown in Figures 20 and 21. GC column improvements (Nickel Capillary ON870 - 300' X 0.2") gave typical

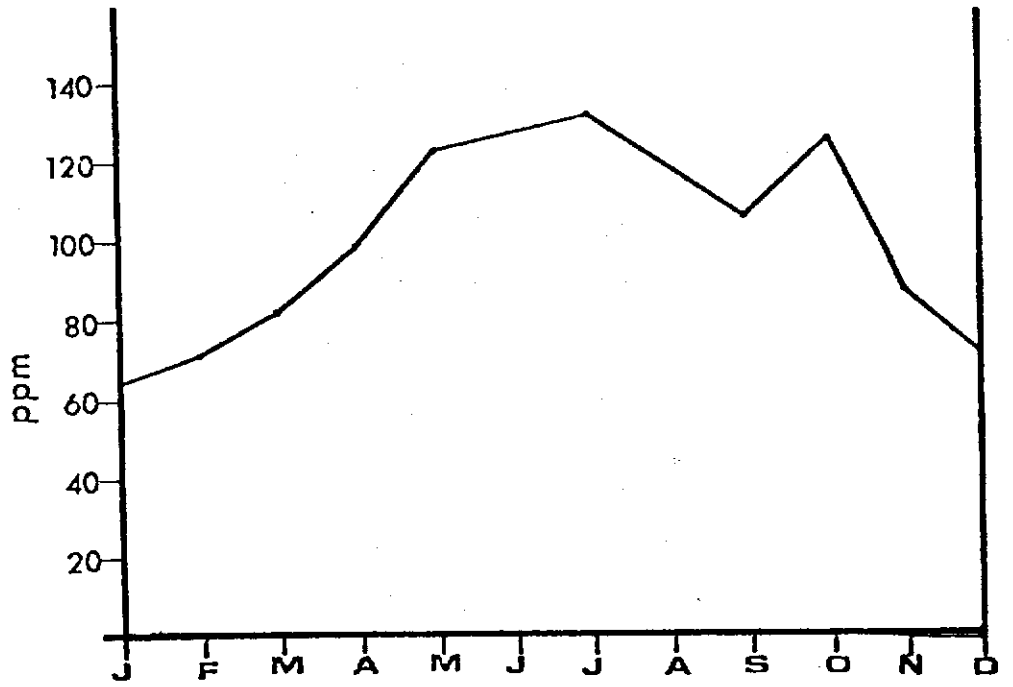

Figure 17. Monthly Mean Variation of Total Dissolved Solids in Anderson Creek Embayment

Table 6. Nitrate Concentrations at Each Sampling Station for Anderson Creek Embayment

ANDERSON CREEK

Station	Nitrate (ppm)														
	1974			1975											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	* Dec
1a	.20	.30	.37	.24	---	.96	.09	.07	.18	.20 .10	---	.14	.22	.28	.00
1b	.20	.20	.32	.57	---	.10	.12	.12	.13	.23 .21	---	.22	.17	.28	.00
1c	.20	.10	.26	.60	---	.38	.36	.10	.02	.14 .09	---	.30	.14	.32	.00
2a	.10	.30	.23	.13	---	.17	.20	.07	.37	.16 .28	---	.18	.34	.23	.00
2b	.10	.20	.32	.47	---	.43	.23	.12	.17	.15 .07	---	.20	.22	.26	.00
2c	.30	.10	.30	.47	---	.30	---	.21	.42	.34 .43	---	.30	.23	.37	.00
3a	.10	.20	.23	.27	---	.21	.24	.00	.17	.32 .15	---	.50	.11	.33	.00
3b	.30	.20	---	.54	---	.50	.21	.07	.08	.07 .07	---	.21	.51	.13	.00
3c	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
4a	.10	.30	.30	.21	---	.37	.30	.04	.05	.18 .00	---	.12	.30	.00	.00
5a	.00	.30	.30	.24	---	.28	.11	.00	.07	.17 .23	.11	.13	.13	.11	.00
5b	.30	.10	.49	.47	---	.28	.06	.07	.09	.11 .26	---	.20	.00	.00	.00
6a	.10	.50	.53	.17	---	.36	---	.12	.29	.12 .35	---	.10	.22	.12	.00
6b	.20	.20	.24	.37	---	.28	.06	.06	.06	.28 .10	---	.19	.24	.21	.13
7a	.00	.30	.42	.22	---	.33	.09	.08	.15	.09 .42	---	.12	.22	.33	.00
7b	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
8a	.00	.20	.29	.18	---	.00	.00	.00	.38	.16 .18	---	.11	.16	.11	.14
9a	.10	.10	.24	.14	---	.23	.09	.07	.20	.17 .18	---	.12	.09	.15	.00
10a	.10	.40	.22	.10	---	.23	.23	.22	.11	.13 .20	---	.10	.00	.00	.14
11a	.00	.20	.30	.18	---	.35	.00	.00	.21	.11 .18	---	.18	.46	.12	.00
12a	.00	.30	.14	.35	---	.28	.25	.21	.18	.20 .21	---	.02	.00	.00	.00

* Results for DEC were invalidated due to contaminated preservative.

Table 6. (Continued)

ANDERSON CREEK

Nitrate (ppm)															
Station	1976														
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec			
1a	.72	.80	.54	.10	<.10										
1b	.73	.28	.65	<.10	.10										
1c															
2a															
2b															
2c															
3a															
3b															
3c															
4a															
5a															
6a	.32	.23	.44	.10	<.10										
6b	.68	----	.51	.11	<.10										
7a															
7b															
8a															
9a															
10a															
11a	.32	.38	.65	<.10	<.10										
12a															

Table 7. Phosphate Concentrations at Each Sampling Station for Anderson Creek Embayment.

ANDERSON CREEK

Phosphate (ppm)															
Station	1974			1975											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1a	.16	.15	.04	.04	---	.09	.08	.08	.06	.07 .09	---	.06	.06	.06	.06
1b	.12	.15	.04	.04	---	.07	.06	.05	.07	.06 .05	---	.06	.07	.06	.06
1c	.09	.16	.05	.05	---	.09	.07	.07	.08	.09 .11	---	.06	.06	.05	.06
2a	.15	.15	.02	.05	---	.07	.07	.07	.05	.06 .02	---	.07	.06	.07	.05
2b	.11	.12	.05	.06	---	.06	.09	.06	.09	.11 .14	---	.07	.07	.06	.05
2c	.09	.09	.04	.05	---	.08	.06	.06	.06	.15 .08	---	.11	.09	.05	.08
3a	.10	.07	.04	.05	---	.06	.07	.05	1.00	.07 .08	---	.05	.07	.04	.06
3b	.13	.09	.04	.06	---	.08	.08	.08	.14	.12 .09	---	.07	.05	.03	.07
3c	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
4a	.11	.17	.03	.04	---	.07	.09	.07	.02	.06 .07	---	.03	.04	.04	.04
5a	.10	.11	.04	.05	---	.08	.06	.08	.05	.01 .03	---	.08	.04	.02	.05
5b	.35	.14	.06	.04	---	.06	.08	.06	.09	.08 .06	---	.03	.03	.03	.04
6a	.10	.12	.04	.05	---	.08	.07	.06	.10	.02 .05	---	.04	.03	.03	.07
6b	.08	.13	.05	.08	---	.07	.09	.07	.17	.08 .12	---	.03	.04	.03	.06
7a	.10	.11	.03	.05	---	.01	.03	.03	.06	.05 .13	---	.15	.04	.03	.05
7b	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
8a	.06	.11	.04	.05	---	.13	.11	.11	.06	.07 .08	---	.06	.03	.03	.05
9a	.12	.17	.06	.05	---	.07	.05	.07	.08	.11 .12	---	.07	.05	.03	.04
10a	.15	.05	.05	.05	---	.06	.06	.04	.07	.08 .03	---	.05	.04	.02	.10
11a	.09	.11	.03	.05	---	.05	.06	.07	.06	.02 .00	---	.07	.05	.02	.05
12a	.20	.18	.03	.03	---	.07	.07	.07	.11	.08 .10	---	.04	.01	.00	.06

Table 7. (Continued)

ANDERSON CREEK

Phosphate (ppm)															
Station	1976														
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec			
1a	.01	.02	.05	.01	.04										
1b	.03	.08	.08	.01	.07										
1c															
2a															
2b															
2c															
3a															
3b															
3c															
4a															
5a															
6a	.02	.02	.05	.02	.07										
6b	.03	----	.04	.01	.09										
7a															
7b															
8a															
9a															
10a															
11a	.01	.02	.02	<.01	.06										
12a															

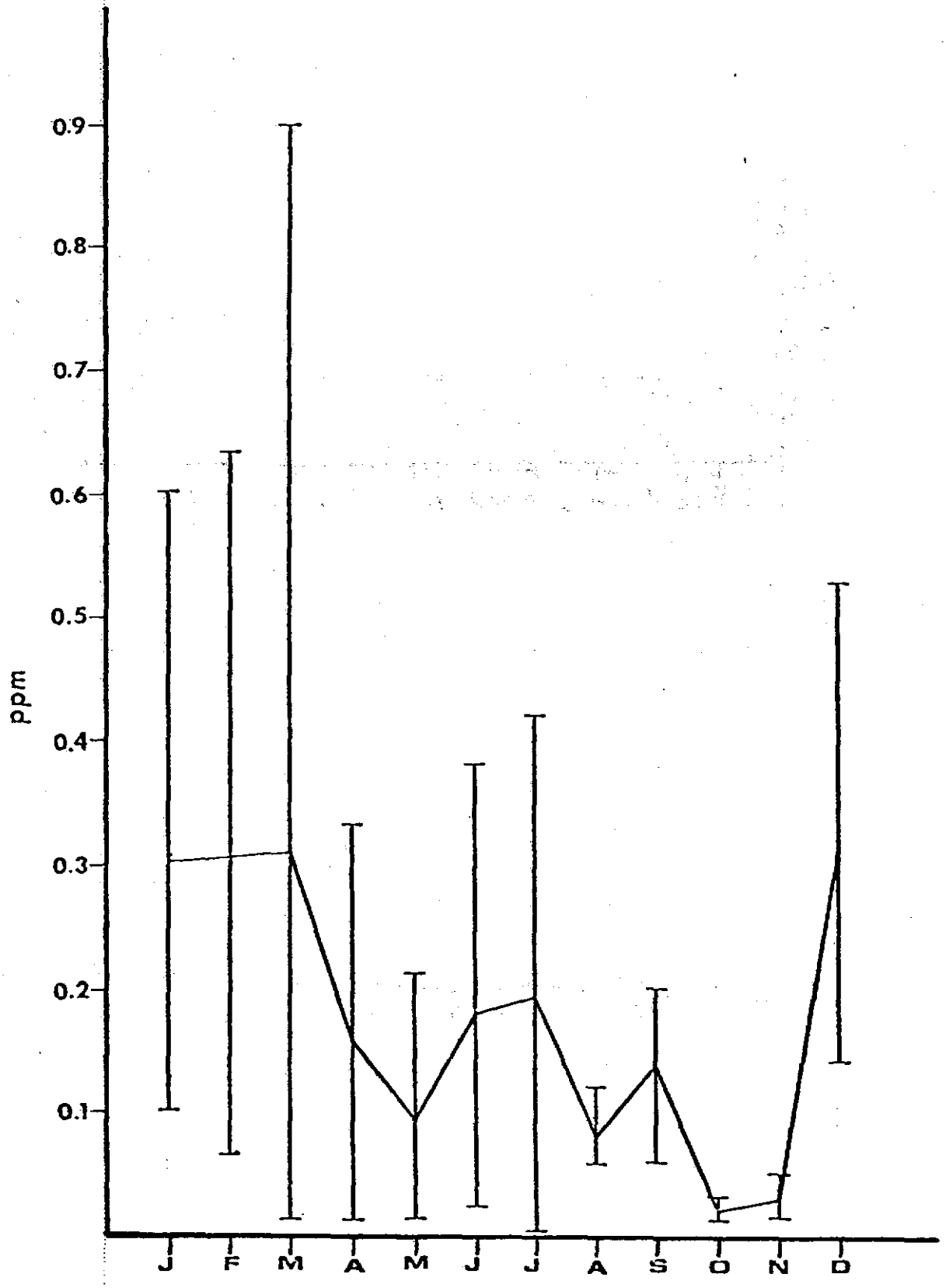

Figure 18. Monthly Range and Mean Variation of Nitrate Nitrogen Concentrations in Anderson Creek Embayment

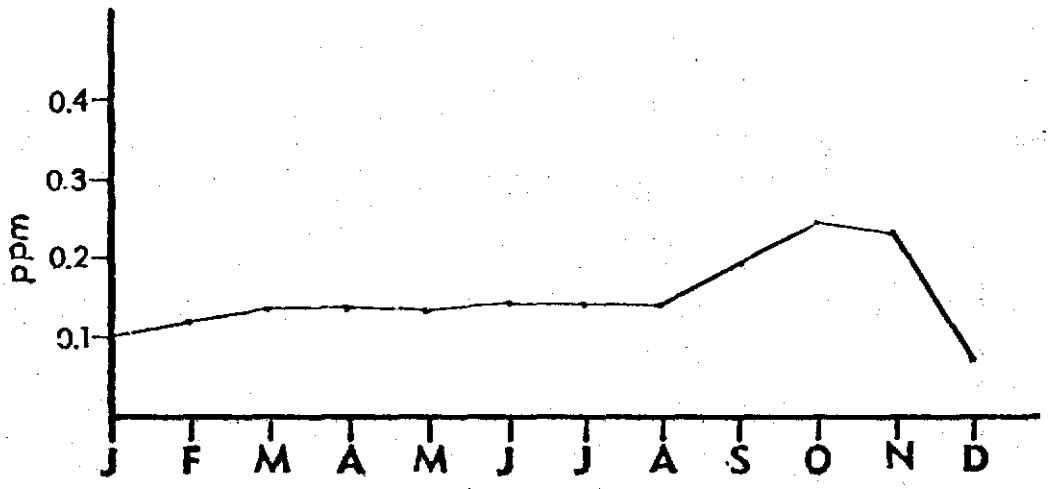

Figure 19. Monthly Mean Variation of Phosphate Concentrations in Anderson Creek Embayment

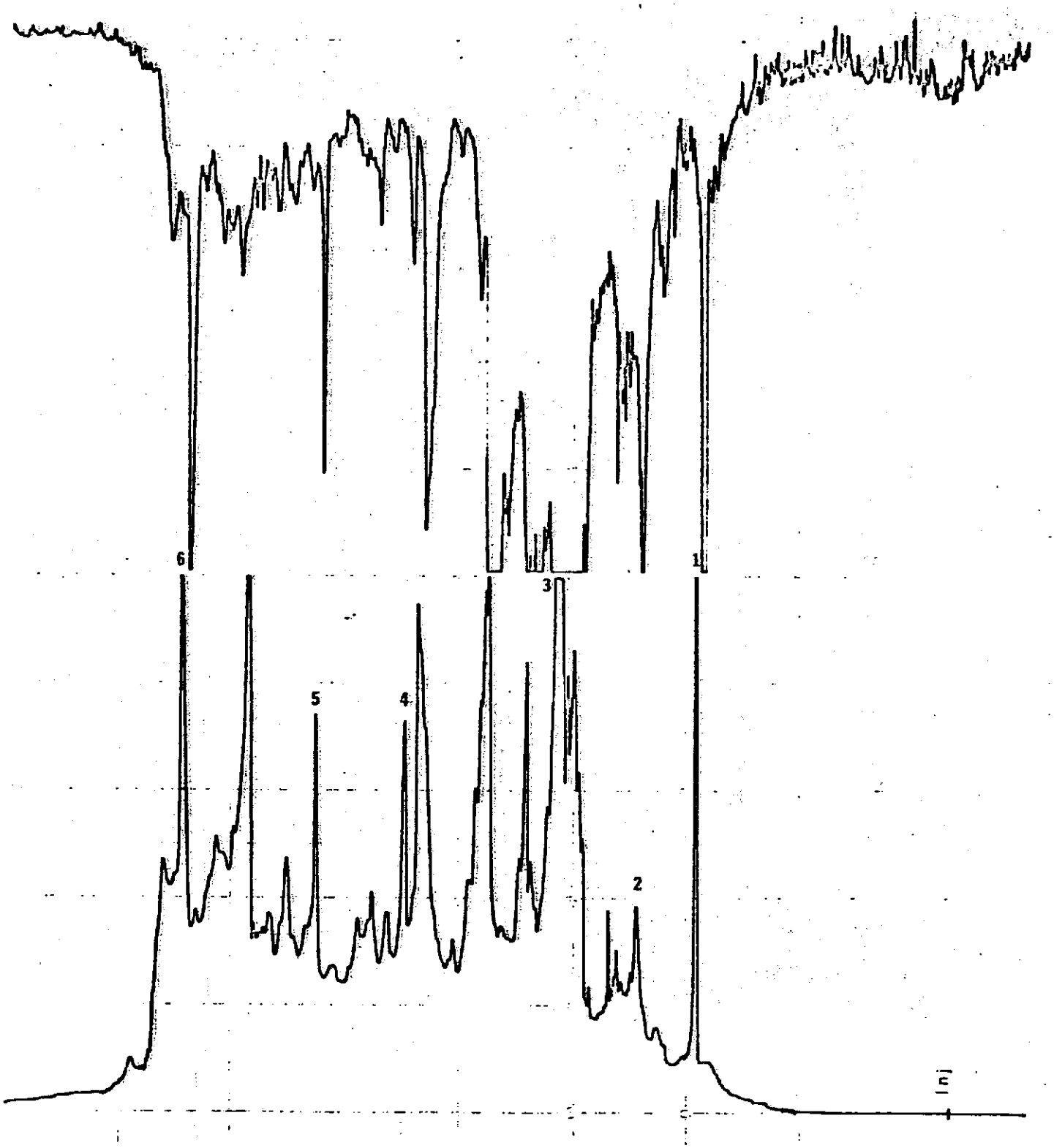

Figure 20. GC/TIM Scan for ACO (Anderson Creek Organic) 11/74

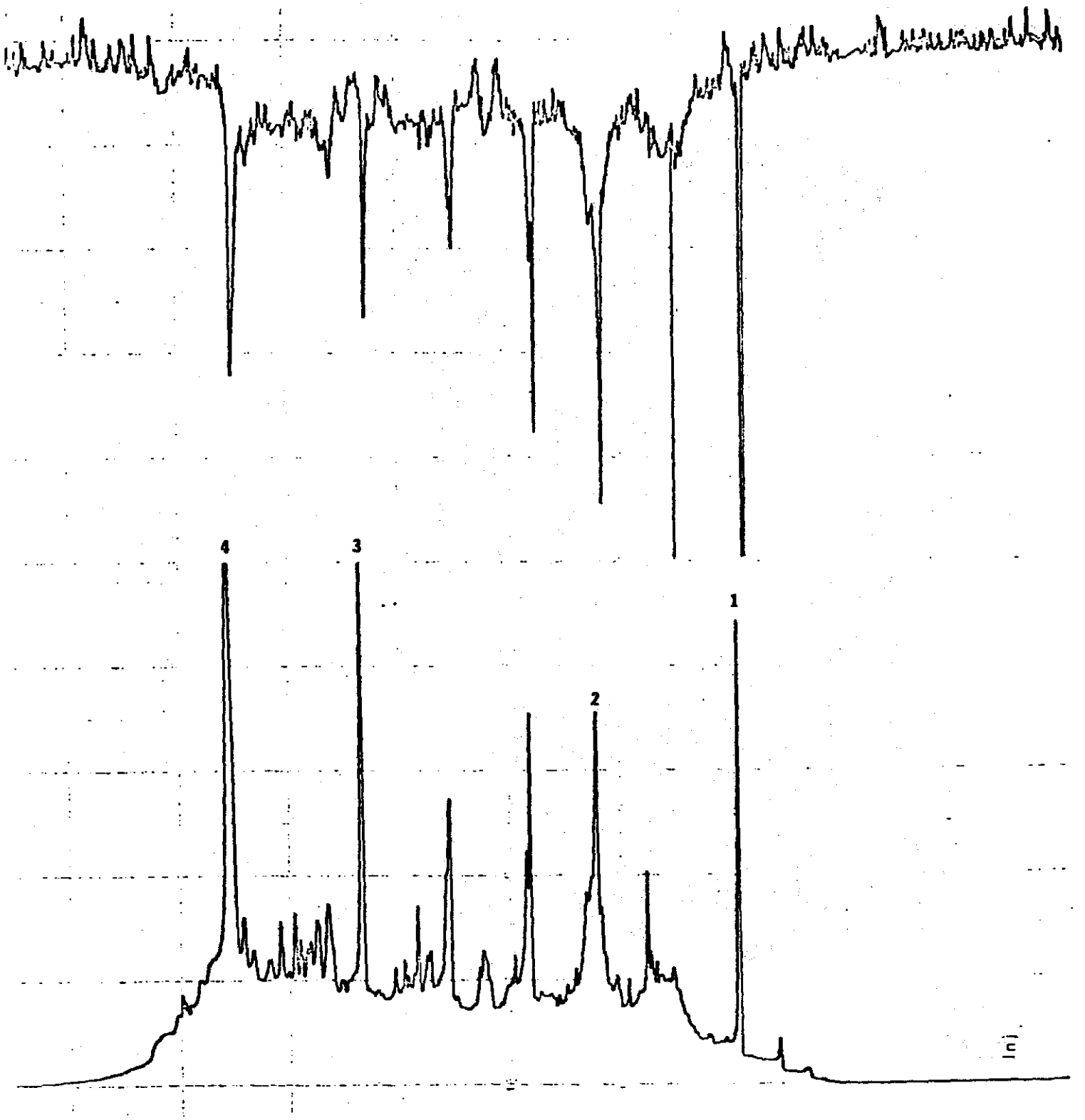

Figure 21. GC/TIM Scan for VBO (Vickers Bay Organic) 11/74

chromatograms a sample which is shown in Figure 22. No attempt will be made to show individual chromatograms for all runs. Figure 23 represents a GC run using a glass capillary column (approximately 100 m X 0.3 mm). The sample was taken from Anderson Creek sparged onto Tenax and desorbed to give the GC profile shown in Figure 23. Table 8 lists compound identities in Figure 23. Compounds were identified using the GC/MS/COM System. No attempt will be made to include copies of all mass spectra in this report. Figure 24 is a copy of a mass spectrum of a calibration compound, perfluorotributylamine, which will serve to show the mass range of the instrument used. Figure 25 and 26 are copies of the mass spectrum and peak intensities for identified compounds.

During the entire study period at least one sample was taken each month for each embayment. Recently, an attempt has been made to obtain relative monthly quantitative comparisons of organic content in the two embayments. To have analyzed each sample in detail would have been too time-consuming and meaningless. Using a Hewlett-Packard Model 5840 GC with accompanying data system, comparisons of total organic content for each sample could be made. Figure 27 is representative of each run. Table 9 gives total organic content for each month sampled for Anderson Creek.

B. Vickers Bay. Twelve stations were set up on the embayment with varying depths. There were a total of 22 sampling sites when summer pool permitted, with 21 at winter pool. At each station, a benthic sample was taken, with plankton and water chemistry samples taken at surface, mid-column, and one meter from the bottom, depending upon the depth of the station, Figure 2.

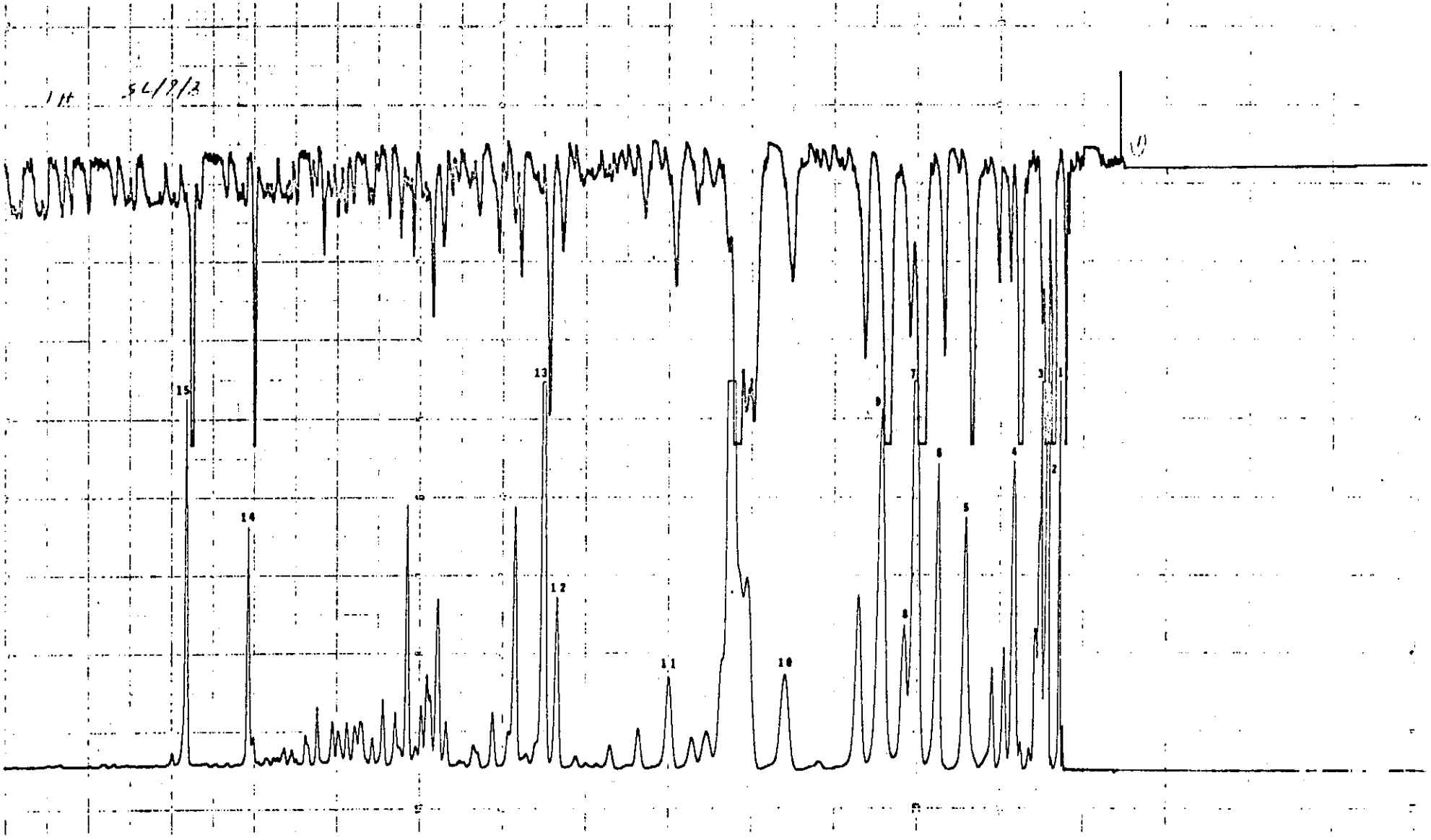

Figure 22. GC/TIM Scan at Higher Resolution Conditions

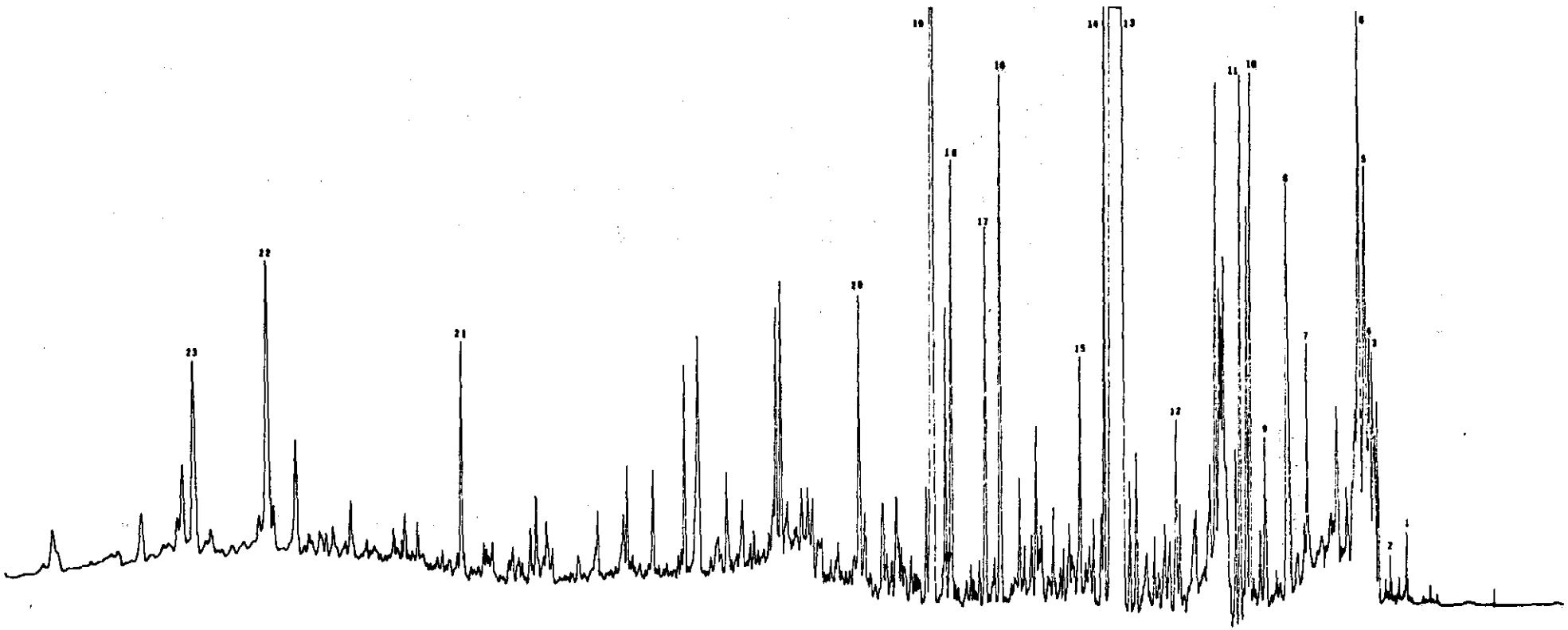

Figure 23. High Resolution GC Profile. ACO 1/76.

Table 8

Peak Identifications in Figure 23

Peak Number	Organic Compound
1	methylene chloride
2	ethylidene chloride
3	vinyl chloride
4	ethylene oxide
5	chloroform
6	bromoform
7	ethylene chloride
8	benzene
9	styrene
10	toluene
11	ethylbenzene
12	indene
13	naphthalene
14	1-methylindene
15	2-methylindene
16	?-methylnaphthalene
17	?-methylnaphthalene
18	1-ethylnaphthalene
19	1,2,4-trichlorobenzene
20	diphenylacetylene
21	diethylphthalate
22	di-n-butylphthalate
23	di-n-octylphthalate

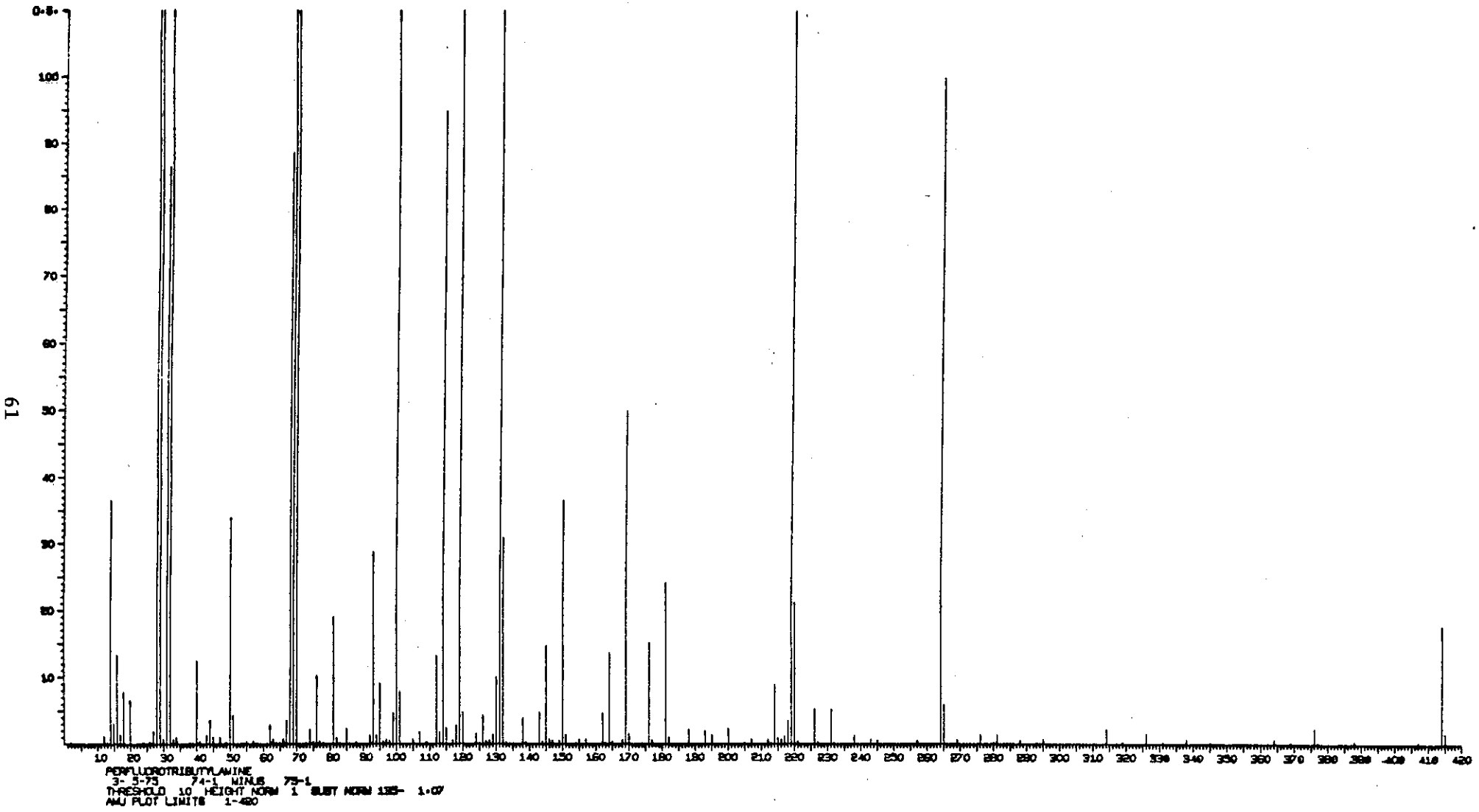

Figure 24. Mass Spectrum of Perfluorotributylamine

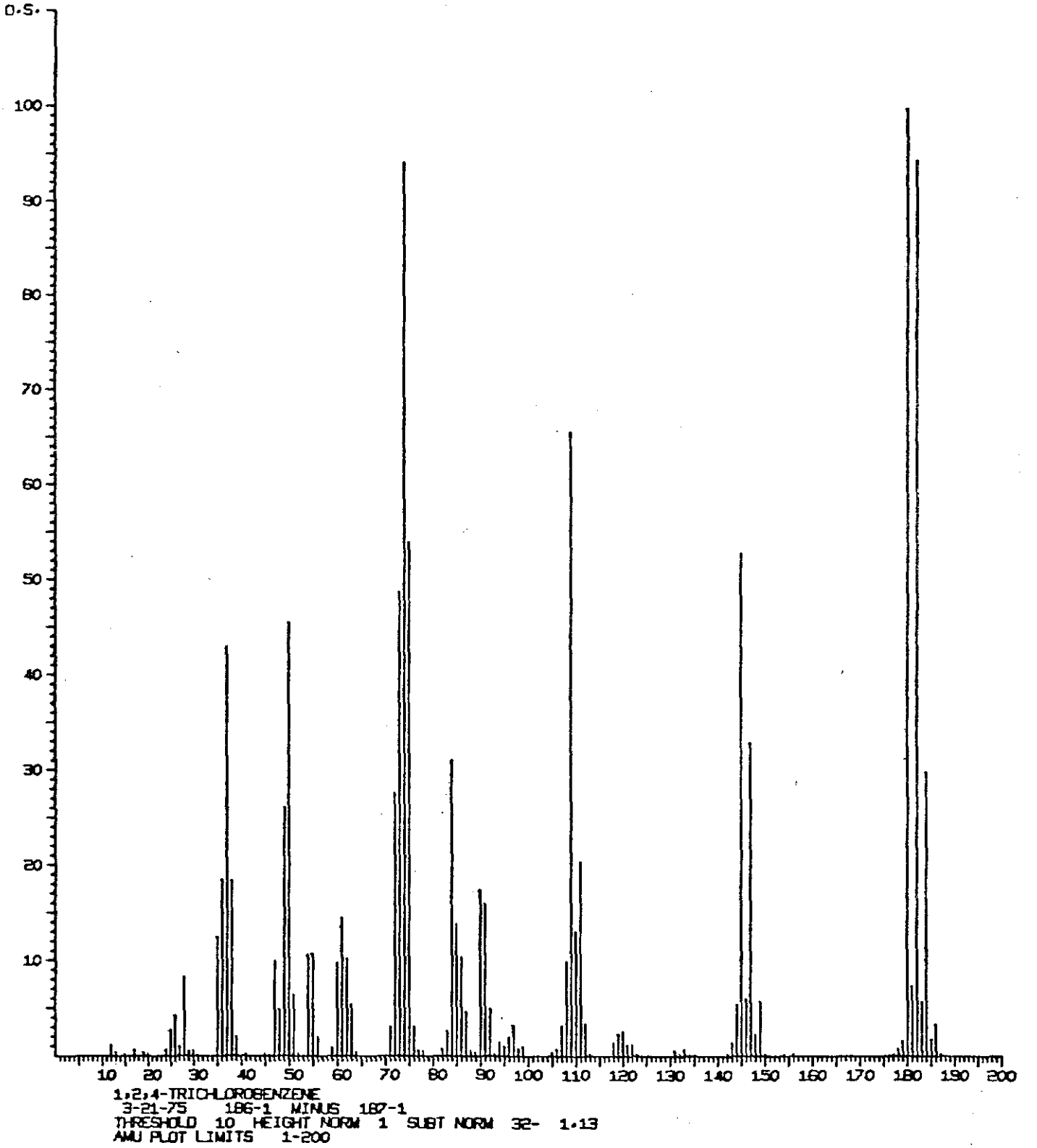

Figure 25. Mass Spectrum of 1,2,4-trichlorobenzene

MASS SPECTRUM PEAK INTENSITY TABULATION

19-1 2/18/75
NUMB OF SAMPLES 5 WIDTH OF SAMPLE 3 NUMB OF SCANS 1
AMU RANGE 1-420 CALIB VALIDITY 2
PK INTENSITY OPTION 0 MAX SIGNAL AMPLITUDE 1695
DRIFT CORRECT OPTION 1 DRIFT ERROR CODE 0 DRIFT ADJUSTMENT 0

BACKGROUND SPECTRUM SUBTRACTED
20-1 2/18/75
NUMB OF SAMPLES 5 WIDTH OF SAMPLE 3 NUMB OF SCANS 1
AMU RANGE 1-420 CALIB VALIDITY 2
PK INTENSITY OPTION 0 MAX SIGNAL AMPLITUDE 230
DRIFT CORRECT OPTION 1 DRIFT ERROR CODE 0 DRIFT ADJUSTMENT 1

4	6.19	47	0.12	67	0.48	89	7.44	112	0.24	133	0.18
12	0.18	49	0.36	69	6.25	90	0.65	113	2.92	136	0.12
13	0.12	50	7.20	70	11.01	91	1.73	114	3.21	137	0.42
16	0.36	51	8.81	71	14.17	92	0.42	115	42.74	138	0.89
17	0.71	52	1.96	74	5.18	93	0.12	116	4.35	139	10.71
18	3.39	53	0.54	75	4.70	96	0.18	117	1.01	140	5.42
19	0.48	55	0.95	76	2.86	97	0.36	118	0.24	141	83.75
20	1.01	56	0.54	77	3.45	98	1.31	119	0.83	142	100.00
26	1.19	57	8.93	78	0.83	99	0.65	120	0.12	143	10.77
27	3.81	58	5.60	79	0.42	100	0.54	125	0.12	144	0.71
28	3.51	60	0.24	81	0.24	101	0.77	126	1.90	145	0.95
37	0.54	61	1.55	83	0.24	102	1.43	127	1.01	149	0.48
38	2.32	62	6.37	84	0.12	103	0.18	128	0.83		
39	11.19	63	15.77	85	1.13	105	0.48	129	0.89		
40	0.95	64	2.20	86	3.04	109	0.24	130	0.30		
41	0.89	65	4.17	87	3.75	110	0.36	131	0.95		
44	0.42	66	0.42	88	1.90	111	0.54	132	0.30		

Figure 26. Peak Intensity Tabulation for 1-methylnaphthalene

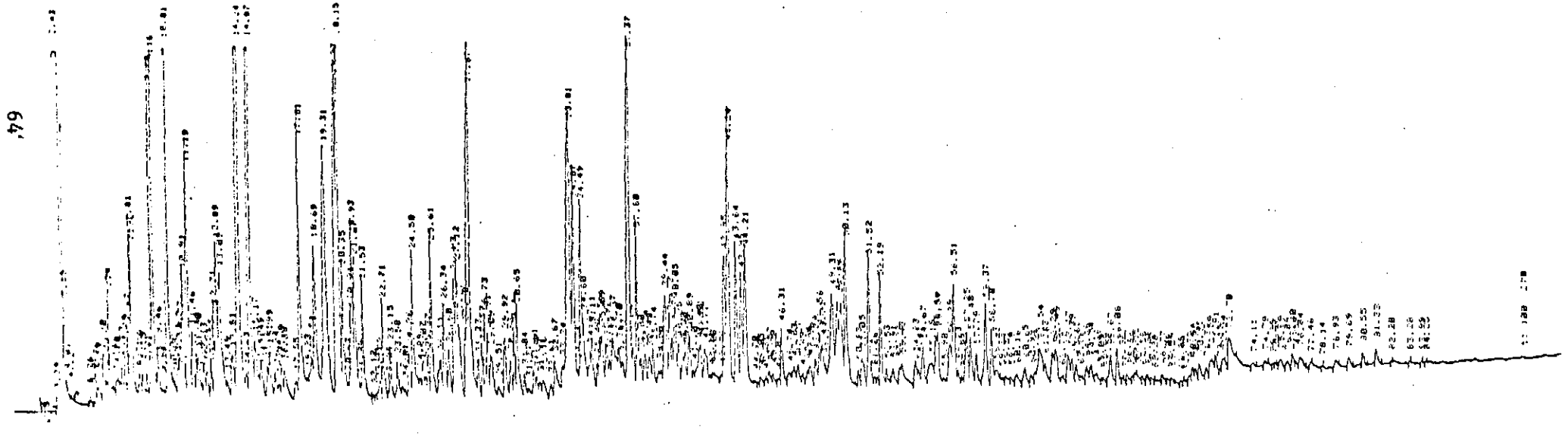

Figure 27. Typical GC Run on HP Model 5840 used for Monthly Quantitative Results

Table 9

Monthly Variation of Total Organic Content via GC (HP 5840) for Anderson Creek Embayment

Month	Total Organic Content (ppm)
October	14.9
November	11.1
December	5.20
January	1.04
February	1.50
March	0.10
April	0.35
May	3.00
June	6.50
July	17.1
August	38.2
September	15.0
October	16.8
November	12.0
December	7.80
January	1.78
February	2.01
March	0.32
April	1.75
May	5.40

All stations were sampled once a month from October, 1974, through December, 1975. Each parameter was sampled at a different week of the month. An attempt was made to sample each parameter at the same time each month, but weather conditions and logistical problems sometimes interferred.

1. Plankton Results. Plankton was sampled with a Juday plankton trap. Samples were brought back to the lab and chilled until counts and identifications were made. During warm months, the samples were put on ice immediately in the field. Counts were made with a Sedwick-Rafter counting cell and whipple ocular disc.

a. Phytoplankton. Phytoplankton collected from Vickers Bay are shown in Table 10. Increases in phytoplankton numbers were noticed in April due to initial warm temperatures and an influx of nutrients due to rains. The largest increase in the population was noticed in June probably due to constant warm temperatures and a prolonged influx of nutrients. After June, the numbers dropped drastically, with a slight increase in August. Months of considerably lower populations are December through March, then May and July, then September to December. The organisms of most abundance in April were the Chrysophyta, or the diatoms. In June it was mainly the Chlorophyta, with the Cyanophyta having their highest numbers this month. In August the Chlorophyta reached a peak in abundance.

The Cyanophyta, indicative of undesirable water conditions, were never dominant or present in great numbers. The Chlorophyta were usually the most abundant throughout the study, and are not representative of

Table 10. Percent Frequency of Occurrence by Collecting Stations of all Phytoplanktons Collected from Vickers Bay

	1974	1975												TOTAL
	D	J	F	M	A	M	J	J	A	S	O	N	D	
CHLOROPHYTA														
Chlorophyceae														
Volvocales														
Chlamydomonas			62	50	100	32	48	100	96	68	100	91	95	65
Carteria		5		30		14	10	55	91	9	14	5		18
Volvox			10											-1
Pleodorina						96	33	9	14					12
Eudorina					10	82	24	86	91					23
Pandorina		5		35	43	100	100	100	100	68	23	19		46
Gonium							5	5	14			5		2
Platydorina			5			5	86	86	100	23				24
Pteromonas								32	9	27	9			6
Tetrasporales														
Gloeocystis						14								1
Sphaerocystis								9						-1
Tetraspora			91			91	14							15
Ulotrichales														
Ulothrix			19	15										3
Microsporales														
Microspora			10											-1
Chaetophorales														
Stigeoclonium		5												-1
Chaetophora						5								-1
Chaetosphaeridium								27						2
Oedogonales														
Oedogonium		10	14	5			5			5	32	10		6
Chlorococcales														
Golenkinia						9	10	59	41	46		5		13
Characium							10	91	77	9				15
Pediastrum	38	43	14	60	14	100	100	100	100	100	77	91	29	67
Coelastrum	5			5			91	96	91	41	32		14	29
Botryococcus								5	5					-1
Tetraedron						18	29	55	82	50	46	19	10	24
Treubaria							29	59	68	23	5			14
Chlorella			5	15								5		2
Eremosphaera						32		5						2
Trochiscia				5										-1
Echinosphaerella								5						-1
Franceia						9		5						1
Lagerheimia							33	9	18	5		5		5
Kirchneriella						5		9	32		9			4
Ankistrodesmus	14	33			33			96	82	77	100	67	76	45
Cerasterias						5								-1
Chodatella								100	64					13
Shroederia						5	33	64	73					14
Closteriopsis													10	-1
Dictyosphaerium					19	5	10		91	68	32	14	52	23
Dimorphococcus		5												-1

Table 10. (Continued)

	1974	1975												TOTAL
	D	J	F	M	A	M	J	J	A	S	O	N	D	
(CHLOROPHYTA)														
(Chlorophyceae)														
(Chlorococcales)														
Selenastrum							5							-1
Polyedriopsis						5		9	18					3
Scenedesmus	19	33			14	100	100	100	100	100	96	62	14	58
Tetradesmus								5		5				-1
Micractinium							24	23	23	32	5	10	10	10
Tetrastrum	5	10						14	14	50	18	24	14	12
Crucigenia						5	5	14	32	41	9		5	9
Actinastrum	48	43	19		71	100	100	100	100	96	96	43	76	69
Tetrallantos		5				14								1
Siphonales														
Vaucheria				5										-1
Zygnematales														
Spirogyra	19	48	5		24			23	14	9	27	24	10	16
Mougeotia	5	14					10	41	9	5	5	5		7
Cylindrocystis							19	73						7
Closterium	10	14		15			14	18	23		5	10		8
Staurastrum						23	33	23	9	9		5		8
Euastrum						5	19	59	64	55		10		17
Cosmarium		5				5	14	27	27	14		5		8
Xanthidium								5	5					-1
Desmidium											5	62		5
EUGLENOPHYTA														
Euglenophyceae														
Euglenales														
Trachelomonas	91	81		65	91	100	67	96	86	82	96	81	86	79
Phacus	14						19		5	27		5	5	6
Euglena	5	38	10	20	14		29	32	23	55	100	95	71	38
Lepocinclis	48	14						14		59	91			18
CHLOROMONADOPHYTA														
Chloromonadineae														
Gonyostomum										5				-1
PYRRHOPHYTA														
Dinophyceae														
Peridiniales														
Glenodinium		100		65	62	86	100	100	100	77	5		24	55
Peridinium								5						-1
Ceratium	5					36	71	64	59	14	32			22
CYANOPHYTA														
Myxophyceae														
Chroococcales														
Chroococcus				10			19	86	32	55				16

Table 10. (Continued)

	1974	1975												TOTAL
	D	J	F	M	A	M	J	J	A	S	O	N	D	
(CYANOPHYTA)														
(Myxophyceae)														
(Chroococcales)														
Marsoniella							33	73	86		5			16
Dactylococcopsis								14	77	18				9
Gloeocapsa											9			-1
Merismopedia							62	73	86	82	64	19		30
Coelosphaerium				5			5							-1
Aphanocapsa							10							-1
Microcystis			5				14	36	96	64	32	10	5	21
Aphanothece						23	33	14	64	5		10	19	13
Chamaesiphonales														
Chamaesiphon				5			5							-1
Hormogonales														
Phormidium							5							-1
Lyngbya		5	10			5	5	18	14	9		14		6
Spirulina											5			-1
Arthrospira		5						18						2
Oscillatoria		5	5	15			5	18	27	50	41	48	14	18
Anabaena	5	5				9		32	100	86		19	100	28
Nostoc						5								-1
Stigonema							5							-1
Calothrix											5			-1
Gloeotrichia									9					-1
CHRYSOPHYTA														
Xanthophyceae														
Heterococcales														
Ophiocytium							5			5				-1
Chrysophyceae														
Chrysomonadales														
Mallomonas								9						-1
Synura													19	1
Dinobryon			5			14					5	19	5	4
Uroglenopsis						5	10							1
Chrysococcus	81	95		15		68	38	96	100				5	39
Bacillariophyceae														
Centrales														
Melosira	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cyclotella	95	86	62	35	95	27	86	100	100	100	91	91	91	91
Stephanodiscus			71	40	14	9								10
Rhizosolenia						18								1
Pennales														
Tabellaria			58			5	5							4
Meridion		10		10	19	14					5	10		5
Diatoma	19	100	95	80	100	64	95	100	96	91	96	81	100	86
Asterionella	5	62	100		95	100	82	5				19	100	43
Fragilaria			52	60	67	41	14						10	18
Synedra	48	48	91	75	95	100	100	100	100	91	64	86	91	84

Table 10. (Continued)

	1974	1975												TOTAL
	D	J	F	M	A	M	J	J	A	S	O	N	D	
(CHRYSOPHYTA)														
(Bacillariophyceae)														
(Pennales)														
Cocconeis			19				5	5						2
Gyrosigma	62	86	43	80	48	46	24	41	14	27	32	29	10	41
Pinnularia			10				5					5		1
Navicula	86	95	86	60	76	73	62	96	59	27	68	91	48	71
Gomphoneis						5								-1
Gomphonema	5	19	10		5	9		9		5	14	10	10	7
Cymbella	33	91	33	45	24	46	52	27	9	18	32	71	48	40
Rhopalodia												5		-1
Nitzschia	38	95	24	40	29	5	5		5	86	96	95	5	40
Cymatopleura		10						5		5		10		2
Surirella	10	24	14	70	38	27	24	64	27	46	41	33	10	32
Centronella		5												-1
Hydrosera				5	100									8
RHODOPHYTA														
Rhodophyceae														
Bangiales														
Porphyridium							5							-1

poor water conditions. The Chrysophyta, were most abundant during the cooler months, with a peak in April and a minimum in August. Characteristic organisms of the phytoplankton are Melosira sp., Pediastrum sp., Cyclotella sp., Cymbella sp., Synedra sp., Gyrosigma sp., Nivicula sp., Diatoma sp., Surirella sp., Trachelomonas sp., and Glenodinium sp.

Seasonal fluctuations in the total phytoplankton standing crop are seen in Figure 28. Monthly variations of Cyanophyta, Chlorophyta, and Chrysophyta are shown in Figure 29.

b. Zooplankton. Monthly frequency of occurrence and relative abundance of Zooplankton are shown in Table 11 and Figure 30, respectively. Highest numbers were recorded in April and August, with lower numbers in early fall throughout the winter and early spring. Warm water and greater amounts of nutrients were the stimulants for the spring and summer abundance. Characteristic organisms were Difflugia sp., Codonella sp., Keratella sp., Brachionus sp., and Polyarthra sp.

2. Benthos Results. Benthic organisms were sampled with an Ekman dredge with an area of 524 sq. cm. One grab sample was taken at each station, with each sample being sifted and washed in the field. The samples were also preserved with 40% isopropyl alcohol in the field. The samples were later picked for organisms, with counts and identifications also being made. Season variation in total numbers of all benthic organisms is shown in Figure 31. Benthic numbers fluctuated considerably, mainly due to recruitment of young and cyclic emergences of the Dipterans and Ephemeropterans. Peaks in numbers were observed in January, May, August, and December. The Diptera, mainly consisting of three families, were dominant along with the Order Ephemeroptera. The Oligochaetes and

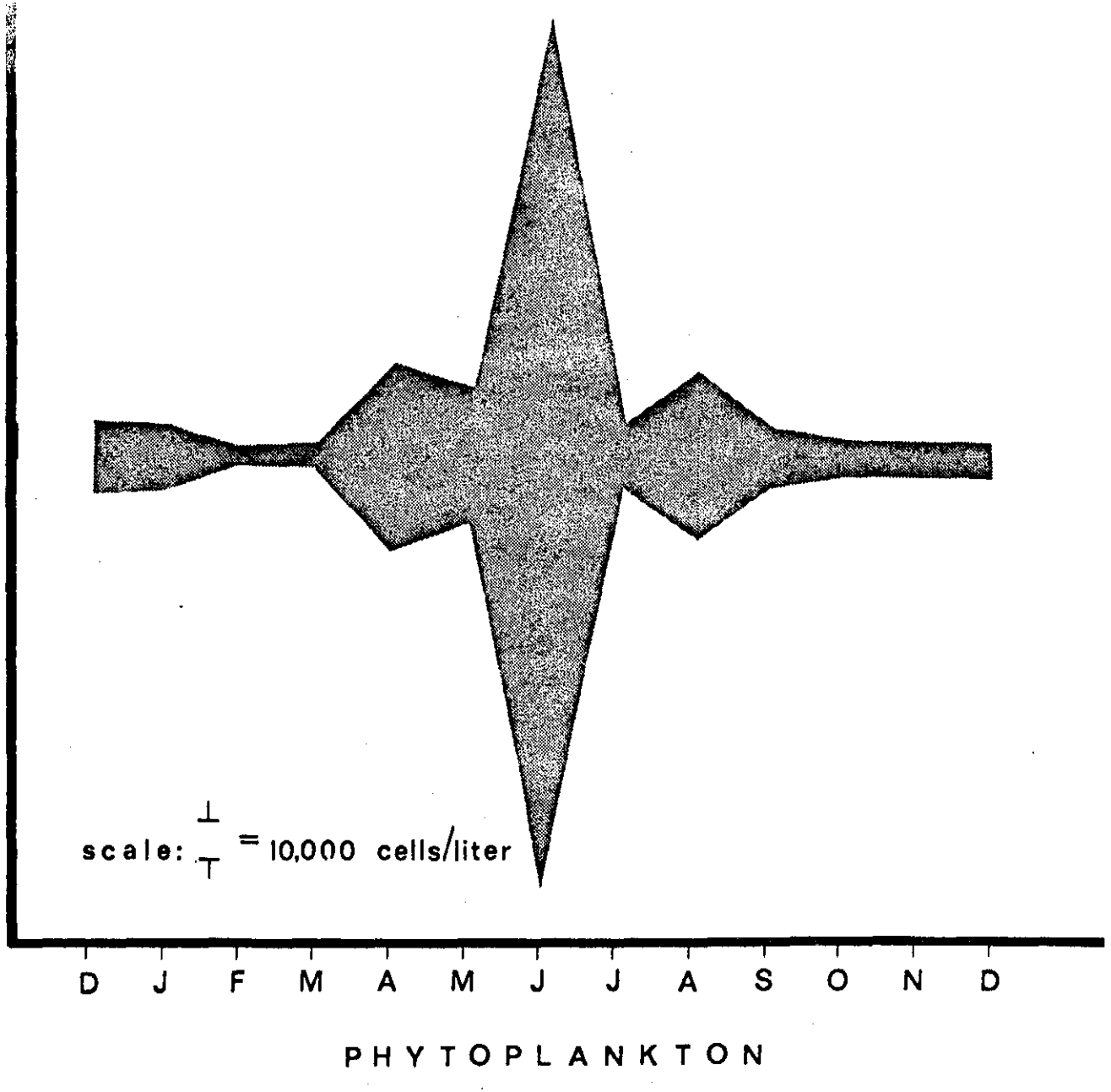

Figure 28. Monthly Variation in Total Phytoplankton Cell per Liter in Vickers Bay

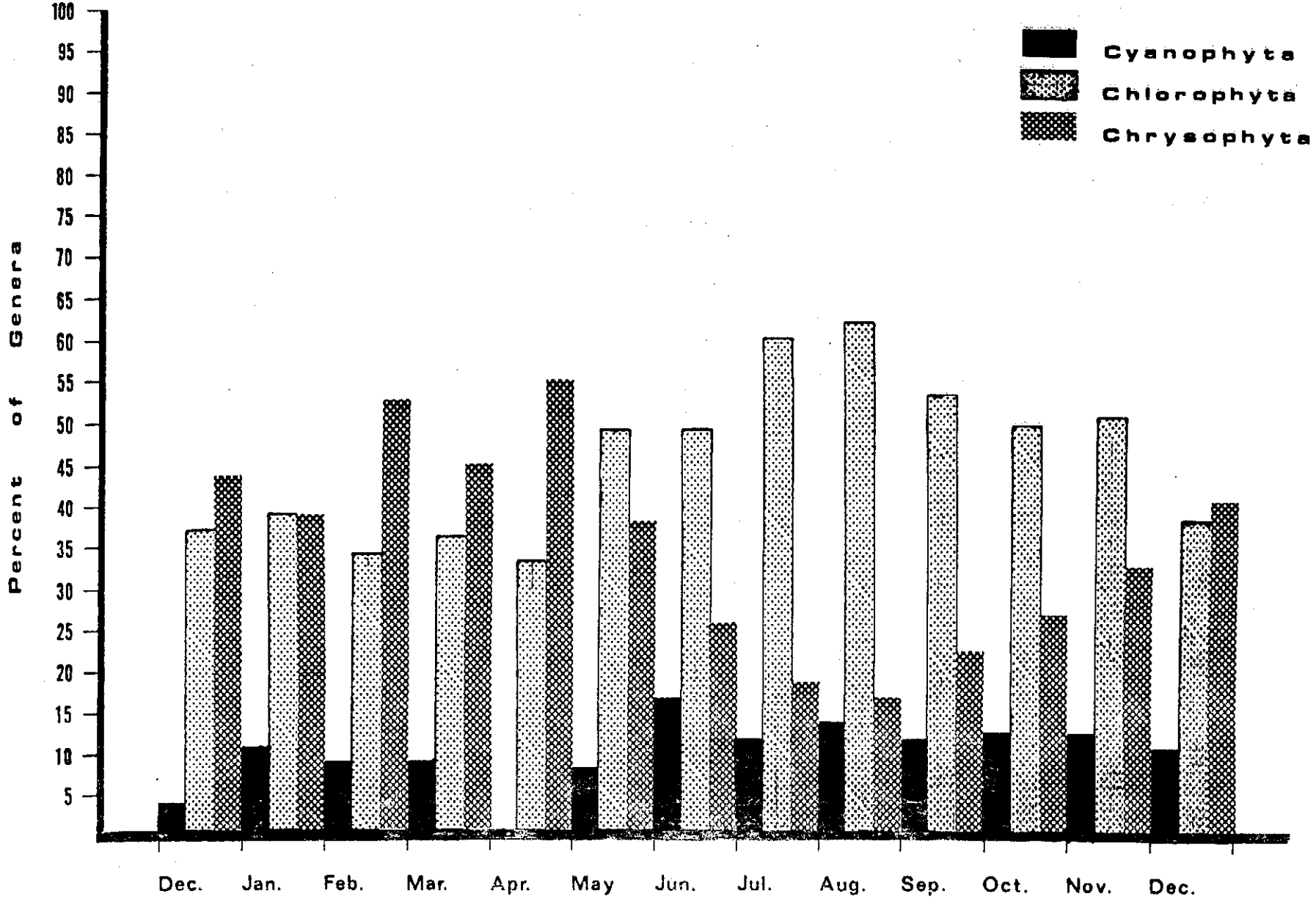

Figure 29. Major Phytoplankton Taxa in Vickers Bay

Table 11. Percent Frequency of Occurrence by Collecting Stations of All Zooplanktons Collected from Vickers Bay

	1974	1975												TOTAL
	D	J	F	M	A	M	J	J	A	S	O	N	D	
PROTOZOA														
Sarcodina														
Difflugia	14	19	10	75	76	100	95	100	100	77	59	81	5	63
Actinospaerium			5		86	100	62	82	86	41	18		5	38
Amoeba								5						-1
Ciliata														
Codonella	43	38	43		86	91	100	96	32	100	14	67	24	57
Vorticella				10		5			9	5		5	10	3
Podophrya												5		-1
Staurophrya												48	76	9
Sphaerophrya													5	-1
GASTROTRICHA														
Chaetonotus								5						-1
DIPTERA														
Chaoborus									5					-1
unidentifiable larva						5								-1
ANNELIDA														
Oligochaeta			5								5	5		1
COPEPODA														
nauplius larva	24	29			62		81	96	96	100	59	57	52	51
Cyclopoida		5	71	50	52	96	91	73	46	55	9	24	10	45
Calanoida					10		14	9	5			5		3
HYDRACARINA	10			5	29	9								4
NEMATODA	5			15				18		5	5	5		4
TARDIGRADA		10	5	10							5			2
CLODOCERA														
Daphnia			29	25	5		43							8
Bosmina			5		38	91	57	55	32	32	41	38		30
Leptodora							5			5				-1
Diaphanosoma							62	46	46	14				13
ROTATORIA														
Keratella	24	67	48	40	95	100	100	91	73	55	9	52	33	61
Brachionus	67	57	95	40	95	91	76	100	100	86	32	100	52	77
Synchaete	48	86			95	64		82	100	91	91	76	91	64
Polyarthra	33	57	24	15	91	100	86	96	96	100	86	81	81	73
Trichocera	14	5				86	100	91	100	77	77	57		48
Colurella		10												-1
Kellicotia		5		5	14								5	2
Epiphanes		5					100							8

Table 11. (Continued)

	1974	1975											TOTAL
	D	J	F	M	A	M	J	J	A	S	O	N	D	
Philodina			5		5									-1
Tetramastix				5										-1
Enteroplea				15		5								1
Asplanchna				10	14	55	5	100	86	100	68			35
Rotaria neptunia				5					5					-1
Ploesoma					5	86	48	96	100	100	64	5		40
Chromogaster						5								-1
Asplanchnopus						5								-1
Filinia						9	14	50	91					13
Notommata						5		9						1
Platyias							19	18	36	23				8
Euchlanis											5			-1
Cephalodella											5			-1
Lecane												5		-1

NEMATODA

BRYOZOA
Plumatella sp.
Urnatella sp.
statoblasts

ANNELIDA
Oligochaeta
Hirudinea
Helodella sp.
Placobdella sp.

ARTHROPODA
Eucrustacea
Branchiopoda
Cladocera
Leptodera kindti
Copepoda
Calanoida, Cyclopoida
Malacostraca
Isopoda
Lirceus sp.
Amphipoda
Crangonyx sp.
Arachnoidea
Hydracarina
Acarina
Insecta
Diptera
Chironomidae
Ceratopogonidae
Culicidae
Chaoborus punctipennis
Tabanidae
Chrysops sp.
Trichoptera
Leptoceridae
Ephemeroptera
Hexagenia bilineata
Stenonema sp.
Coleoptera
Collembola
Isotoma sp.
Lepidoptera

MOLLUSCA
Gastropoda
Amnicola sp., Gyraulus sp., Helisoma sp., Physa sp.
Pelecypoda
Sphaerium sp., Corbicula sp., Ligumia sp.,
Quadrula sp., Margarita sp.

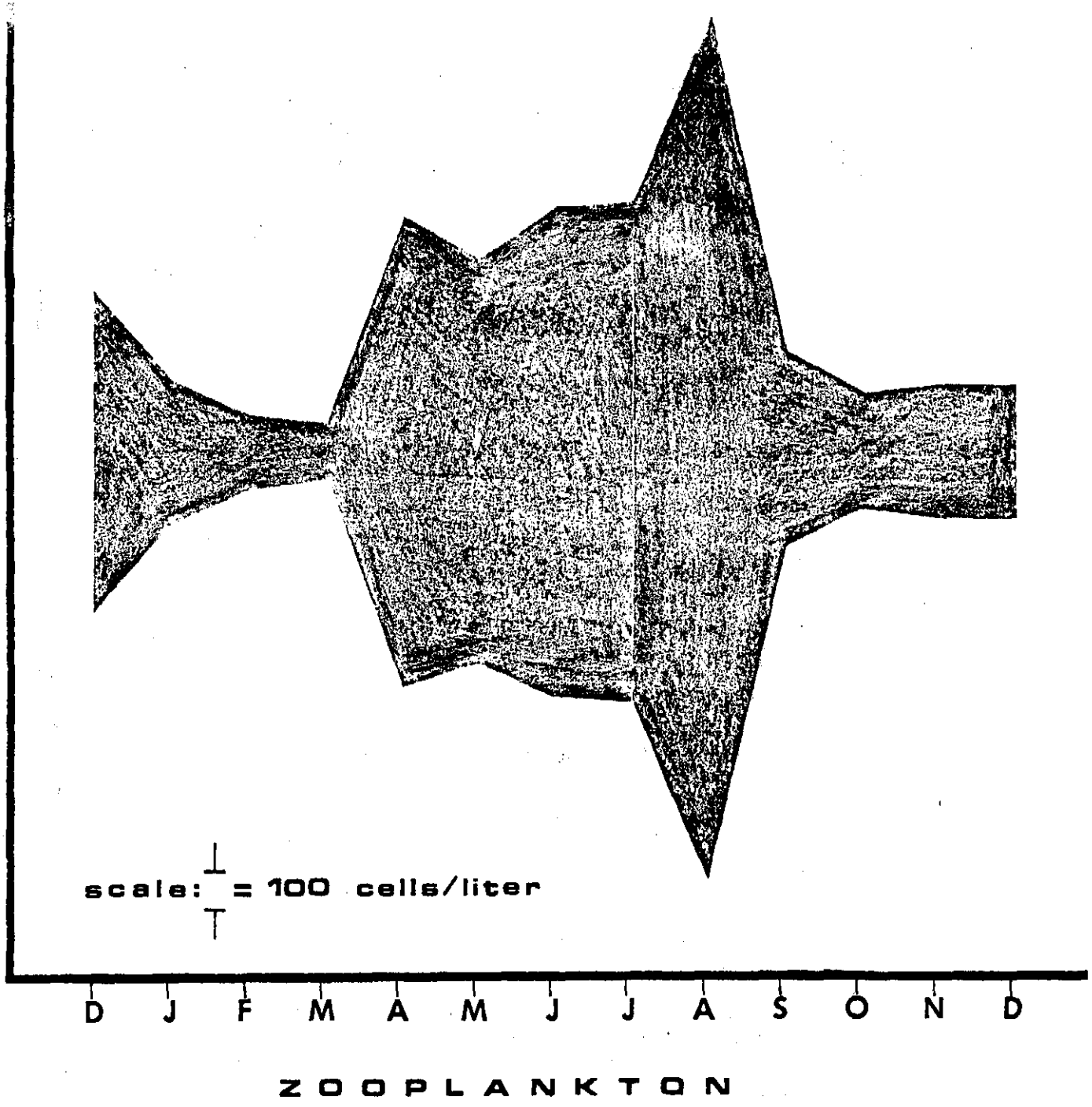

Figure 30. Monthly Variation in Total Zooplankton Cell per Liter in Vickers Bay

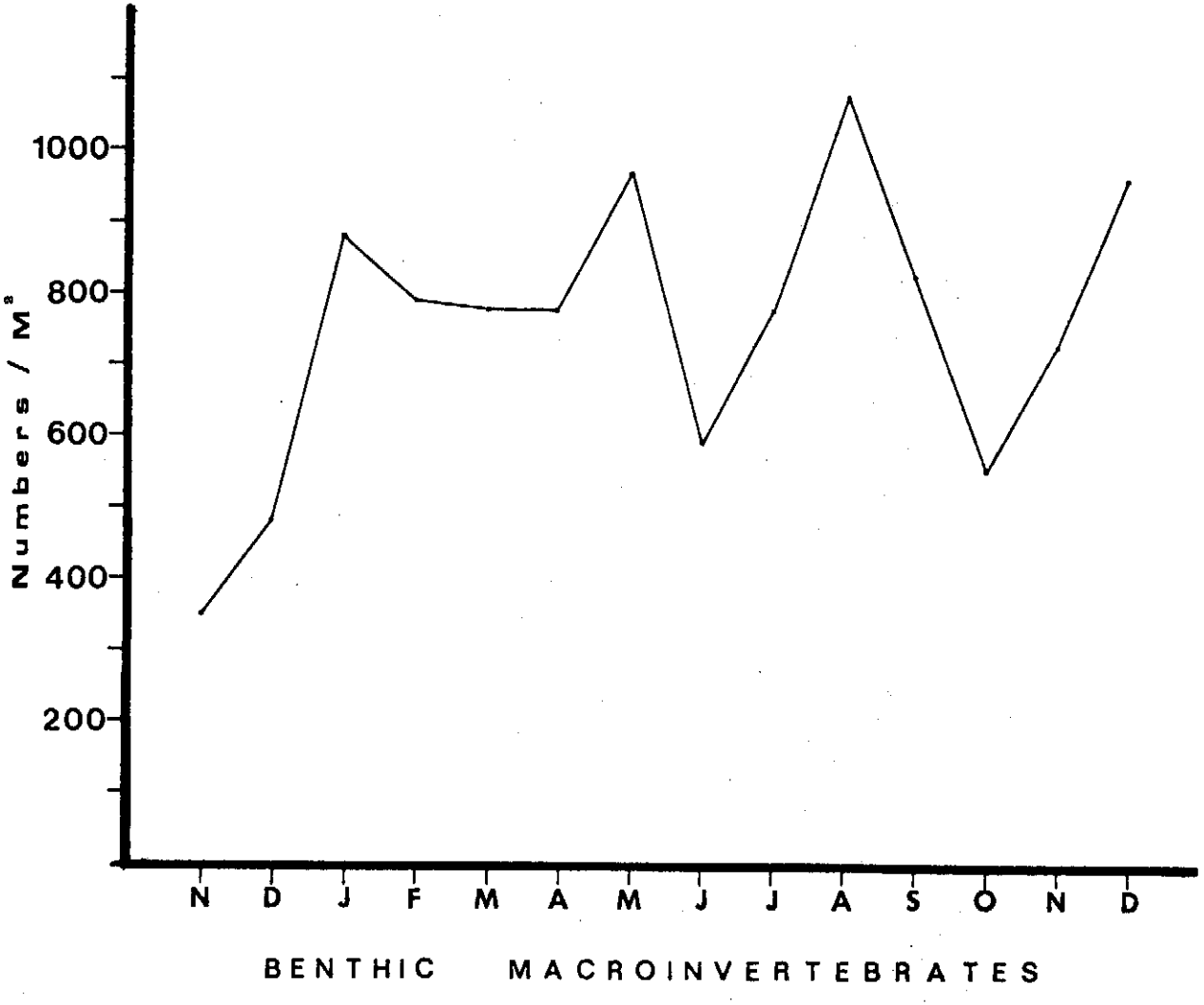

Figure 31. Monthly Mean Variation in Total Macroinvertebrates Collected in Vickers Bay

Molluscs were of lesser importance. However, the Oligochaetes did increase considerably in August due to poor water conditions. Characteristic organisms were Hexagenia sp., Chironomids and the Pelecypod, Sphaerium sp.

3. Water Quality Results. Water level fluctuations and turbidity values for the study period are shown in Figure 32. Turbidity was determined with a Secchi disc, while another transparency test was conducted with a Hach kit. Results from both tests were quite parallel. High readings in spring and fall were attributed to rainfall and wind adjetation whereas high readings in June were attributed to the plankton bloom.

Temperatures of the water ranged quite nicely with lows in December and January and a high in August, Figure 33.

Dissolved oxygen was acceptable at all depths throughout the sampling period, having a low of 6 ppm at deep stations in June and August, and a high of 15 ppm at a surface station in December; Figure 34.

Free carbon dioxide levels fluctuated with highs of 12 ppm in October, February and August, and lows in June through August.

pH values varied little, usually remaining near 8. A low of 6.9 was recorded in December, 1975, and a high of 8.8 was recorded in June, Figure 35.

Total alkalinity was at a satisfactory level throughout the sampling period with highs in the warmer months of 70 ppm and a low in April of 10 ppm, Figure 30.

Total dissolved solids, Figure 36, greatly fluctuated with highs in January and July, plus a tremendous increase in April. The highs can be attributed to increased amounts of materials washed in by rains and a large plankton population.

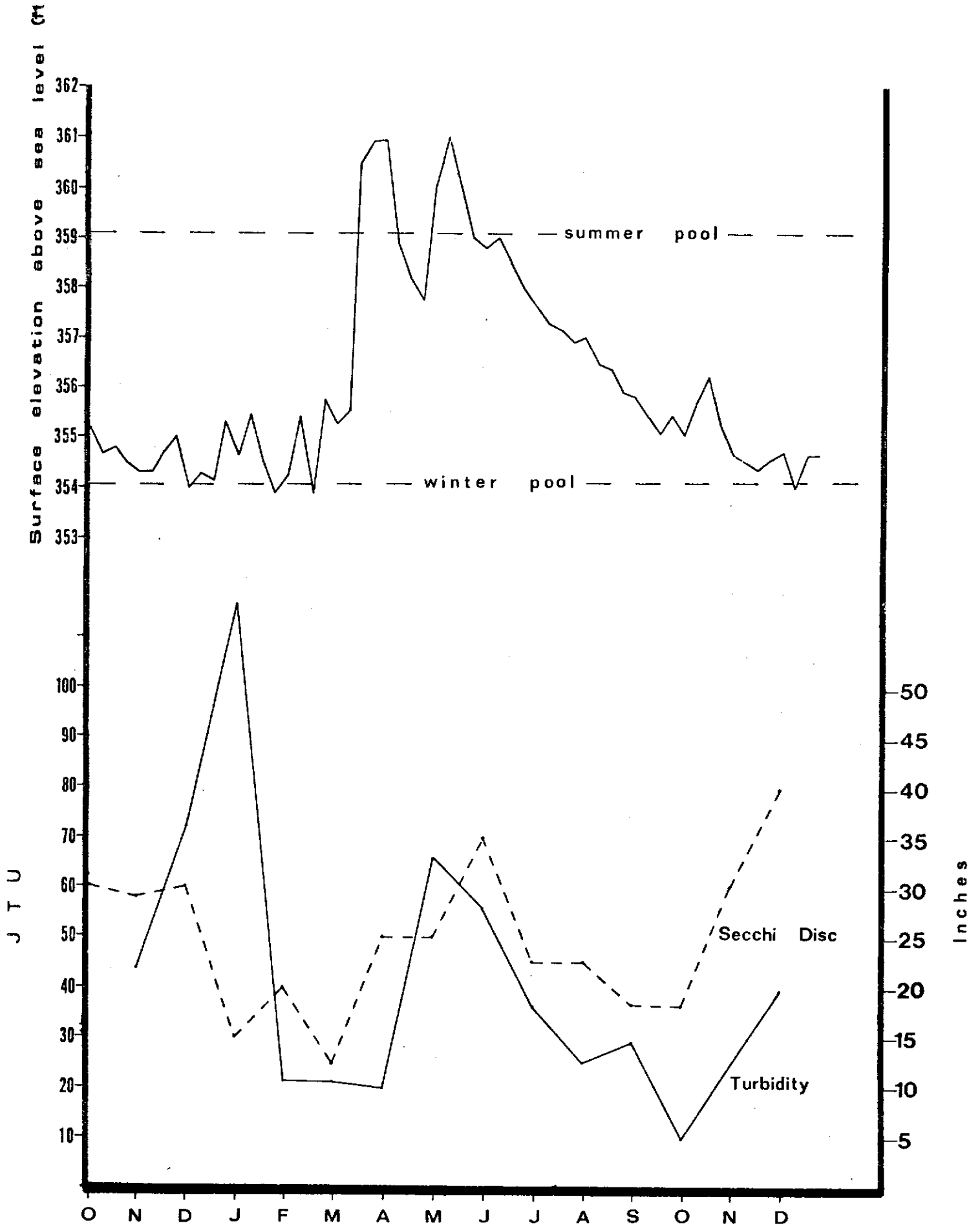

Figure 32. Monthly Mean Variation of Turbidity and Secchi-Disc Transparency in Vickers Bay and Surface Elevation Fluctuation of Kentucky Lake During the Study Period

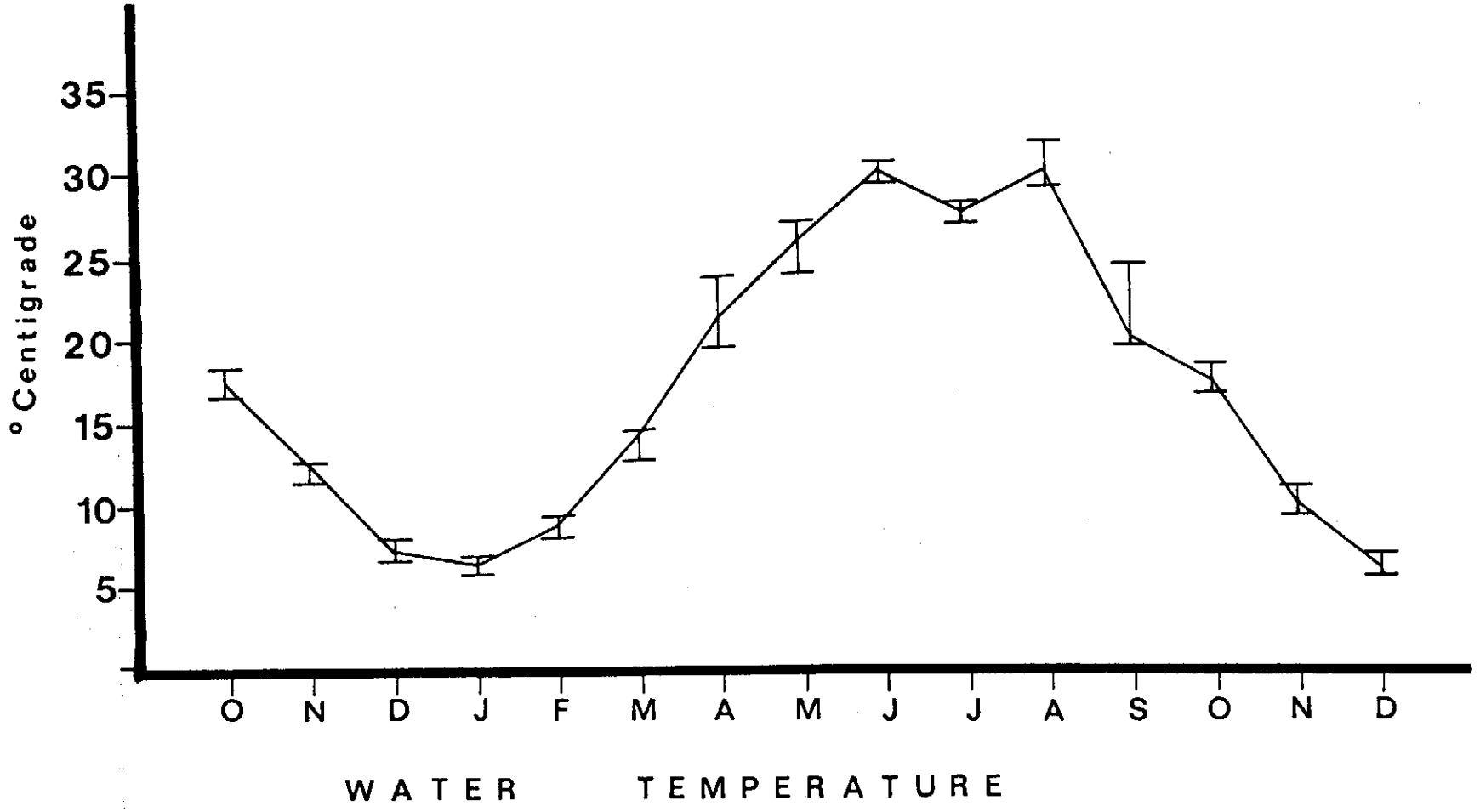

Figure 33. Monthly Range and Mean Variation of Water Temperature in Vickers Bay

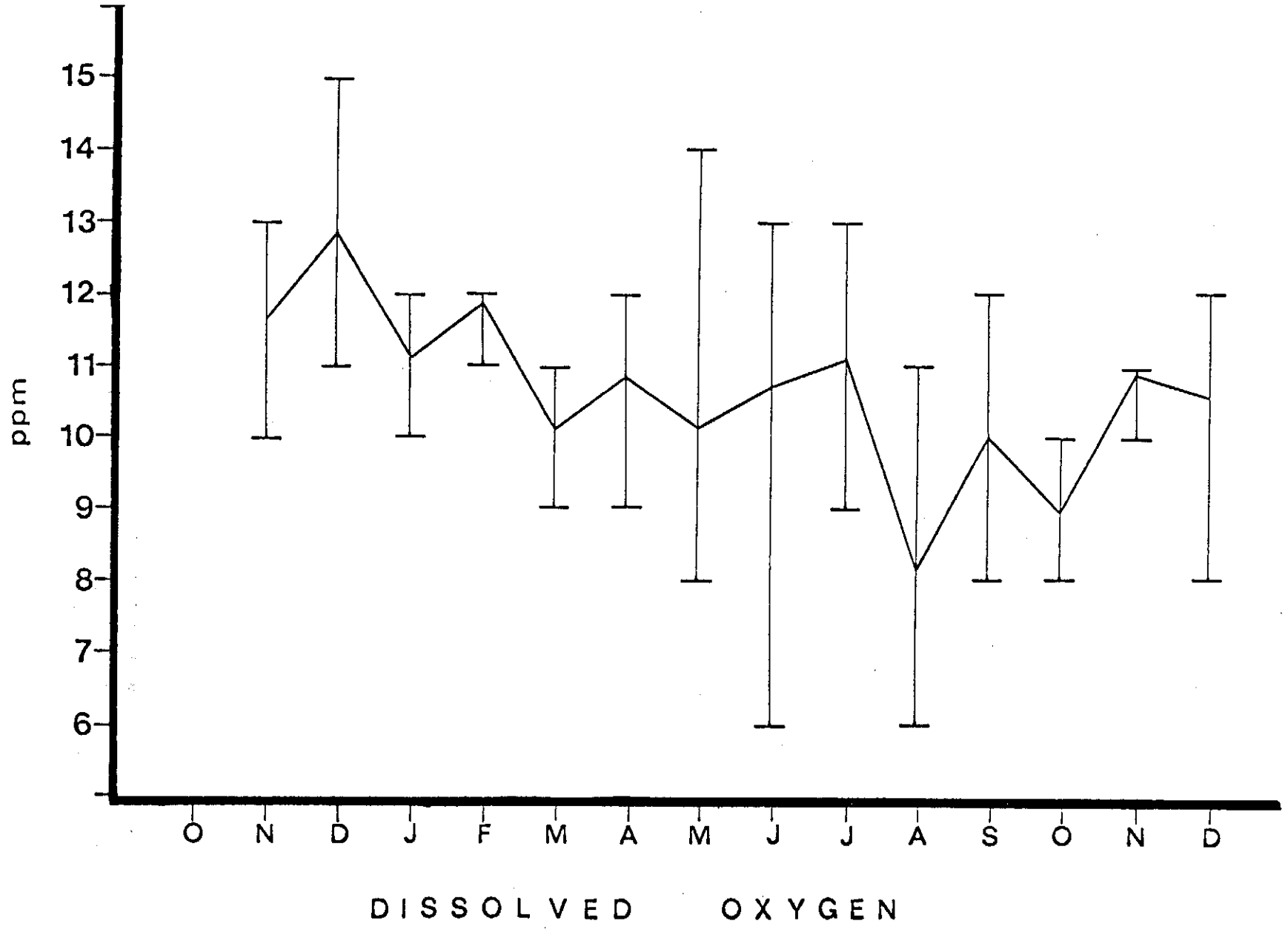

Figure 34. Monthly Range and Mean Variation of Dissolved Oxygen in Vickers Bay

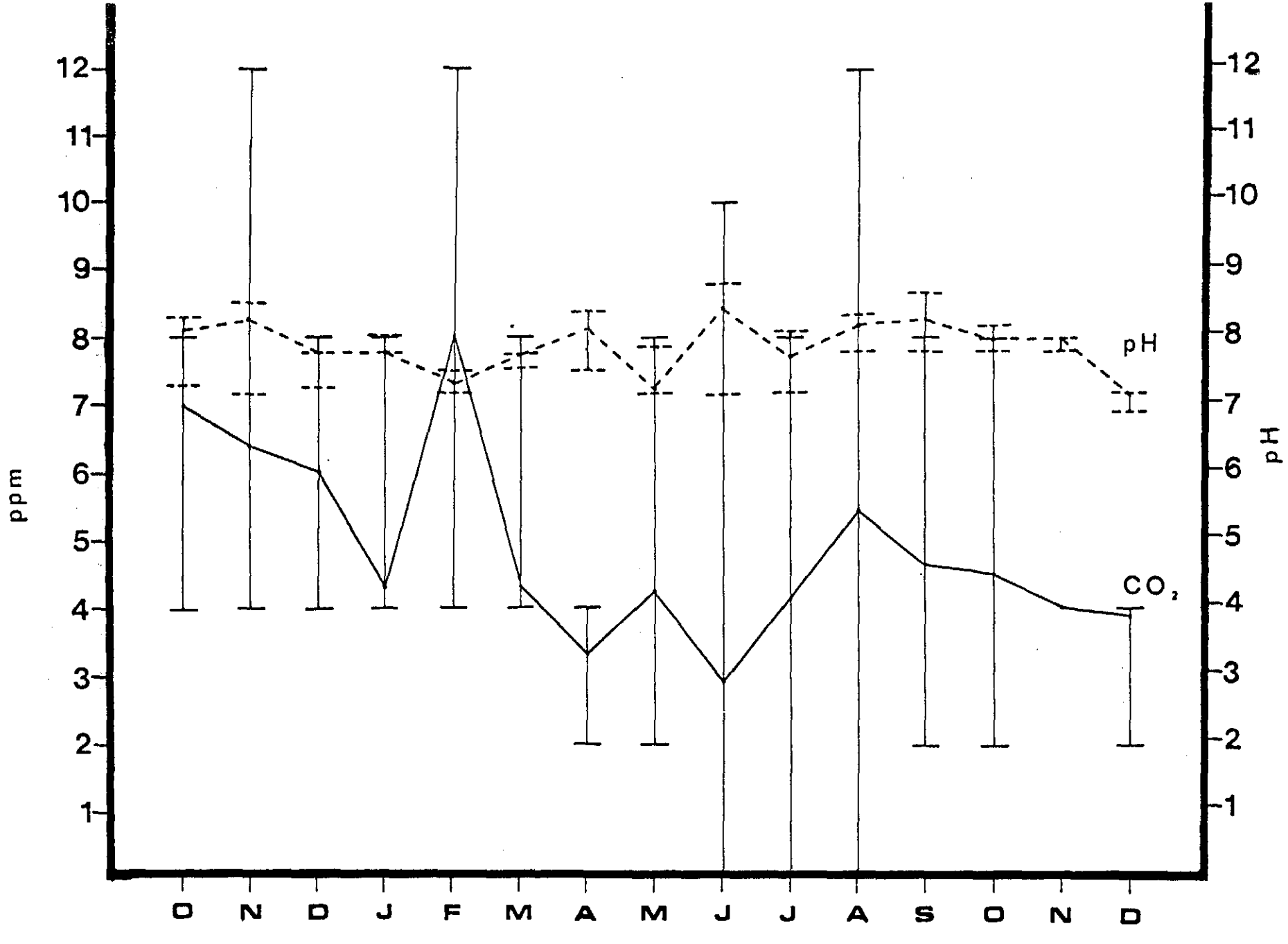

Figure 35. Monthly Range and Mean Variation of pH and Free Carbon Dioxide in Vickers Bay

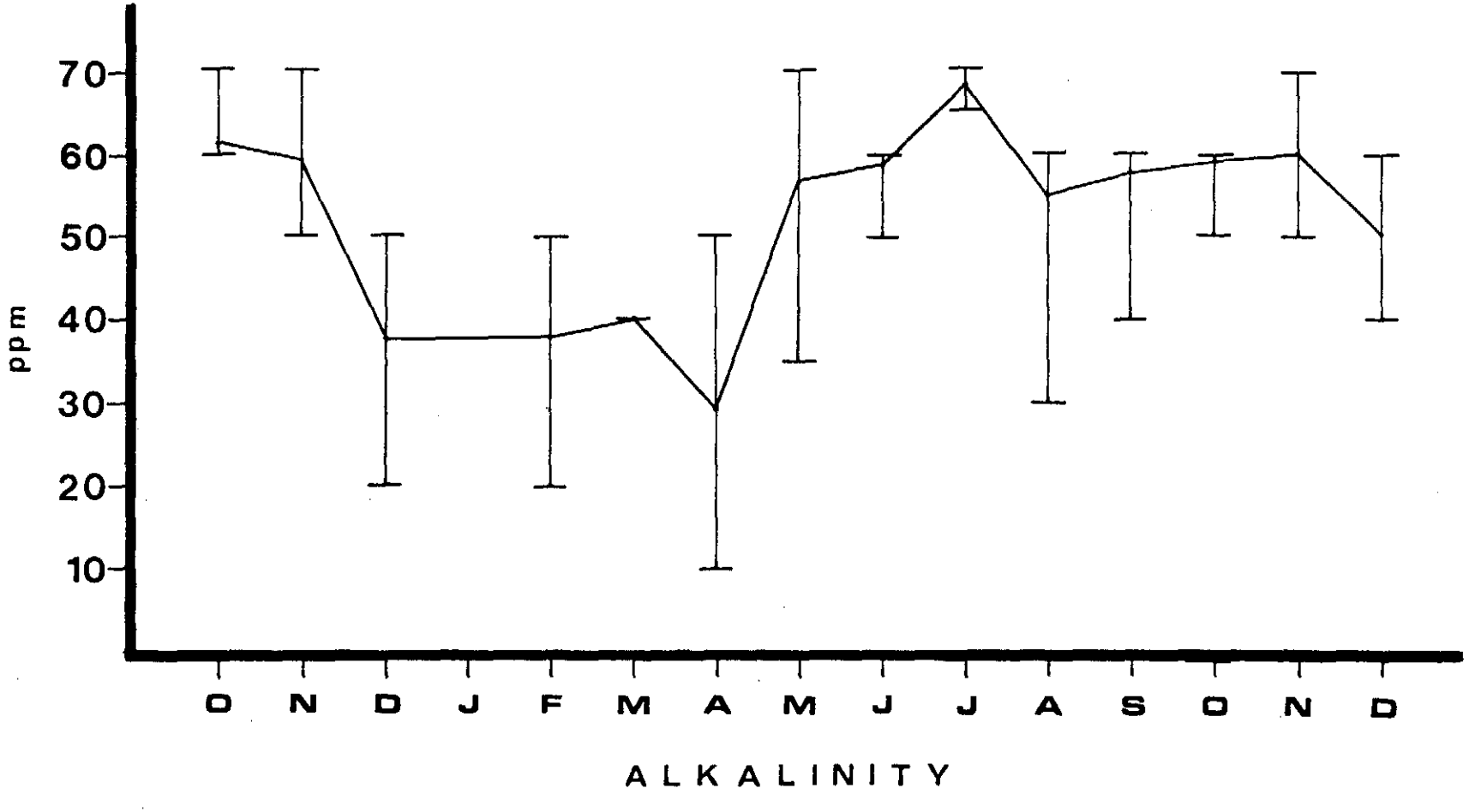

Figure 36. Monthly Range and Mean Variation of Total Alkalinity in Vickers Bay

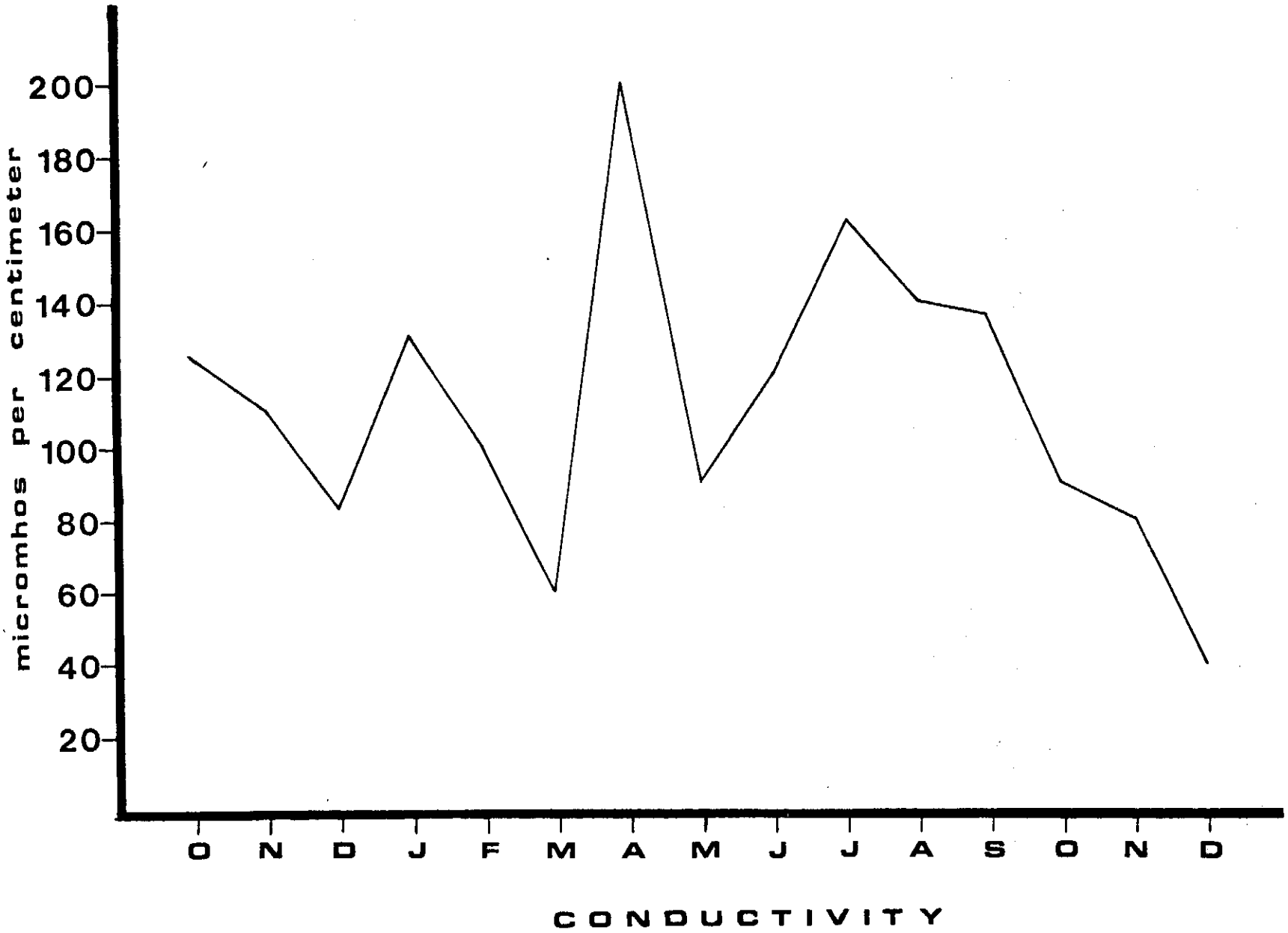

Figure 37. Monthly Mean Variation of Total Dissolved Solids in Vickers Bay

Nitrate concentrations at each sampling station for Vickers Bay are given in Table 12. Monthly ranges and mean variations are plotted in Figure 38. Nitrates were highest in March at 1.02 ppm, and virtually undetectable in March, May, June, and July.

Phosphate concentrations at each sampling station are given in Table 13. Monthly ranges and mean variations are plotted in Figure 39. Phosphates were highest in May at 0.35 ppm, and lowest in March at 0 ppm. Readings were higher in the warmer months probably due to wastes from increased human activity both on the lake itself and throughout the watershed.

Table 12. Nitrate Concentrations at Each Sampling Station for Vickers Bay

VICKER'S CREEK

Nitrate (ppm)															
Station	1974			1975											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1a	.00	.20	.26	.49	---	.42	.42	.45	.48	.31 .43	---	.15	.27	.42	.10
1b	.00	.10	.40	.45	---	.43	.43	.43	.50	.36 .42	---	.23	.23	.33	.12
1c	.00	.20	.26	.50	---	.50	.50	.51	.54	.28 .53	---	.28	.39	.00	.12
2a	.00	.20	.44	.47	---	.21	.46	.45	.48	.21 .35	---	.24	.20	.59	.21
2b	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
3a	.20	.20	.27	.41	---	.36	.45	.38	.43	.00 .62	---	.29	.14	.00	.10
4a	.00	.20	.30	.44	---	.43	.42	.44	.52	.34 .48	---	.11	.13	.13	.27
4b	.00	.30	.42	.53	---	.43	.41	.46	.48	.18 .42	---	.13	.13	.18	.28
5a	.30	.20	.35	.52	---	.36	.45	.47	.00	.20 .43	---	.16	.23	.00	.24
5b	.00	.20	.19	.58	---	.32	.46	.51	.42	.25 .54	---	.23	.14	.46	.31
5c	.00	.20	.30	.49	---	.22	.50	.55	.51	.36 .26	---	.30	.20	.11	.13
6a	.30	.10	.42	.49	---	1.02	.43	.42	.46	.52 .45	---	.22	.16	.00	.13
6b	.00	.30	.32	.56	---	.27	.51	.55	.53	.31 .32	---	.26	.23	.27	.20
6c	.00	.20	.32	.56	---	.30	.52	.53	.54	.44 .36	---	.23	.17	.52	.00
7a	.10	.10	.36	.45	---	.42	.41	.51	.43	.48 .41	---	.12	.18	.00	.11
7b	.00	.10	.37	.47	---	.21	.45	.73	.32	.38 .50	---	.13	.23	.10	.15
8a	.00	.20	.36	.47	---	.42	.52	.45	.61	.35 .53	---	.27	.16	.13	.17
8b	.00	.20	.36	.49	---	.00	.48	.00	.50	.26 .35	---	.07	.14	.00	.00
9a	.00	.20	.47	.41	---	.63	.53	.65	.50	.26 .47	---	.11	.27	.11	.47
9b	.00	.20	.32	.49	---	.30	.47	.66	.53	.21 .62	---	---	.29	.00	---
10a	.00	.20	.32	.37	---	.47	.48	.45	.48	.24 .00	---	.18	.10	.00	.59
11a	.00	.10	.30	.35	---	.42	.46	.44	.46	.32 .43	---	.08	.19	---	.20
12a	---	---	---	---	---	.21	.43	.42	.00	.48	---	.04	---	---	---

Table 12. (Continued)

VICKER'S CREEK

Nitrate (ppm)															
Station	1976														
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec			
1a	.66	.26	.38	.22	.16										
1b	.70	<.10	.47	<.10	.30										
1c															
2a															
2b															
3a															
4a															
4b															
5a															
5b															
5c															
6a															
6b															
6c															
7a	.54	.21	.42	.14	.10										
7b	.50	.15	.48	.17	.13										
8a															
9a															
10a															
11a															
12a	.72	.21	.37	.23	.11										

Table 13. Phosphate Concentrations at Each Sampling Station for Vickers Bay

VICKER'S CREEK

Phosphate (ppm)															
Station	1974			1975											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1a	.02	.07	.06	.12	---	.10	.11	.15	.06	.04 .04	---	.04	.07	*	.03
1b	.09	.07	.07	.10	---	.07	.08	.27	.03	.07 .08	.05	.08	.08		.04
1c	.28	.07	.06	.09	---	---	---	.00	---	---	---	.01	.08		.06
2a	.04	.09	.07	.14	---	.06	.10	.12	.13	.08 .11	---	.05	.08		.04
2b	.06	---	---	---	---	---	---	.10	---	---	---	---	---		---
3a	.06	.09	.08	.15	---	.11	.08	.35	.07	.06 .12	---	.05	.07		.04
4a	.06	.09	.07	.11	---	.08	.15	.20	.10	.11 .07	---	.05	.08		.06
4b	.08	.08	.06	.08	---	---	---	.12	.05	.02 .08	---	.07	.07		.05
5a	.08	.09	.08	.11	---	.11	.14	.15	.06	.13 .06	---	.04	.08		.04
5b	.02	.09	.03	.09	---	.07	.10	.28	.16	.11 .21	---	.03	.10		.04
5c	.02	.10	.05	.11	---	.08	.09	.20	.10	.06 .03	---	.06	.08		.05
6a	.08	.07	.07	.15	---	.11	.12	.00	.06	.08 .24	---	.03	.07		.05
6b	.03	.08	.07	.05	---	.08	.09	.14	.07	.11 .20	---	.05	.09		.04
6c	.11	.07	.07	.09	---	.07	.11	.09	.08	.10 .18	---	.10	.09		.03
7a	.06	.08	.03	.15	---	.10	.13	.12	.12	.13 .11	---	.04	.09		.05
7b	.06	.06	.06	.12	---	.09	.16	.10	.08	.05 .08	---	.04	.10		.06
8a	.05	.09	.07	.14	---	.09	.08	.12	.09	.07 .04	---	.04	.09		.07
8b	.18	.04	.05	.10	---	.10	.07	.06	.10	.09 .12	---	.05	.08		.06
9a	.03	.08	.05	.13	---	.14	.15	.10	.08	.15 .15	---	.05	.08		.04
9b	.03	.06	.06	.11	---	.09	.23	.25	.04	.03 .06	---	---	---		---
10a	.03	.09	.05	.11	---	.09	.24	.13	.08	.06 .08	---	.08	.09		.05
11a	.03	.09	.08	.10	---	.00	.25	.24	.10	.15 .11	---	.03	.08		.04
12a	.07	---	---	---	---	.10	.22	.24	---	---	---	.04	---		---

* Results for NOV were invalidated

Table 13. (Continued)

VICKER'S CREEK

Phosphate (ppm)															
Station	1976														
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec			
1a	.04	.04	.04	.05	.06										
1b	.10	.02	.08	.11	.16										
1c															
2a															
2b															
3a															
4a															
5a															
5b															
5c															
6a															
6b															
6c															
7a	.04	.01	.08	.10	.10										
7b	.15	.02	.09	.11	.13										
8a															
8b															
9a															
9b															
10a															
11a															
12a	.06	.01	.11	.18	.11										

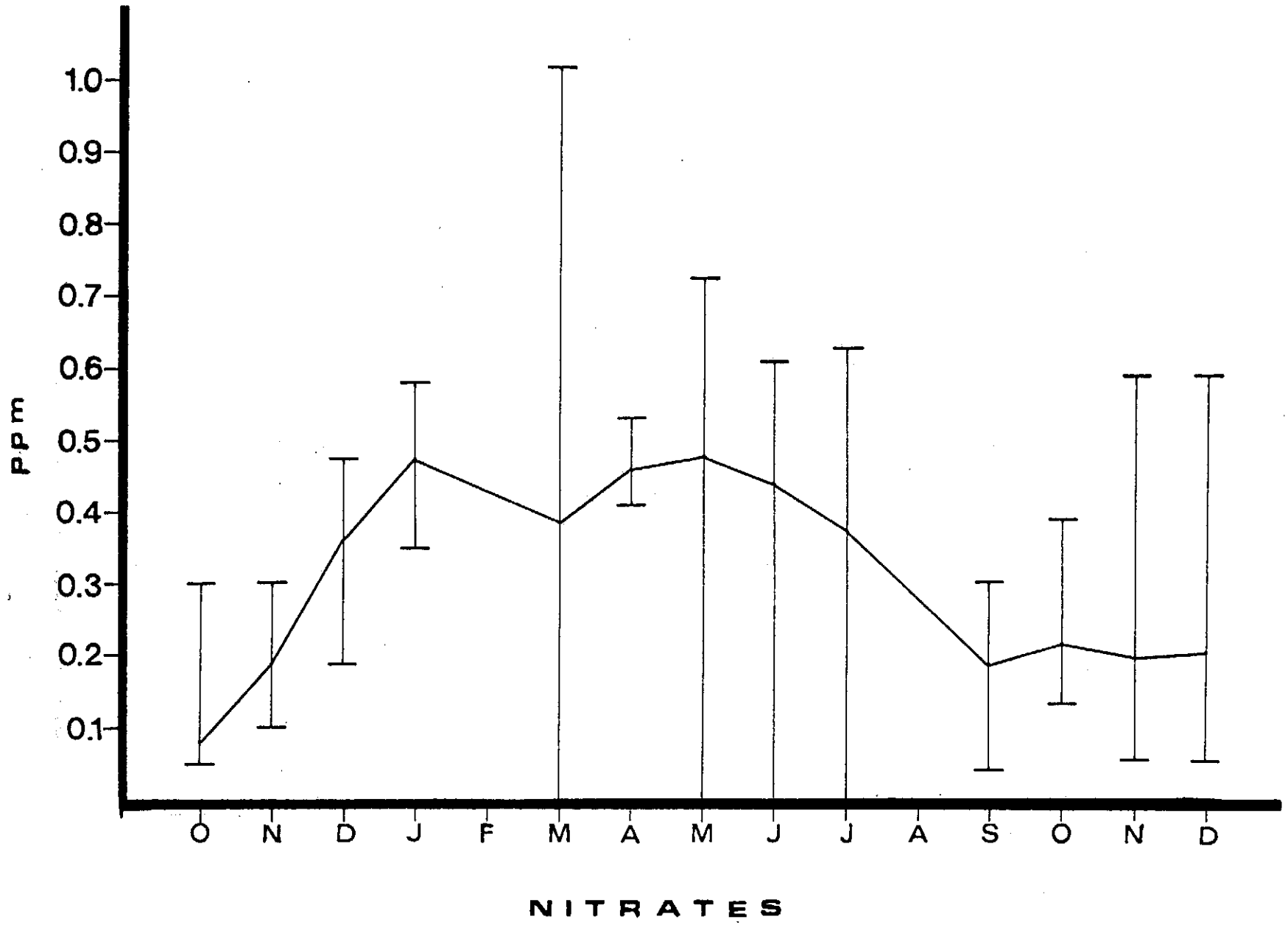

Figure 38. Monthly Range and Mean Variation of Nitrate Nitrogen Concentrations in Vickers Bay

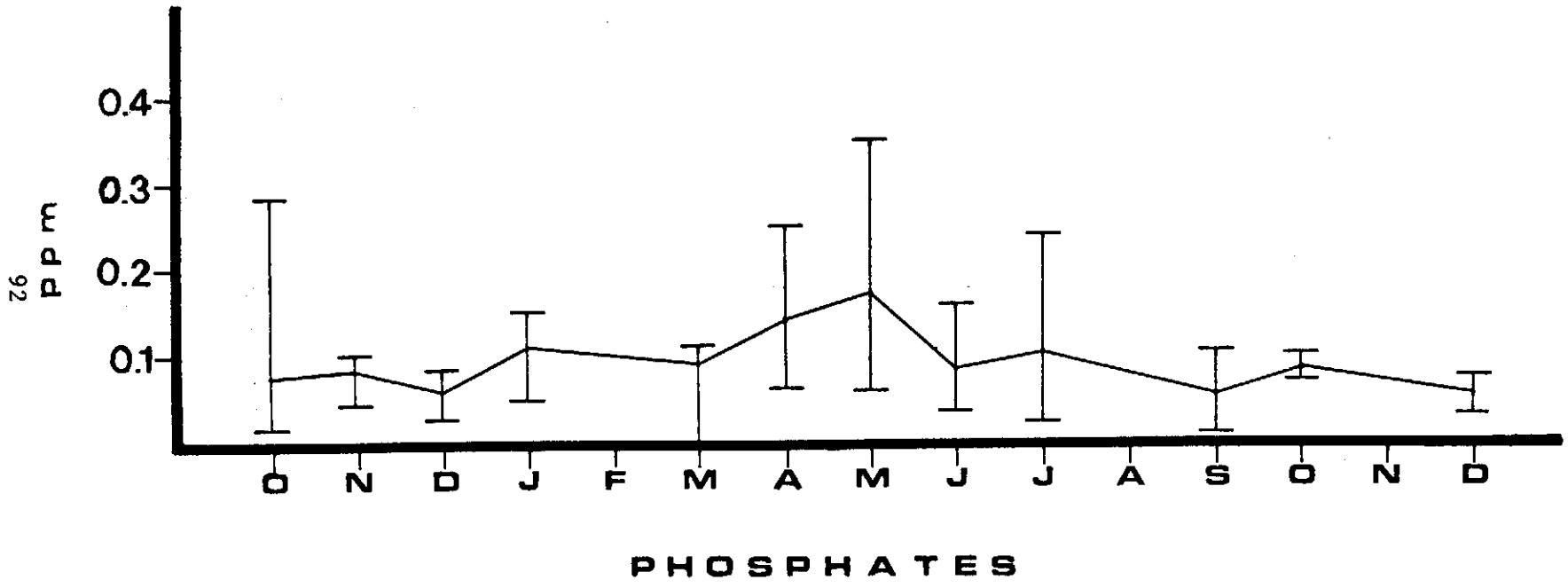

Figure 39. Monthly Mean Variation of Phosphate Concentrations in Vickers Bay

Table 14

Monthly Variation of Total Organic Content for Vickers Bay

Month	Total Organic Content
October	11.3
November	9.20
December	5.35
January	2.01
February	1.50
March	0.46
April	0.40
May	1.82
June	4.05
July	6.00
August	8.70
September	10.1
October	8.40
November	4.30
December	3.55
January	2.05
February	1.76
March	0.68
April	1.73
May	4.79

CHAPTER IV

CONCLUSION

Only small differences in biological and chemical parameters measured were recorded between surface and subsurface waters. The small difference in temperature between surface and subsurface waters prevented thermal or chemical stratification. Continuous mixing of the waters by wind and current produced a rather constant environment throughout the water column. Without stratification there was no unusual horizontal or vertical distribution of the flora and fauna of the embayment. For this reason, all station data were combined and averaged instead of each station discussed separately. Several of the parameters measured relate to quantitative and qualitative changes in the phytoplankton. Also changes in the phytoplankton can subsequently change the physical and chemical parameters of the embayment.

Nitrate nitrogen and phosphate stimulate excessive growths of the flora of a body of water. Chu (1943) found that optimum growth of all organisms studied in cultures can be obtained in nitrate-nitrogen concentrations from 0.9 to 3.5 mg/l and phosphorus concentrations from 0.09 to 1.8 mg/l, while a limiting effect on all organisms will occur at nitrogen concentrations from 0.1 mg/l downward and in phosphorus concentrations from 0.009 mg/l downward. The lower limit of optimum range of phosphorus concentrations varies from about 0.018 to about 0.09 mg/l; and the upper limit from 8.9 to 17.8 mg/l when nitrate is the source of nitrogen, while it is approximately 17.8 for all plankters studied when ammonium is the source of nitrogen (Chu, 1943).

Inorganic phosphates remained relatively stable throughout the collecting periods. The average monthly concentrations never exceeded 0.13 ppm (yearly range 0.04-0.13 ppm). Nitrate nitrogen values increased in the winter months possibly resulting from a buildup during the period of low standing crops of phytoplankton. A decrease in nitrates could have been the result of utilization of this nutrient with increased phytoproductivity. However, values increased in June and July when there was a definite bloom. With infrequent sampling there is no way to speculate whether increased runoff due to spring rains increased nitrate concentrations nor whether more nitrate was utilized. The Tennessee Valley Authority Water Quality Branch (1974) sampled three miles down river from Anderson Creek in the main channel and obtained phosphate values in the 0.11 and 0.39 ppm range. Taylor (1971) reported that Kentucky Lake yielded a mean nitrate value of 0.30 mg/1 and a mean phosphate value of 0.27 mg/1. In his study, Kentucky Lake had a higher concentration of total phosphates than any other reservoir that he sampled. Phosphate concentrations decreased steadily from the Duck River embayment downstream and then levels stabilized. These higher phosphate values are apparently the result of waste discharges which drain into Duck River from the second largest phosphate mining complex in the United States. Apparently, Anderson Creek embayment is not affected by waste discharges this far from the point source. Nitrate concentrations in the embayment (0.014-0.31 ppm) are comparable to concentrations obtained in the main channel.

There was no correlation between variations of phytoplankton numbers and changes in chemical factors (nitrates, phosphates, and organics) as derived from the formula for correlation for raw data $r = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$

(Ferguson, 1971). Tucker (1957) reported that Prescott found positive correlation between phosphorus content and productivity of plankton in Iowa lakes. Hutchinson (1944) and Prescott (1939) found that nitrates have a controlling influence on phytoplankton productivity. Patrick (1948) believed that nitrogen-phosphorus ratio was the significant factor in the growth of freshwater diatoms.

Prescott (1962) stated there was a negative correlation of relatively high concentrations of nitrogen and phosphorus with periods of phytoplankton minima. When nitrates and phosphorus are low the phytoplankton population is high, these nutrients being consumed and stored in the organisms. When phytoplankton decreased through an accelerated death rate and disintegration occurs, the elements are released and their percentages in the lake rises. This condition mainly applies to large lakes with a closed ecosystem and summer stratification. Pennak (1946) found that in shallow bodies of water with essentially complete circulation throughout the year there was no appreciable accumulation of plant nutrients. He further stated that it could be postulated that mineralization and reutilization would occur more regularly and constantly and there would not be pronounced variation in nutrients. Kentucky Lake and more specifically Anderson and Vickers Creek embayments are open ecosystems and the recipients of allochthonous material, thus generalizations on the chemical parameters and the phytoplankton density are difficult to make.

Several qualitative changes in the phytoplankton were observed throughout the year. The most drastic of these changes was the increase of blue-greens during late summer. Pearsall (1932) contended that blue-green blooms developed in late summer when inorganic nutrients are

practically exhausted. Chemical determinations of the embayment did not reveal any significant nutrient depletion by the phytoplankton standing crop. Hutchinson (1944) stated that in analyzing known properties of planktonic alga, that clear-cut correlations between chemical conditions and the qualitative composition of the phytoplankton are not to be expected and that the physiological condition of a population and its relation to populations of other species are likely to explain many of the apparent inconsistencies. The increase in blue-greens was attributed to the higher water temperatures during the late summer.

Beginning in June and continuing through July, a decrease in numbers of diatoms was observed which has been correlated with silicates. Diatoms utilize this substance more rapidly than it is recycled, thus producing decline in diatom populations, (Hutchinson, 1944). The increase of diatoms beginning in August which was dominated by Melosira sp. can, in turn, be related to the replenishment of silica and not due to the resuspension of filaments. Lund (1954) attributed autumnal rises in populations of Melosira sp. to the resuspension of filaments that had fallen to the bottom in the spring and had survived the summer in a resting condition at the surface of the mud. Silica concentration should be examined in future studies.

Water temperature was a controlling factor in phytoplankton density. The high count in June was attributed to the yearly high in water temperature of approximately 30°C. Theoretically, the yearly low count should have been observed in the winter, yet it occurred in May. This condition was probably met since the next lowest total phytoplankton count occurred in December when water temperature approached 7°C.

In October, a definite increase in phytoplankton numbers was observed that could not be correlated with existing data. Possibly the difference in sampling times for water quality and plankton failed to reflect the local conditions at the time of the plankton sampling. Also some unmeasured parameter (wave, wind, etc.) may relate to this increase. There was a rapid drop in water temperature in October coupled with a decrease in light penetration. The October increase in numbers could possibly reflect a "semi"-fall pulse that is generally associated with thermally stratified lakes (Reid, 1961). Since no thermal stratification was observed a complete turnover was impossible, therefore, the pulse was drastically reduced. Following the October increase phytoplankton standing crop stabilized during the winter months. The low numbers were attributed to declining water temperatures. An increase in water temperature occurred in April and a slight increase in light penetration in early April allowed for more favorable growth conditions, thus contributing to the increased phytoplankton density at that time.

As might be expected, there was only slight differences in dissolved oxygen at all collecting sites except during the summer months. These differences are probably related to the temperature/pressure-dissolved gas relationship. Cold water has a greater capacity for gas than does warm water. This inverse relationship between the two is discussed by Hutchinson (1957). The yearly high and low values of dissolved oxygen in ppm were both near 100% saturation when compared on a nomagram for determining oxygen saturation values. Water temperatures and dissolved gases are subject to daily fluctuations due to changes in the air temperature, atmospheric pressure, and other environmental factors.

As mentioned, the data collected in August exhibited the greatest vertical profile in temperature. During this same month, the greatest range in free carbon dioxide was recorded. Concentrations as high as 12 ppm were recorded due to the presumed decreased amount of photosynthetic activity at the lower level collecting locations. The fact that samples were taken during daylight hours when photosynthesis was occurring may account for the variation in free carbon dioxide. Free carbon dioxide average values and ranges remained relatively stable during the colder months due to decreased phytoproductivity.

Changes in the free carbon dioxide during March through April, May through July, and again in September through October produced corresponding changes in the pH. This was possibly related to increased growth of phytoplankton during these times. Large populations of algae increase the pH of the water by removing carbon dioxide from the water during photosynthesis. As carbon dioxide dissolves in water, it enters a buffering system; fluctuating from the acidic carbonic acid through bicarbonate to the basic carbonate (Reid, 1961). The remaining average values could not be correlated with free carbon dioxide values, perhaps again due to only one sample being obtained monthly and daily differences.

Two parameters that are related to the optic properties of water are turbidity and light penetration. Turbidity is a measure of the suspended particulate matter due to allochthonous and autochthonous material. This suspended material has a direct relationship with the transmission of light, which is a factor in productivity (Corfitzen, 1939). Secchi disc reading is a measure of the transparency of water. Generally, higher turbidities result in less light penetration.

The highest Jackson Turbidity value was recorded in March (83 JTU) and at the same time the least amount of light penetration occurred according to Secchi Disc readings. This same type of trend was observed throughout the study. Light penetration steadily increased following the yearly low in March and simultaneously the phytoplankton standing crop increased in peak numbers in the summer. Maximum light penetration occurred in September, following the decline in phytoplankton counts. Corresponding low turbidity readings were recorded during the peak numbers of phytoplankton, thus allowing maximum light penetration. More frequent sampling of these two parameters is needed to adequately evaluate their correlation with phytoplankton numbers.

Two other variables possibly related to the productivity in a reservoir environment are water level fluctuations and water retention time. The first of these, water level fluctuations, was recorded and some correlation was noted with respect to light penetration. As mentioned, the yearly high in Jackson Turbidity value and the yearly low in Secchi Disc transparency were recorded in March. At the same time, summer pool conditions were first being approached resulting in increased lake elevations. Turbidity was increased by spring rains transporting allochthonous material into the Tennessee River and tributary streams and this material being retained in the reservoir. The maximum light penetration in September was associated with a decrease in the phytoplankton standing crop.

Perhaps one of the obscure limiting factors in the phytoproductivity is the short water retention time in Kentucky Lake. Kentucky Lake has the shortest water exchange rate (21 days) of the mainstream reservoirs in the Tennessee River. The rate for other storage impoundments in the

system ranges from 106 to 286 days. This water exchange rate is the hypothetical time required for a complete change of water volume in one reservoir. Long water retention time of storage impoundments provides more time for phytoplankton growth and it is believed that "old" water stimulates growth (Taylor, 1971). This same phenomenon may be true in embayments also, since the embayment is exposed to considerable mixing of water from the reservoir proper.

Except for the summer months, there was no correlation between the magnitude of algal and zooplankton populations. Reid (1961) stated that in ponds and lakes in temperate North America, phytoplankton volume exceeds that of zooplankton by 2-6 times. The relationship between phytoplankton and zooplankton pulses are not clear. Reid further stated that although it has been suggested that sudden, conspicuous increases in population density of zooplankton follow phytoplankton blooms, a number of studies have shown a lack of significant correlations between the two events. Reid (1961) indicates that at least in some lakes, food (phytoplankton) does not appear to constitute an important limiting factor with respect to the over-all zooplankton population.

The only relationship detected between zooplankton and phytoplankton was in May. The bloom of Bosmina sp. in May was attributed to the low numbers of phytoplankton.

Pennak (1946) reported in Colorado lakes, food of zooplankters consisted mainly of detritus, rather than algae. Pennak found very little evidence that the grazing of zooplankton had an important effect on the control of phytoplankton populations under natural conditions. Pennak also seldom found relationships between pulses of zooplankton

and phytoplankton.

The importance of macroinvertebrates in relation to the food chain link between phytoplankton and high animals cannot be overemphasized. Also, the presence of macroinvertebrates and sometimes their absence reflect some of the chemical characteristics of the body of water. Many macroinvertebrates have been categorized as to degree of pollution tolerance (Weber, 1973). Jonasson (1970) pointed out that competition between groups or species of bottom fauna seem to be confined mainly to oxygen requirements. Oxygen concentrations above limiting levels as established by the Federal Water Pollution Control Administration (1968) provided suitable habitat for most invertebrate life throughout the embayment.

Considerable seasonable variation was noted in the total numbers of all benthic organisms. This variation was primarily due to the seasonal variation of the insect populations, more specifically the dipterous larva population. Also the number of Ephemeroptera showed a particular pattern, a maximum in the winter and the minimum in the summer. The emergence of mayflies began in late June and continued through the summer. The same type of life history was seen by Swanson (1967) in a Missouri river reservoir. Fremling (1960) found that shallow bodies of water provide excellent habitat for burrowing mayflies. The greatest decline in total numbers was noted in August and was due to the low numbers of dipteran larvae and mayfly numphs at that time. The peak in total numbers of benthic organisms appeared in January and the same peak was seen in the number of dipteran larvae and mayfly nymphs. Generally, the three major dipterous families followed the same trend as the order Diptera did collectively. However, the family

Culicidae showed a decrease in August and September, while Ceratopogonidae and Chironomidae increased. This difference is believed to be related to the difference in the life cycle of the organisms, since a large emergence of Chaoborus sp. (Culicidae) was personally observed in late August.

The increased numbers of macroinvertebrates in the winter and the scarcity in the summer followed a definite seasonal abundance observed by Ball and Hayne (1952), Lindeman (1942), Eggleton (1931), and Sisk and Tubb (Unpublished Manuscript). The reduced numbers in spring and summer months were due to emergence of the insects having a terrestrial phase in their life cycle and the peaks resulted from the buildups of larvae during the non-emergence periods. The peak in September can be attributed to the buildup larval populations of different generations. There followed a decline in October which may be the last period of emergence prior to winter. Waters (1966) reported several generations per year in the life history of Baetis vagans (Ephemeroptera). Macon (1957) found that the number of generations per year to be determined by the environment.

The decline in total numbers of macroinvertebrates during the spring can be attributed to fish predation since the young of year are confined to the shallower portions of the reservoir (Beckman & Elrod, 1971). Mathur and Robbins (1971) found that chironomid larvae and pupae are the dominant insects eaten throughout the year by white crappie (Pomoxis annularis Rafinesque) in a Pennsylvanis reservoir and most were comsumed during April and May. Fish do exert a definite pressure on benthic populations, since Ball and Hayne (1952) found that when fish are removed that standing crops of benthic organisms increase.

The two methods of collecting macroinvertebrates revealed differences

in the taxa Ephemeroptera, Tricoptera, and Megaloptera. One specimen of Sialis sp. of the order Megaloptera was collected with the artificial substrates. Specimens of the mayfly genus Oreianthus and the caddis fly genus Polycentropus were collected in larger numbers with the Hester-Dendy samplers. Only one specimen of the genus Oreianthus was collected during the study utilizing the Ekman dredge. It is speculated that these different organisms were washed into the embayment from tributary streams and perhaps the artificial substrates provide a suitable habitat in the new environment.

In summary, water quality determinations demonstrate that no major pollution problem is present in the embayment. Levels of phosphates, nitrates, and organics are in low to moderate concentrations. The concentrations of dissolved oxygen is not a limiting factor, since stress and/or death does not occur in aquatic life until the dissolved oxygen is below 4 ppm, (F.W.P.C.A., 1968). The hydrogen ion concentration is between 5.0 and 9.0 that Doudoroff and Katz (1950) concluded was not lethal to most freshwater fishes. Alkalinity is within the normal range for surface waters (TVA, 1974). Specific conductance is less than 100 micromhos, the maximum value for most waters in Eastern United States (Brown, Skougstad, and Fishman, 1970). The total dissolved solid concentration derived from specific conductance (100 to 200 ppm) is within the range for most open basin lakes (Reid, 1961). Average monthly total phytoplankton counts in the embayment indicate low to moderate levels of enrichment. Both clean water and pollution tolerant genera occur in the embayment. The presence of clean water genera indicates no gross pollution, since these genera have narrower ranges of tolerance. The composition and distribution

of macroinvertebrates is such that it provides an adequate food supply for higher food chain organisms. The benthic fauna is characterized by pollution tolerate, facultative, and intolerant organisms according to Weber's (1973) classification. Again the presence of intolerant organisms indicates no major pollution problem in the embayment. This survey was designed to study some of the physical, chemical, and biological parameters of Anderson and Vickers Creek embayments. Infrequent sampling prevented demonstrating complex inter-relationships between limnological conditions and planktonic species. To characterize an aquatic environment based on its level of pollution, data from all three parameters are necessary. After evaluating all three parameters, it may be concluded that Anderson and Vickers Creek embayments are relatively free of gross organic and industrial pollutants. This survey provides established physical, chemical, and biological data which may be useful in detecting future changes in the environment before deleterious effects are produced.

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