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Onondaga Lake Management Conference

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Summary

Phytoplankton

Average density and biomass for the 1994 study period was 103,246 cells/mL ± 23,869 (mean ± S.E.) and 5.72 μg/mL ± 1.14 (mean ± S.E.). Based on phytoplankton biomass and the occurrence of indicator species, Onondaga Lake's pelagic waters would be classified as eutrophic. Abundance of phytoplankton, especially Cryptophyta, are greater than any previous year since 1987 with the exception of the Cyanobacteria. A "clear phase" in the lake was apparent in June, when phytoplankton abundance decreased from a high of over 250,000 cells/mL to less than 25 cells/mL in two weeks. Small, unicellular algae dominated prior to the clear phase while colonial and filamentous algae were dominant after the clear phase. An intense bloom of Cryptophyta (mostly Rhodomonas minuta and Cryptomonas erosa), which has not been observed previously, occurred in the spring. Abundance of Cyanobacteria is similar to 1990. However, the duration of the Cyanobacteria bloom has progressively increased from 1987: one month (August) in 1987, two months (August and September) in 1989, three months (July, August and September) in 1990, four to five months (April, June, July, August, and September) in 1994. The number of species has apparently increased with several new phytoplankton species having abundances in excess of 1000 cells/mL. The Euglenophyta are clearly not present in the lake and several filamentous or colonial species have become ubiquitous including: Oscillatoria limnetica, Synechococcus elongatus, Gomphosphaeria lacustris, Anabaena flos-aquae, and Sphaerocystis schroeteri.

Zooplankton

In 1994, 32 species representing 18 genera from the Calanoida, Cladocera, Cyclopoida, and Rotifera comprised the offshore zooplankton community of Onondaga Lake. Average density and biomass for the 1994 study period was 452.3 organisms/L ± 87.9 (mean ± S.E.) and 520 μg/L ± 114 (mean ± S.E.). Seasonally, multiple biomass peaks occurred: mid-July and mid-August. Both were caused by Cladocera: Daphnia galeata mendotae and D. pulex in mid-July and a second peak of D. galeata mendotae in mid-August. Dominant species in 1994 included: Daphnia galeata mendotae (Cladocera), Cyclops bicuspidatus thomasi (Cyclopoida), Diaptomus siciloides (Calanoida), and Keratella cochlearis (Rotifera).

The changing nature of the zooplankton community of Onondaga Lake was evident by differences between the 1994 data and that of earlier surveys. Although Diaptomus siciloides continues to be the dominant calanoid in 1994, the 1994 sampling revealed a cladoceran and copepod community that has changed from the 1987-89 period. During the 1987-1989 period only Cyclops vernalis was considered common, while by 1994, abundance of C. bicuspidatus thomasi (mean abundance =3.4/L), C. vernalis (mean abundance=2.8/L), and Mesocyclops edax (mean abundance=1.4/L) were high enough to be considered common species. Another interesting change is in the Cladocera populations. As in the 1987-89 period, Diaphanosoma leuchtenbergianum (mean abundance=1.6/L), Daphnia pulex (mean abundance=1.5/L), and Daphnia galeata mendotae (mean abundance=32.3/L) were common. However, two new species of Daphnia are present and are common, D. catawba and D. ambigua. Similar, to the 1986-89 period, Daphnia biomass represented 53.3% of the zooplankton biomass during the 1994 study period..

Benthic Macroinvertebrates

The composition of the macroinvertebrate community in 1994 represents a very different macroinvertebrate community from what was observed in 1989 offshore from the Allied Waste Beds. In particular, the relative abundance of the chironomids near the waste beds (Sites W-1 and W-2) has decreased from 94% in 1989 (mean of all sites) to 34% in 1994 (mean of all sites and seasons), while the relative abundance of the oligochaetes and gammarids have increased. Along with relative abundance, the diversity indices suggest that the invertebrate community near the old Allied Waste Bed site on the west side in 1994 are more comparable to the invertebrate community on the east side of the lake in 1989. Deformities in chironomids were observed in 7% of the individuals examined in June. Deformities in chironomids have been correlated with teratogens in a study from the Niagara River watershed.

Ichthyoplankton

Only one juvenile fish was observed offshore near the former Allied Waste Bed site on the west shore. Reproductive success of fish at this location appeared to be poor.

Introduction

Once a pristine recreational center and a productive fishery that supplied New York City markets with fresh fish, Onondaga Lake is now considered one of the most badly degraded bodies of water in the entire world (Sage 1993). The Onondaga Lake Management Conference was established to develop a comprehensive restoration, conservation, and management plan for Onondaga Lake that recommends priority corrective actions and a compliance schedule for cleanup of the lake. Biological assessment of the lake has been infrequent and concentrated on a few biological groups. This study either updates or establishes baseline characteristics for the following biological components of the Onondaga Lake ecosystem: phytoplankton, zooplankton, ichthyoplankton and macrobenthos.

Phytoplankton, which have short carbon turnover rates, are sensitive to water quality conditions and grazing by zooplankton, and thus respond rapidly to perturbations of the lake ecosystem. The determination of phytoplankton abundance and species composition is one method to trace long-term changes in lakes (Munawar and Munawar 1982, Makarewicz 1993a, Makarewicz and Bertram 1991). Similarly, whether aquatic ecosystems are perturbed by changes in the top predator fish that cascade down the food web or by nutrients or other stressors that are expressed from the first trophic level upward, the zooplankton are sensitive integrators of such changes (McNaught and Buzzard 1973). Zooplankton have also proved useful for complementing phytoplankton data to assess the effects of water quality (Gannon and Stemberger 1978) and fish populations on biota (e.g. Brooks and Dodson 1965). However, the large interannual variability in abundance of zooplankton requires long-term data sets to detect trends in abundance (Evans 1992). Thus, zooplankton have value as indicators of water quality and the structure of the biotic community. Similarly, presence or absence of ichthyoplankton document the reproductive health of the fishery, while the macrobenthic populations reflect long-term effects on organisms residing in the sediments. In this study, the 1994 phytoplankton, zooplankton, macrobenthic and ichthyoplankton data assemblages presented make it possible to examine the historical and seasonal relationships prevailing in Onondaga Lake and to compare them, where possible, to previous studies.

Methods

Onondaga Lake was sampled biweekly between 11 April and 10 October, 1994 (n = 14) (Table 1). Additional ichthyoplankton samples were taken weekly from 11 April to 30 June 1994 (n = 6 additional, n = 20 total) to provide seasonal estimates of ichthyoplankton during the likely period of highest production. All phytoplankton and zooplankton samples were taken from a single central station at the deepest point in the South Basin (Figure 1). Much of the previous limnological work on the lake has sampled at this site (UFI 1994). Additional sites were chosen to address specific issues. Macrobenthic invertebrate samples were taken at two sites: the South Basin and at the west shore near the former Allied Waste site (Fig. 1). Long mid-lake oblique ichthyoplankton tows were chosen to encompass all depths and both pelagic and littoral zones of the lake (Fig. 1). Specific sampling protocols for each target category follow.

ZOOPLANKTON

Zooplankton samples were collected biweekly at one site (South Basin) (Table 1 and Figure 1) using a 67 micron mesh Wisconsin net equipped with a General Oceanics flowmeter. Vertical tows from the bottom minus two meters were made. All samples were preserved with 4% buffered formalin. Three random 1 mL aliquots were drawn from the sample and placed in a Sedgewick-Rafter cell for evaluation. Identification and enumeration (Crustaceans and Rotifera) were performed using a phase contrast microscope at 100X for general identification and higher power for taxonomic verification. Enumeration of zooplankton followed Gannon (1971) while identification followed Stemberger (1979), Edmondson (1959), Brooks (1957) and Ruttner-Kolisko (1974).

The volume of each rotifer species were computed by using the geometrical shape that most closely resembled the species (Downing and Rigler 1984). For each sampling date, the length of at least 20 specimens of each rotifer species was measured. Assuming a specific gravity of one, volume was converted to fresh weight and to dry weight assuming a ratio of dry to wet weight of 0.1 (Doohan 1973) for all rotifer species except Asplanchna spp. A dry weight/wet weight ratio of 0.039 was used for Asplanchna spp. (Dumont et al. 1975).

Because of the considerable variability in length and thus weight in the Crustacea, the dry weights of Crustacea were calculated using length-weight relationships (Downing and Rigler

1984, Makarewicz and Likens 1979). Average length of crustaceans (maximum of 20 for each station) was determined for each sampling date. The weight of the Copepoda nauplii followed Hawkins and Evans (1979).

PHYTOPLANKTON

Phytoplankton were collected biweekly by compositing samples from 0m, 3m, 6m and 9m (depth from the surface) to form a 100 mL composite sample at the South Basin site (Table 1 and Figure 1) and fixed with gluteraldehyde (final concentration of 0.25 to 0.5%). Three permanent mount slides were made of each sample (Crumpton 1987). A minimum of 15 fields and a minimum of 300 cells total were counted at 200X. Small species (< 7 µm) were counted at 400X (minimum of 15 fields and 100 cells). The whole slide was scanned for large species (400 - 1000 µm). Counting was deemed complete when the standard error of the mean total number of cells is less than 10%.

The cell volume of each species was computed by applying average dimensions for each species from each date to the geometrical shape that most closely resembled the species form (e.g., sphere, cylinder, prolate spheroid, etc.). At least 10 specimens of each species were measured from each sample for the cell volume calculation. When fewer than 10 specimens were present, they were measured as they occurred. For most organisms, the measurements were taken from the outside wall to outside wall. The dimensions of the protoplast were measured for loricated forms, while the dimensions of individual cells were measured for filaments and colonial forms. Biovolume ($\mu m^3/L$) was converted to biomass (mg/m^3) assuming a specific gravity of 1.0 for all phytoplankton ($mm^3/L=mg/m^3$) (Willen 1959, Nauwerck 1963).

ICHTHYOPLANKTON

Ichthyoplankton were collected biweekly, except from April 11 to June 30 when ichthyoplankton samples were taken weekly, using a Miller High Speed Sampler (5 minute tows) in a series of five oblique tows along a north/south transect in mid-lake (Table 1 and Figure 1). An additional nearshore five minute tow was initiated on 18 April 1994 to ensure that the littoral zone was adequately sampled. A net mesh of 0.5 mm and a towing speed of approximately 2 m/sec (7.2 km/hr) were used. Samples were fixed with a 4% formalin solution buffered to a pH of

6.5 to 7.5 (Nielsen and Johnson 1983). The entire sample for ichthyoplankton was counted and identified.

MACROBENTHOS

Benthic samples were taken on 16 May, 18 July and 10 October 1994 (Table 1) at the South Basin site, in the hypolimnion, and near the Allied Waste Bed site on the west shore, an epilimnetic site. Three replicates were taken at each site (total of 18 for the project) using a Ponar Dredge. Dredge samples were sieved (U.S. Standard No. 30 - 0.595 mm) in the field to remove sediments and non-biota (APHA 1992). Samples were preserved in 95% ethanol. The entire sample for macrobenthos was counted and identified.

FIELD SAMPLING

The positioning of the research vessel was accomplished by determination of depth with a fathometer and the use of landmarks and GPS (Global Positioning System). Physical lake station observations (temperature, conductivity, secchi disk depth, air temperature, wind speed and direction, % cloud cover and wave height) were recorded on the field data sheet on site.

Several precautions were undertaken to ensure sample integrity. All containers were pre-coded to ensure exact sample identification, cleaned prior to sampling and remained sealed until needed. All samplers were rinsed on site prior to use. Laboratory glassware and equipment were cleaned and calibrated routinely. Table 2 summarizes the field sampling effort for Onondaga Lake.

SAMPLE CUSTODY

A chain of custody procedure was followed for this project. Prior to arrival on station, all sample containers were labeled. The Quality Assurance Officer designated sample custodians in the field and they verified that all appropriate samples were collected and preserved properly. All bench sheets were under the control of the Quality Assurance Officer and were collected and reviewed on a daily basis.

QA/QC

In general, plankton sampling, identification, enumeration and QA/QC procedures, including precision goals, followed the protocol set up by the United States Environmental Protection Agency's Great Lakes National Program Office for the Great Lakes Surveillance Program (e.g. Makarewicz 1987, Makarewicz 1988, Makarewicz and Bertram 1991, Makarewicz et al. 1991, Makarewicz 1993b).

$$\text{RPD}\ (\%) = \frac{(x_1 - x_2)}{(x_1 + x_2)/2} \times 100$$

Precision for phytoplankton and zooplankton are in units of Relative Percent Difference (RPD) that are based on the number of organisms counted in duplicate determinations:

PHYTOPLANKTON

Replicate identifications and enumeration were made on every 5th sample and compared for consistency in species nomenclature and abundance. The precision goals of various groups of algae in the replicated samples are listed below:

	RPD
Total blue-green algae	110%
Total green algae	130%
Total flagellates	90%
Total other algae	70%
Total centric diatoms	240%
Total pennate diatoms	225%
Total algae	66%

If values are outside the precision goal, the count was rejected and the samples recounted. Actual relative percent differences (RPD) were within the precision goals for all groups (Table 3).

ZOOPLANKTON

Replicate identifications were made by different analysts on every 5th sample and compared for consistency in species nomenclature and abundance. The precision goals of various groups of zooplankton in the replicated counts are listed below:

	RPD
Total immatue Copepods	± 15%
Total mature Copepods	± 15%
Total Cladocera	± 15%
Total Rotifera	± 15%
Total Zooplankton	± 60%

Actual relative percent differences (RPD) were within the precision goals except in one case. In May of 1994, the RPD for Cladocera was 200% and is attributed to observing only two Bosmina longirostris in one replicate and none in the other (Table 4).

ICHTHYOPLANKTON AND MACROBENTHOS

The entire sample for ichthyoplankton and macrobenthos were counted and identified.

VOUCHER SPECIMENS

Voucher specimens for benthic invertebrates and a permanent slide of each sampling day for phytoplankton are on record with the Onondaga Lake Management Conference. Photographs of common phytoplankton and zooplankton species, in lieu of voucher specimens, are also on record with the Onondaga Lake Management Conference.

Results and Discussion

Phytoplankton

Annual Abundance and Biomass of Major Algal Groups

Transparency, water temperature, and conductivity of the surface waters of Onondaga Lake are presented in Table 5. In 1994, 89 species representing 53 genera comprised the phytoplankton community of Onondaga Lake. Common species were arbitrarily defined as having an abundance of ≥0.5% of the total cells or ≥0.5% of the total biomass. 17 common species and varieties accounted for 97.9% of the total abundance and 95.1% of the total biomass over the study period (Table 6). Twelve species of the Cyanophyta (Cyanobacteria) accounted for over 62% the phytoplankton cell abundance (average for the study period=63,977 cells/mL) and 40% of the phytoplankton biomass (2.26 µg/mL) (Table 7). The Chlorophyta (39 species, 44% of all taxa identified) followed by the Bacillariophyta (25 species, 28% of all taxa identified), however, contained the largest number of species (Table 7). Few species of Pyrrophyta were present, but their relative biomass (mean = 23%) was the second highest (Table 7). Unidentified microflagellates accounted for 23.4% of the total cells observed, but only 3.7% of the biomass. Average density and biomass for 1994 study period was 103,246 cells/mL ± 23,869 (mean ± S.E.) and 5.72 µg/mL ± 1.14 (mean ± S.E.). Phytoplankton abundance and biomass is not reported in the available literature for the 1986-90 period. However, graphical data are available (Figs. 2 and 3) that suggest abundance in 1994 was considerably higher than 1990 and was somewhat higher as compared to the 1986-89 period for the cryptophytes, diatoms, and chlorophytes. Cyanobacteria abundance was similar to 1990 (Fig. 4).

Dominant and Indicator Species

In 1994, the dominant phytoplankton from each major group were Rhodomonas minuta (Cryptophyta), Aphanizomenon flos-aquae and Anabaena flos-aquae (Cyanobacteria), Sphaerocystis schroeteri (Chlorophyta), Ceratium hirundinella (Pyrrophyta) and Diatoma vulgaris, Fragilaria crotonensis, and Stephanodiscus hantzschii (Bacillariophyta)(Table 6). These eight species represented 83.2% and 73.7% of the phytoplankton biomass and abundance, respectively.

Diatoms are particularly useful as indicator organisms associated with trophic state of a lake (Stoermer 1978, Makarewicz 1993a). Of the 25 diatom species observed in Onondaga Lake, seven are considered indicator species (Tarapachak and Stoermer 1976). Stephanodiscus hantzschii (a co-dominant diatom), S. niagarae, Fragilaria capucina and F. construens are classified as eutrophic species. Fragilaria crotonensis, another co-dominant diatom in Onondaga Lake, Asterionella formosa and Tabellaria fenestrata are mesotrophic species tolerant of nutrient enrichment. Along with the pre-dominance of eutrophic indicator species of the Cyanobacteria (Aphanizomenon flos-aquae and Anabaena flos-aquae) that account for 60.9% of the phytoplankton abundance, analysis of indicator species would strongly suggest that Onondaga Lake is still eutrophic. Similarly, using the average community phytoplankton biomass as an indicator of trophic status (Munawar and Munawar 1982), Onondaga Lake's pelagic waters (1994 mean= 5.72 g/m^3) would be classified as eutrophic (4.0-8.0 g/m^3).

Seasonal Distribution

Considering total abundance of the phytoplankton community, the seasonal distribution of phytoplankton was basically bimodal with a spring bloom consisting mainly of Cryptophyta and unidentified microflagellates and a late summer peak consisting of Cyanobacteria (Fig. 5). As in previous years (UFI 1994), a "clear phase" was apparent in June, when phytoplankton abundance decreased from a high of over 250,000 cells/mL to less than 25 cells/mL in two weeks. Prior to the clear phase, small (< 10-20 µm), unicellular alage predominated in the water column (Fig. 6). After the clear phase, filamentous and colonial algae predominated in the lake.

A seasonal succession of phytoplankton did occur in Onondaga Lake in 1994 (Fig. 7 and 8). Phytoplankton populations were low in April. In May a bloom of diatoms, predominantly Stephanodiscus hantzschii (Fig. 9), reached a maximum of ~ 5,700/mL before decreasing by early June. The Cryptophyta, mostly Rhodomonas minuta and Cryptomonas erosa, peaked quickly in early June (~100,000 cells/mL) (Figs. 7 and 10) before disappearing by late June. The Chlorophyta also bloomed in late June (~6,000 cells/mL) but remained at this level throughout the month of June before slowly decreasing through July and August (Fig. 7). As the Chlorophyta decreased, a major bloom of Cyanobacteria Aphanizomenon flos-aquae (~220,000/mL) and Anabaena flos-aquae (~100,000/ml) occurred in July (Figs. 7 and 11). The Pyrrophyta, especially Ceratium hirundinella, become dominant in the lake during September on a biomass basis (Figs. 8 and 12). By mid-October, the diatoms and green algae increased in abundance. Seasonal distribution of common species are presented in Figures 9-14.

Historical Comparisons - Community Trends Historical Review

An excellent review of previous work on the phytoplankton of Onondaga Lake is presented in The State of Onondaga Lake (UFI 1994). The first regular annual phytoplankton sampling program began in 1968 (Onondaga County 1971). Prior investigations were limited in the number of samples taken and identification was usually to the genus level (Kingsbury 1971) except for the diatoms which were identified to the species level (Hohn 1951). The first report of a summer bloom was in 1962 and this consisted mainly of euglenoids, diatoms and green algae (Chlamydomonas, Chlorella, Scenedesmus) (Compton et al. 1966, Moore 1967, Jackson 1968, 1969). In 1968, sampling at the north and south deep water sites demonstrated a succession of diatoms dominant in the spring, green algae in early summer and cyanobacteria in late summer and fall. Weekly sampling in 1969 found diatoms and Chlamydomonas dominant in the spring and chlorococcalean green algae common in early summer. Cyanobacteria blooms were frequent from late summer to early fall. The Onondaga Lake Study (Onondaga County 1971) concluded that the phytoplankton in the lake were typical for eutrophic conditions and the composition of less abundant species tended to be representative of marine algae (Kingsbury and Sze 1971).

This seasonal pattern continued in 1970 and 1971 and annual sampling took place over the period of 1972-1978 (Sze 1972, 1975, 1980, Sze and Kingsbury 1972). A major observation during the 1972-78 period was the absence of late summer blooms of Cyanobacteria (UFI 1994). Diatoms and flagellated green algae were still dominant in the spring and chlorococcalean green algae were abundant from summer into fall. Devan and Effler (1984) attribute the disappearance of the Cyanobacteria to the reduction in phosphorus loading over that interval.

From 1978 to 1990, data on the phytoplankton were collected yearly and recently published in The State of Onondaga Lake report (UFI 1994) where they are summarized and discussed in some detail. The following comments are extracted from this report:

Over the interval of 1978 - 1982, the seasonal patterns observed in the previous six years continued. Also, centric diatoms decreased in importance over this period. For the years 1983 to 1986, increased variability in phytoplankton composition was observed and overall abundance declined in late summer and early fall. During the summer of 1986 an intense bloom of Binuclearia began in late July and continued into September with a peak in August. From 1987 to 1990 eukaryotic phytoplankton declined and the abundance of Cyanobacteria increased significantly in 1990. Flagellated green algae and cryptomonads were common in spring; flagellates and chlorococcalean green algae dominated during summer and fall. Cyanobacteria showed a steady increase over this period and Aphanizomenon flos-aquae was common in the summer of 1990.

Over the 13 year period from 1978 to 1990 there was a steady decline of spring diatoms and reduced frequency of occurrence during summer and fall over the 1986 to 1990 interval. While the intensity of blooms of eukaryotic phytoplankton declined over the 1978 to 1990 interval, cyanobacteria increased in 1989 and 1990 with the return of Aphanizomenon flos-aquae.

This shift in the phytoplankton community was not thought to be the result of changes in nutrient concentrations but may have been the result of a selection process initiated by the return of efficient zooplankton grazers in the late 1980's (UFI 1994).

Comparing the 1994 phytoplankton assemblage at the species level to historical records is difficult because of the lack of historical quantitative data on species in the literature with the exception of Table 8 from the State of Onondaga Lake report (UFI 1994). For the 1973 to 1989 period, phytoplankton species observed with an abundance over 1000 cells/mL are separated from rarer species. Whether 1000 cells/mL represents the average number for a period or any occurrence where density exceeds 1000 cells/mL is not clear. In this report, we have assumed that greater than 1000 cells/mL refers to any occurrence above this level.

Scanning Table 8, it is readily apparent that more species of phytoplankton were observed in 1994 than in any other previous year since 1978. Are these real changes or simply a more thorough job with identification? It is a little of both. For example, Anabaena sp. and Oscillatoria sp. are listed as present or having an abundance in excess of 1000 cells/mL from 1981 onward. In 1994, both genera are present but have been identified to species as Anabaena flos-aquae and Oscillatoria limnetica. There are some entities that were not observed previous to 1994, such as the Chrysophyta and Rhodomonas minuta in the Cryptophyta that probably represent differences in opinion and preservation and counting techniques. Prior to 1990, Chroomonas sp. is listed as being dominant; yet in 1994 we did not observe it. The difference between the two species is a gullet that is not easily seen. Generally, Chroomonas has a blue color which we did not observe. Thus the identification as Rhodomonas. The chlorophyte Platymonas observed prior to 1990 could be the species of Carteria observed in 1994. Coelospharium (prevalent prior to 1990) could be confused with Gomphosphaeria (prevalent in 1994). Appendix 5 has some notes discussing possible areas of confusion. In addition, Table 8 has several catch all categories, such as, "Other Centric Diatoms", "Other Pennate Diatoms", "Other Dinoflagellates", "Non-motile Blue Greens", etc. For 1994, we have not generally included those categories and identified organisms to species where possible. Thus, there are more species listed on Table 8.

The following changes in species composition are suggested from 1986-90 to 1994 (Table 8). Diversity, as number of species, of the green algae has increased with several species

(Ankistrodesmus falcatus, Chlamydomonas globosa, Dicthosphaerium pulchellum, Pediastrum duplex, Scenedesmus sp., S. dimorphus, Sphaerocystis schroeteri, Ulothrix sp.) of chlorophytes having abundance above 1000 cells/mL. The cryptophyte, Cryptomonas erosa, continues to be prevalent. Several new species of Cryptomonas were observed for the first time in 1994. The occurrence and prevalence of Rhodomonas minuta in 1994 and its complete absence prior to 1994 and the inverse abundance of another cryptophyte, Chroomonas sp. suggest a problem with identification. To resolve this issue, specimens from prior to 1990 need to be examined. Compared to the 1978-90 period, diversity of the Cyanobacteria has increased with several species (Anabaena flos-aquae, Aphanizomenon flos-aquae, Aphanocapsa elachista, Gomphosphaeria lacustris, Oscillatoria limnetica, Synechococcus elongatus) having abundances greater than 1000 cells/mL. The easily identifiable Ceratium hirundinella continues to be present and Gymnodinium sp. was observed for the first time in 1994. Similarly, the readily identifiable Euglenophyta were not observed in the lake in 1994, as in 1989 and 1990.

In summary, abundance of phytoplankton, especially Cryptophyta, are greater than any previous year since 1987 (Figs. 2 and 3) with the exception of the Cyanobacteria (Fig. 4). A "clear phase" was apparent in June, when phytoplankton abundance decreased from a high of over 250,000 cells/mL to less than 25 cells/mL in two weeks. Small, unicellular algae dominated prior to the clear phase while colonial and filamentous algae were dominant after. An intense bloom of Cryptophyta (mostly Rhodomonas minuta and Cryptomonas erosa) occurred in the spring which has not been observed previously in Onondaga Lake. Abundance of Cyanobacteria is similar to 1990 (Figure 4). However, the duration of the Cyanobacteria bloom has progressively increased from 1987: one month (August) in 1987, two months (August and September) in 1989, three months (July, August and September) in 1990, four to five months (April, June, July, August, and September) in 1994. The number of species has apparently increased with several new phytoplankton species having abundances in excess of 1000 cells/mL. The Euglenophyta are clearly not present in the lake and several filamentous or colonial species have become ubiquitous in the lake including: Oscillatoria limnetica, Synechococcus elongatus, Gomphosphaeria lacustris, Anabaena flos-aquae, and Sphaerocystis schroeteri.

Zooplankton

Mean Annual Abundance and Biomass of Zooplankton Groups

In 1994, 32 species representing 18 genera from the Calanoida, Cladocera, Cyclopoida, and Rotifera comprised the offshore zooplankton community of Onondaga Lake. Species were arbitrarily classified as common if they accounted for ≥0.1% of the total abundance or ≥1.0% of the total biomass, with the exception of rotifers. Rotifer species were considered common if they accounted for ≥1.0% of the total abundance. Eighteen common species plus their juvenile stages accounted for 99.7% of the total biomass and 98.8% of the total abundance (Table 9). The Rotifera contained the largest number of species (18) and accounted for the highest relative abundance (40.5%, Table 9). The Calanoida, Cyclopoida and the nauplius stage of the Copepoda represented 45.1% of the total zooplankton abundance (Table 9). The Cladocera (57.3%) followed by the Cyclopoida (16.3%) and the Calanoida (13.2%) contributed the most biomass to the zooplankton community, while the Rotifera represented only 1.3% of the zooplankton biomass over the study period. Average density and biomass for the 1994 study period was 452.3 organisms/L ± 87.9 (mean ± S.E.) and 520 µg/L ± 114 (mean ± S.E.). In comparison to lakes worldwide, a mean biomass of 520 µg/L ranks in the range of biomass for eutrophic lakes (Schindler and Noven 1971).

Seasonal and Historical Changes in Community Biomass and Composition

Seasonally, multiple biomass peaks are common in Onondaga Lake (UFI 1994). In 1994, two major peaks in biomass occurred: mid-July and mid-August (Fig. 15). Both were caused by Cladocera: Daphnia galeata mendotae, D. pulex and D. catawba in mid-July and a second peak of D. galeata mendotae in mid-August (Fig. 16). However, the cladoceran community reached its greatest length in late May prior to the "clear phase" (Fig. 17). Rotifers were significant numerically, but not on a biomass basis in the spring (Figs. 18 and 19). Their high abundances, but low individual weight result in a low overall biomass for rotifers. Zooplankton biomass has varied considerably over the past 10 years with no obvious pattern (Fig. 20).

Community composition has varied greatly over the 1969-1994 period. The zooplankton community in 1969 was dominated by rotifers through May, shifted to cyclopoids in early June and then to cladocerans through August (Waterman 1971). By 1978, rotifers were still dominant in the spring, but Cladocera were sharply reduced (Meyer and Effler 1980, UFI 1994). Cyclopoid copepods dominated the biomass. Dominance by cyclopoid copepods was even more pronounced from 1979 to 1981 (UFI 1994). Zooplankton community composition in 1985 and 1986 was similar to that recorded in 1979-1981 (UFI 1994). Beginning in 1987, zooplankton community composition changed dramatically through 1989. Cladocera and calanoid copepods increasingly dominated biomass (UFI 1994). Cyclopoid copepods were dominant in the spring of 1987 and 1988 but were replaced by calanoid copepods and cladocerans by mid-July in 1987 and by mid-June in 1988 (UFI 1994). Cladocera and calanoid copepods dominated zooplankton biomass throughout much of 1989 (UFI 1994). A similar situation was observed in 1994. Considering biomass in 1994, cyclopoid copepods were dominant in May followed by the Cladocera through October (Fig. 19). Calanoid copepods were the co-dominant group from June through August. During July and August, the cladocerans accounted for 40.4% of the zooplankton biomass. On a numerical basis, rotifers were the dominant group in the spring (Fig. 18). Seasonal distribution of common zooplankton species are presented in Figures 21-25

Historical Changes in Species Composition

Several intensive zooplankton studies of the pelagic waters of Onondaga Lake do exist. Waterman (1971) and Meyer and Effler (1980) sampled Crustacea and Rotifera several times a week with a Wisconsin net (10m to the surface) equipped with a number 20 (73µm) mesh net from April through October in 1969 and 1978. Only weekly summaries were reported as the average of the samples at both the deepest point in the north and south basins. The sampling program established in 1978 was continued at the south basin station through 1981, renewed in 1985, and continued through 1989 (UFI 1994). The frequency of sampling varied somewhat between years but results are generally available for weekly intervals from May through August of each year except for 1985 and 1987, when samples were collected monthly and biweekly, respectively. Previous zooplankton sampling is directly comparable to the current results presented here.

An excellent review of the zooplankton work conducted on Onondaga Lake is presented in the State of Onondaga Lake (UFI 1994). In 1978, fifteen species were identified with rotifers dominating through May, cyclopoids (Cyclops vernalis) in June and cladocerans (Daphnia pulex,

D. similis) late June through August (Waterman 1971). The identification of D. similis is thought to be a misidentification of D. pulex or D. pulicaria (UFI 1994).

Meyer and Effler (1980) conducted the next study in 1978 and reported community changes since 1969. They found that there was no significant difference in zooplankton assemblages between the north and south basins and collections were made only in the south basin of the lake in subsequent studies during 1979, 1980 and 1981 (UUI 1994). Rotifers dominated in the spring of 1978 but were important only in July of 1979 - 1981. Cladocera were significantly reduced from approximately 10/L in 1969 to 1/L in 1978 and small Cladocera were present during July and August of 1979 - 1981, but did not dominate total zooplankton biomass. Cyclopoid copepods (Cyclops vernalis) dominated in most samples taken in 1978 through 1981. The mean summer zooplankton biomass varied widely over the four years (625 µg/L 1978, 1340 µg/L 1979, 220 µg/L 1980 and 420 µg/L 1981).

In 1985, limited sampling found a zooplankton community similar to that observed in the 1979-1981 period. Samples taken in 1986 produced the same results.

The zooplankton community changed significantly over the interval of 1987 - 1989. Cladocera (Daphnia galeata, D. pulex (pulicaria), Diaphanosoma leuchtenbergianum, Bosmina longirostris) and the calanoid copepod, Diaptomus siciloides, dominated with the biomass of Daphnia spp. increasing from less than 1% of the total zooplankton biomass in 1986 to 57% in 1989 (39% in 1987 and 43% in 1988).

Dominant species in 1994 included: Daphnia galeata mendotae (Cladocera), Cyclops bicuspidatus thomasi (Cyclopoida), Diaptomus siciloides (Calanoida), and Keratella cochlearis (Rotifera) (Table 9). The changing nature of the zooplankton community of Onondaga Lake was evident by differences between our data for 1994 and that of earlier surveys (Table 10). Although Diaptomus siciloides continues to be the dominant calanoid in 1994, the 1994 sampling revealed a cladoceran and copepod community that has changed from the 1986-89 period. During the 1986-1989 period only Cyclops vernalis was considered common (UFI 1994), while by 1994, abundances of C. bicuspidatus thomasi (mean abundance =3.4/L), C. vernalis (mean abundance=2.8/L), and Mesocyclops edax (mean abundance=1.4/L) were sufficient to be considered common species (Tables 9 and 10).

Another interesting change is in the Cladocera populations. As in 1986-89 period, Diaphanosoma leuchtenbergianum (mean abundance=1.6/L), Daphnia pulex/pulicaria (mean abundance=1.5/L), and Daphnia galeata mendotae (mean abundance=36.3/L) were common (Tables 9 and 10). However, two new species of Daphnia are present and are common, D. catawba and D. ambigua. Abundance of D. cawtaba peaked in June (Fig. 16) at 27.2 individuals/L while abundance of D. ambigua reached a maximum abundance of 4.3 individuals/L in July (Fig. 16). Similar, to the 1986-89 period, Daphnia biomass represented 53.3% of the zooplankton biomass in 1994.

Considerable discussion has taken palce on the identification of the Daphnia pulex/pulicaria complex (UFI 1994). Daphnia pulex was reported from Onondaga Lake in 1969 (Waterman 1971) and 1978 (Meyer and Effler 1980) but not in subsequent collections (UFI 1994). However, recent determinations have indicated that D. pulicaria were present in the 1986-89 interval and that earlier reports of D. pulex should be considered D. pulicaria (UFI 1994). Our work suggests that both entities are present. Reticulation differences in the area between the ocellus and the ventral margins of the rostrum are diagnostic for the pulex/pulicaria complex (Brandlova et al. 1972). Reticulation is enlongated for D. pulicaria and is as uniform polygons for D. pulex. Both types exist concurrently in Ononadaga Lake in 1994. Since these differences are not easily distinquished in routine enumeration, we have listed them as a complex of Daphnia pulex/pulicaria. From a functional point of view, these entities are probably not different.

In the spring of 1988, 1989 and 1994 (Fig. 18), rotifers were dominant as they may have been in 1987 when sampling did not begin until June (UFI 1994). The dominant rotifer species in the pelagic waters of Onondaga Lake during 1994 included Keratella cochlearis (18.0% of total abundance) and K. quadrata (8.7% of total abundance); two species that were also reported as dominant or common in the 1986-89 period (Table 10). Other common species in 1994 include in descending order of relative abundance: Pompholyx sulcata (6.7%), Filinia terminalis (3.4%), Brachionus angularis (1.6%), Brachnious calyciflorus (1.1%), and Polyarthra vulgaris (1.0%) (Table 9).

Six rotifer species (Kellicottia longispina, Kellicottia bostoniensis, Polyarthra remata, Brachionus variabilis, Filinia longiseta, and Keratella testudo) listed as common in the 1986-89 period were either not observed or considered to be rare in 1994 (Table 10). Some of these differences may be related to problems in taxonomic identification. For example, the difference between P. vulgaris (common in 1994) and P. remata (common from 1986-89) is in a difficult to see ventral finlet. Nevertheless, the distinguishing characteristics of P. dolichoptera and P. euryptera, first observed in 1994, are fairly evident. The absence of any of the easily distinquished Kellicottia species in 1994, compared to the 1986-89 period, is not due to problems in identification or collection. They were simply not present. Similarly, Notholca squamula (common from 1986-89) and N. acuminata (common in 1994) are easily distinqished by the presence or absence of the broad spine-like extension of the lorica. Also, Filinia longiseta observed in the 1986-89 period has a relatively long lateral bristle as compared to the caudal bristle (ratio of lateral bristle to caudal bristle is greater than 1.8) that makes it readily identifiable from the common Filinia terminalis in 1994. Keratella testudo was listed as a common species during the 1986-89 period but not observed in 1994. K. testudo, which has short or absent caudal spines, is readily distinguishable from K. quadrata, which has long caudal spines. Pompholyx sulcata and Hexarthra mira, two other readily identifiable genera, have not been reported previously in Onondaga Lake (Table 10).

Benthic Macroinvertebrates

Prior to 1989, little data existed on the macroinvertebrate community of Onondaga Lake (UFI 1994). In 1969 a very limited sampling of the benthos was initiated. No detailed identification or quantification was published. Chironomid larvae and ostracods were mentioned as being present and chironomids were found in fish stomachs collected in May of that year (Onondaga County 1971). A more detailed study in June of 1989 collected samples at four sites. Chironomids dominated the community, especially at the two sites on the west shore near the Allied Waste Beds (96.3% and 91.5% of total density) (UFI 1994). Oligochaetes and amphipods made up the remainder of the benthic macroinvertebrate community and were more common on the east shore near the park and marina.

In 1994, seasonal samples (May July, October) were taken in the South Basin site and at the Allied Waste Bed sites (Fig. 1). The occurrence of various organic and inorganic chemicals in the sediments and the anaerobic conditions of the sediments and the overlying waters (UFI 1994) are undoubtedly the likely reasons why no organisms were observed at the deepest point of the lake in May, July or October.

At the waste bed sites in 1994, a seasonal succession in relative abundance occurred. Oligochaetes (56%) are the dominant group in the spring followed by the chironomids (31%) (Table 11). In July, the Gammaridae are overwhelmingly dominant (65%) with the chironomids accounting for 20% of the total abundance. In October, the chironomids (52%) and oligochaetes (34%) were predominant (Table 11). The community composition in 1994 represents a very different macroinvertebrate community from what was observed in 1989 near the waste beds. In particular, the relative abundance of the chironomids near the waste beds (Sites W-1 and W-2) has decreased from 94% in 1989 (mean of all sites) to 34% in 1994 (mean of all sites and seasons), while the relative abundance of the oligochaetes and gammarids have increased (Fig. 26). In particular, abundance of Chironomus sp. and Glyptotendipes sp. declined from over 6,000 and over 1,000/m^2, respectively in 1989, to less than 300 and 200/m^2, respectively, in 1994 (Table 11). However, Chironimus sp. still was the dominant species of the Chironomidae in 1994 (36 to 54% of the total abundance in 1994 compared 22 to 42% in 1989) (Table 11 and Fig. 27). Although abundance of Glyptotendipes sp. has decreased from 1989 (Table 11), relative abundance or importance within the chironomid community increased from ~20% in 1989 to ~ 48% in 1994 (Fig. 27). Cricotopus sp., which constituted 34% to 45% of the community in 1989 were not observed in 1994. The loss of this genus from the community appears to be real in that the lack of well-developed ventromental plates or possession of striated ventromental plates without striations readily separates this particular genus with the other genera of Chironomidae observed in this study. Considering relative abundance, the 1994 May and October macroinvertebrate community near the waste beds more closely resemble the macroinvertebrate community from the east side of the lake in 1989 (Table 11). However, abundance is considerably lower in 1994 than in 1989 for the Chironomidae (Table 11).

Diversity indices (Shannon-Weiner) were much lower near the west shore (0.18 and 0.35), adjacent to the Allied Waste Bed sites, than at the eastern sites (0.84 and 0.90) in 1989

(UFI 1994)(Table 12). Reasons for the differences between the west and east sites are believed to be related to the higher degradation of the benthos on the western side due to industrial wastes (UFI 1994). In 1994, the diversity indices averaged around 0.72 (range= 0.65 to 0.75) at the Allied Waste Bed sites (Table 12). Along with relative abundance, the diversity indices suggest that the invertebrate community at the Allied Waste Bed site on the west side in 1994 is more comparable to the invertebrate community on the east side of the lake in 1989. This may suggest an improvement in benthic habitat at this location.

Toxic Effects of Contaminant Sediments using Biological Indicators

Increasing attention has been focused on the responses of affected organisms as general indicators of environmental degradation. Several studies have demonstrated the connection between chemical contamination of several chironomid genera, and the apparent lack of any influence of nutrient loading or thermal discharge (Diggens and Stewart 1993). Because the chironomid larvae are in close contact with the sediments, they are vulnerable to teratogens in the benthos. For example, contaminated sediments have been shown to correlate with mentum deformities of chironomids in the Niagara River watershed (Dickman et al. 1992). Thus, deformities in chironomid larvae can and have become a tool for evaluating the presence of teratogens in aquatic systems. Because the larvae are benthic in nature, they are localized to a given area and thus provide some indication of the spatial distribution of chemical effects on the biota of a lake or stream.

In polluted sediments from the Niagara River watershed, Dickman et al. (1992) found that 14% of the several hundred individuals collected had deformities. This was attributed to teratogens present in the sediments. In June in Onondaga Lake, we examined the mentum of several chironomid individuals. One clear deformity and one possible deformity was observed in the 31 specimens observed or approximately 7% of the individuals have deformities. Obviously our sample size was too small to develop any valid rate of incidence. But it is an interesting result that suggests the teratogens in Onondaga Lake sediments are affecting biota. This avenue of research should be considered further because it does not only identify problems but can demonstrate remediation with a decreased incidence of abnormal menta.

Ichthyoplankton

By the time The New York State Biological Survey (Greeley 1928) conducted a fishery study of Onondaga Lake in 1927, significant changes had already occurred and only 10 species were identified in the lake. Before 1900, historical accounts report that Cisco (Coregonus artedii) and Atlantic salmon (Salmo salar) were abundant, but were gone by 1927. A survey in 1946 (Stone and Pasko 1946) observed 14 species and found carp (Cyprinus carpio) to be 93% of the catch. In a 1969 survey, Noble and Forney (1971) found 15 species. The most significant change was the appearance of white perch (Morone americana) (Murphy 1978). Noble and Forney (1971) also used a half-meter plankton net with 0.5 mm mesh to collect pelagic fry. They classified the lake as a warm water fishery and found growth rates comparable to those in other northeastern lakes. An important finding was that the northeastern corner of the lake was the most favorable for fish success and the southern and western portions of the lake had few fish. The hypolimnion was anoxic and oxygen levels in the epilimnion were sometimes marginal for survival (Kingsbury 1971). In 1980 and 1981, Chiotti (1981) found 22 species in a fish community dominated by white perch (Morone americana) and alewife (Alosa pseudoharengus). Carp (Cyprinus carpio) had declined dramatically between 1946 and 1980. He also found that gizzard shad (Dorosoma cepedianum) were abundant in the ichthyofauna but comprised only 2% of the net samples. Chiotti (1981) observed low recruitment and sporadic fish reproduction in all species except white perch (Morone americana). Reproduction of many species is very limited in the lake and species diversity is increased by immigration from the Seneca River and tributaries (Tango and Arrigo 1994).

Since 1989, SUNY-College of Environmental Science and Forestry has continued work on the fisheries of the lake and its tributaries with population studies, assessment of reproductive success and experimental stocking of Atlantic salmon (Salmo salar) in major tributaries. The lake fishery has been dominated by white perch (Morone americana), gizzard shad (Dorosoma cepedianum), bluegill (Lepomis macrochirus) and pumpkinseed (Lepomis gibbosus) from 1989 to 1993 (Tango and Arrigo 1994). In 1989, 1990 and 1991, 33, 36 and 48 species were found respectively. While these recent studies demonstrate an increase in diversity, comparison with previous studies is difficult because of the differences in collection effort. Fish migration between Onondaga Lake and the Seneca River is a major contributor to fish diversity (UFI 1994).

With the exception of the limited plankton net (0.5 meter, 0.5 mm mesh) sampling by Noble and Forney (1971) surveys of the ichthyoplankton of Onondaga Lake have not been reported.

In 1994, ichthyoplankton were collected biweekly with a Miller High Speed sampler, except from April 11 to June 30 when ichthyoplankton samples were taken weekly (Table 13). Because no ichthyoplankton were caught in our first sample (Table 13), we added an additional nearshore five minute tow starting on 18 April 1994 to ensure that the littoral zone was adequately sampled (Fig. 1). Again no ichthyoplankton were caught. In fact, no ichthyoplankton were caught near the former Allied Waste Bed sites (Fig. 1). The possibility existed that night sampling may be more productive. On 13 June 1994, before our normal daylight sampling routine, six transects were completed in the dark from 0330-0510. One ichthyoplankter was caught and identified as a log-perch (Table 13).

Previous work has suggested that spawning, especially of bluegill, pumpkinseed and white perch does occur. However, spawning appears to be quite variable from year to year. For example, young of the year bluegill, pumpkinseed, and white perch were present in large numbers in 1989 and 1990, strongly suggesting reproduction was occurring. Sampling in 1992, revealed few young of the year fish for all species. Our 1994 collections suggest successful spawning is not occurring near the former Allied Waste Bed sites.

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Table 1. Onondaga Lake sampling dates. * denotes sample was taken for that parameter.

Date (1994)	Zooplankton	Phytoplankton	Ichthyoplankton	Macrobenthos
11 April	*	*	*	
18 April			*	
25 April	*	*	*	
2 May			*	
9 May	*	*	*	
16 May			*	*
23 May	*	*	*	
31 May			*	
06 June	*	*	*	
13 June			*	
20 June	*	*	*	
27 June			*	
05 July	*	*	*	
18 July	*	*	*	*
01 Aug	*	*	*	
15 Aug	*	*	*	
29 Aug	*	*	*	
12 Sept	*	*	*	
26 Sept	*	*	*	
10 Oct	*	*	*	*

Table 2. Field sampling protocol.. NA = not applicable.

Analyte / Parameter	Sample Matrix	Total Number of Samples	Sample Volume	Sample Container	Method of Sample Preservation
Ichthyoplankton	Aqueous	5 tows	NA	Polyethylene bottle	4% buffered formalin
Phytoplankton	Aqueous	1 composite	100ml total (25 ml each from 0, 3, 6, 9 m)	Amber glass bottle	Gluteraldehyde to a final concentration of 0.25 - 0.5%
Zooplankton	Aqueous	1 tow	NA	Clear glass bottle	4% buffered formalin
Macrobenthos	Sediment	3 Ponar grabs/ site	NA	Polyethylene bottle	Field sieved, preserved in 95% ethanol

Table 3. Phytoplankton replicate counts and relative percent difference (RPD) for Onondaga Lake, 25 April 1994.

TAXON		CELLS/ML	CELLS/ML	RPD
BACILLARIOPHYTA				
	Achnanthes deflexa	0.0	8.7	
	Cyclotella sp.	17.4	17.4	
	Fragilaria capucina	8.7	0.0	
	Navicula radiosa	8.7	17.4	
	Navicula sp. 1	17.4	0.0	
	Nitzschia sp.	8.7	8.7	
	Synedra sp.	0.0	8.7	
	Tabellaria fenestrata	0.0	8.7	
	TOTAL	60.9	69.6	13.33
CHLOROPHYTA				
	Ankistrodesmus falcatus	26.0	26.0	
	Carteria platyrhyncha	43.4	34.7	
	Chlamydomonas globosa	78.1	95.5	
	Chlamydomonas gracilis	494.8	486.1	
	Chlamydomonas incerta	34.7	34.7	
	Chlamydomonas platystigma	468.8	329.9	
	Chlamydomonas sp.	0.0	17.4	
	Colonial chlorophyta - type	0.0	8.7	
	Dictyosphaerium pulchellum	0.0	8.7	
	Lobomonas sp.	0.0	8.7	
	Non-motile Chlorococcales	8.7	0.0	
	Scenedesmus dimorphus	8.7	0.0	
	Scenedesmus sp.	43.4	60.8	
	TOTAL	1206.6	1111.2	8.23
CHRYSOPHYTA				
	Colonial Chrysophyte	173.6	251.8	
	Cyst (Chrysophyte)	0.0	8.7	
	Mallomonas sp. 3	8.7	0.0	
	Synura sp. (single)	8.7	17.4	
	TOTAL	191.0	277.9	37.07
CRYPTOPHYTA				
	Cryptomonas erosa	60.8	34.7	
	Cryptomonas ovata	8.7	0.0	
	Rhodomonas minuta v. nannoplanctica	60.8	26.0	
	Rhodomonas minuta	998.3	1067.8	
	TOTAL	1128.6	1128.5	0.01
CYANOPHYTA				
	Oscillatoria sp.	138.9	138.9	0.00
PYRROPHYTA				
	Gymnodinium sp.	26.0	43.4	
	Peridinium umbonatum	8.7	52.1	
	TOTAL	34.7	95.5	93.39
UNIDENTIFIED				
	Misc. micros	1666.8	1771.0	6.06
TOTAL		4427.5	4592.6	3.66

Table 3 (Cont.). Phytoplankton replicate counts and relative percent difference (RPD) for Onondaga Lake, 28 August 1994.

	TAXON	CELLS/ML	CELLS/ML	RPD
BACILLARIOPHYTA				
	Cocconeis sp.	17.4	0.0	
	Cyclotella sp.	8.7	8.7	
	TOTAL	26.1	8.7	100.00
CHLOROPHYTA				
	Chlamydomonas globosa	0.0	17.4	
	Chlamydomonas gracilis	8.7	8.7	
	Coelastrum microporum	8.7	0.0	
	Non-motile Chlorococcales	60.8	17.4	
	Oocystis borgei	0.0	8.7	
	Oocystis parva	0.0	52.1	
	Oocystis sp. 1	86.8	0.0	
	Schroederia judayi	8.7	8.7	
	Selenastrum minutum	0.0	8.7	
	Sphaerocystis schroeteri	0.0	8.7	
	TOTAL	173.7	130.4	28.48
CRYPTOPHYTA				
	Cryptomonas erosa	17.4	17.4	
	Cryptomonas ovata	8.7	0.0	
	Rhodomonas minuta	277.8	468.8	
	TOTAL	303.9	486.2	46.15
CYANOPHYTA				
	Aphanizomenon flos-aquae	7760.9	7344.2	
	Arthrospira sp.	8.7	0.0	
	Non-motile Blue-greens	0.0	34.7	
	Oscillatoria sp.	8.7	0.0	
	TOTAL	7778.3	7378.9	5.27
PYRROPHYTA				
	Ceratium hirundinella	8.7	8.7	
	Gymnodinium sp.	8.7	0.0	
		17.4	8.7	66.67
UNIDENTIFIED				
	Misc. micros	2135.6	1354.3	44.77
	TOTAL	10435	9367.2	10.78

Table 4. Zooplankton replicate counts and relative percent difference (RPD) for Onondaga Lake.

	REPLICATE 1		REPLICATE 2		REPLICATE 3	
	9 May 1994		5 July 1994		15 August 1994	
	COUNT1 (#/m^3)	COUNT2 (#/m^3)	COUNT1 (#/m^3)	COUNT2 (#/m^3)	COUNT1 (#/m^3)	COUNT2 (#/m^3)
MATURE COPEPODA						
Cyclops bicuspidatus thomasi	5637.8	7399.6	391.5	287.9	0.0	0.0
Diaptomus siciloides	1673.7	1057.1	6394.8	6334.6	10309.2	10125.1
Mesocyclops edax	0.0	0.0	261.0	216.0	981.8	0.0
Cyclops vernalis	0.0	0.0	587.3	431.9	0.0	0.0
MATURE COPEPODA	7311.5	8456.7	7634.7	7270.4	11291.0	10125.1
	RPD	**14.5**	**RPD**	**4.9**	**RPD**	**10.9**
IMMMATURE COPEPODA						
Cyclopoid - copepodite	47745.2	50891.0	7569.4	9217.4	62346.1	48784.6
Diaptomus copepodite	1761.8	999.8	28842.0	34710.2	58418.7	58449.4
Copepoda - nauplii	97604.6	104882.0	27798.0	27441.6	116346.6	138990.0
IMMMATURE COPEPODA	147111.6	156772.8	64209.4	71369.2	237111.4	246224.0
	RPD	**6.4**	**RPD**	**10.6**	**RPD**	**3.8**
CLADOCERA						
Daphnia ambigua	0.0	0.0	0.0	737.4	0.0	0.0
Bosmina longirostris	0.0	70.5	1305.1	1316.8	45164.1	58909.7
Daphnia catawba	0.0	0.0	7373.6	9217.4	0.0	0.0
Daphnia pulex	0.0	0.0	2283.9	2949.6	0.0	0.0
Daphnia galeata mendotae	0.0	0.0	14160.0	10586.9	174274.4	173967.6
Chydoridae	0.0	0.0	0.0	0.0	0.0	920.5
Ceriodaphnia quadrangula	0.0	0.0	0.0	0.0	10800.1	12886.5
CLADOCERA	0.0	70.5	25122.6	24808.0	230238.6	246684.2
	RPD	**200.0**	**RPD**	**1.3**	**RPD**	**6.9**

Table 4 (Cont.). Zooplankton replicate counts and relative percent difference (RPD) for Onondaga Lake.

	REPLICATE 1		REPLICATE 2		REPLICATE 3	
	9 May 1994		5 July 1994		15 August 1994	
	COUNT1 (#/m^3)	COUNT2 (#/m^3)	COUNT1 (#/m^3)	COUNT2 (#/m^3)	COUNT1 (#/m^3)	COUNT2 (#/m^3)
ROTIFERA						
Keratella quadrata	135307.5	148690.2	2153.4	1439.7	58909.7	62591.5
Keratella cochlearis	218289.0	223172.8	130.5	431.9	105055.6	128404.6
Polyarthra vulgaris	17618.2	21346.2	0.0	0.0	0.0	1380.7
Polyarthra dolichoptera	5814.0	7512.4	0.0	0.0	0.0	0.0
Polyarthra major	1145.2	1007.8	0.0	0.0	0.0	0.0
Filinia terminalis	58139.9	64954.8	0.0	0.0	0.0	0.0
Brachionus angularis	55673.4	54052.5	0.0	0.0	0.0	460.2
Brachionus calyciflorus	4404.5	3756.2	0.0	0.0	0.0	0.0
Synchaeta sp.	16032.5	13192.5	0.0	0.0	0.0	0.0
Notholca acuminata	440.5	1007.8	0.0	0.0	0.0	0.0
Asplanchna priodonta	1673.7	549.7	0.0	0.0	0.0	0.0
Pompholyx sulcata	0.0	0.0	0.0	0.0	78055.3	86523.6
ROTIFERA	514538.4	539242.9	2283.9	1871.6	242020.5	279360.6
	RPD	**4.7**	**RPD**	**19.8**	**RPD**	**14.3**
TOTAL	668961.6	704542.9	99250.5	105319.2	720661.5	782393.9
	RPD	**5.2**	**RPD**	**5.9**	**RPD**	**8.2**

Table 5. Seasonal temperature, conductivity, and transparency at the main lake station of Onondaga Lake, 1994. Temperature and conductivity represent surface values.

Date (1994)	Temperature (°C)	Conductivity (μmhos/cm)	Secchi disk (m)
11 April	4.8	1,760	0.9
18 April	6.6	1,794	1.3
25 April	11.4	1,719	1.1
2 May	9.6	1,912	1.5
9 May	11.8	1,906	1.3
16 May	11.7	1,967	1.4
23 May	18.3	1,915	1.0
31 May	16.4	2,010	0.5
06 June	19.4	1,956	0.5
13 June	19.0	2,090	4.1
20 June	26.6	2,110	5.0
27 June	22.4	2,200	4.1
05 July	23.3	2,040	3.1
18 July	25.4	2,090	1.0
01 Aug	26.2	2,100	2.5
15 Aug	21.7	2,250	2.0
29 Aug	21.4	2,060	1.0
12 Sept	18.9	2,340	1.0
26 Sept	19.2	2,290	3.4
10 Oct	14.5	2,350	2.3

Table 6. Summary of common phytoplankton species occurence in Onondaga Lake during 1994. Summary includes the maximum population density encountered, the average population density and biomass, and the relative abundance (% of total cells and % of total biomass). Common species were arbitrarily defined as having an abundance ≥ 0.5% of the total cells or ≥ 0.5% of the total biomass.

TAXON		MAXIMUM CELLS/ML	AVERAGE CELLS/ML	% OF TOTAL CELLS	MEAN BIOMASS µg/mL	% OF TOTAL BIOMASS
BACILLARIOPHYTA						
Cyclotella meneghiniana		1771	132.9	0.13	0.052	0.92
Diatoma vulgaris		4473	430.8	0.42	0.235	4.11
Fragilaria crotonensis		1381	122.1	0.12	0.164	2.87
Stephanodiscus hantzschii		5709	410.2	0.40	0.140	2.45
Stephanodiscus niagarae		21	1.5	0.00	0.033	0.59
Synedra gaillonii		174	22.7	0.02	0.061	1.07
				----------		----------
	Total			1.08		12.01
CHLOROPHYTA						
Chlamydomonas globosa		1354	124.5	0.12	0.041	0.71
Chlamydomonas gracilis		972	84.3	0.08	0.055	0.96
Sphaerocystis schroeteri		4740	400.6	0.39	0.116	2.03
				----------		----------
	Total			0.59		3.71
CRYPTOPHYTA						
Cryptomonas erosa		2292	223.0	0.22	0.122	2.13
Cryptomonas ovata		347	42.3	0.04	0.099	1.74
Rhodomonas minuta		102900	11,384.7	11.03	0.544	9.53
				----------		----------
	Total			11.28		13.39
CYANOPHYTA						
Anabaena flos-aquae		104288	8,099.7	7.85	0.700	12.26
Aphanizomenon flos-aquae		233547	54,786.9	53.06	1.554	27.19
Synechococcus elongatus		8403	659.8	0.64	0.004	0.07
				----------		----------
	Total			61.55		39.52
PYRROPHYTA						
Ceratium hirundinella		13	2.1	0.00	1.299	22.73
UNIDENTIFIED						
Misc. microflagellate		140600	24,132.4	23.37	0.210	3.68
				==========		==========
	Total			97.88		95.05

Table 7. Abundance and biomass of phytoplankton by division in Onondaga Lake, 1994.

Division	# of Species	Cells/mL	%	µg/mL	%
Bacillariophyta	25	1,252	1.21	0.74	13.00
Chlorophyta	39	2,048	1.98	0.41	7.13
Chrysophyta	4	55	0.05	0.01	0.13
Cryptophyta	5	11,765	11.39	0.77	13.46
Cyanophyta	12	63,977	61.97	2.26	39.62
Pyrrophyta	4	17	0.02	1.31	22.98
Unidentified	?	24,132	23.37	0.21	3.68
MEAN	89	103,246		5.72	

Table 8. Summary of Onondaga Lake phytoplankton, 1978 to 1994. x = present, xx = ≥ 1000 cells/ml (maximum density in 1994).

Taxon	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1994
BACILLARIOPHYTA														
Achnanthes deflexa														x
Asterionella formosa	x			x					x	x	x	x	x	x
Cocconeis sp.														x
Coscinodiscus sp.		x	x	x		x				x		x		
Cyclotella bodanica														x
Cyclotella meneghiniana	xx	xx	xx	xx	xx	xx	x	xx	xx	x	x	x	x	xx
Cyclotella sp.														x
Cyclotella sp. 2														x
Cyclotella sp. 3														x
Diatoma tenue	x	x	x	x	xx	x	xx	xx	x	x	x	x	x	
Diatoma vulgaris														xx
Entomoneis alata	x		x	x	x		x	x	x					
Fragilaria capucina														x
Fragilaria construens														x
Fragilaria crotonensis	x				x					x	x	xx	x	xx
Melosira granulata			x	x	x					x			x	
Melosira sp.														x
Navicula radiosa														x
Navicula sp.														x
Neidium sp.														x
Nitzschia acicularis														x
Nitzschia perminuta														x
Nitzschia sp.	x	x	x	x	x	x	x	x	x		x	x	x	x
Stephanodiscus hantzschii														xx
Stephanodiscus niagarae														x
Synedra gaillonii														x
Synedra radians														x
Synedra sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tabellaria fenestrata														x
other centric diatoms	xx	xx	xx	xx	xx	xx	xx	xx	xx	x	x	x	x	
other pennate diatoms	x	x		x			x	x	x		x			
CHLOROPHYTA														
Actinastrum hantzschii					x	x	x	xx	xx	x		x		
Ankistrodesmus falcatus	xx	xx	xx	xx	xx	x	xx	xx	xx	x	x	x	x	xx
Binuclearia tectorum					x	xx	xx	xx	xx	x				
Botryococcus braunii														x
Carteria platyrhyncha														x
Characium limnetcum														x
Characium sp.														x
Chlamydomonas globosa														xx
Chlamydomonas gloeopara														x
Chlamydomonas gracilis														x
Chlamydomonas incerta														x
Chlamydomonas platystigma														x
Chlamydomonas sp.	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx		x
Chlorella vulgaria	xx	xx	xx	xx	xx	xx	x	x	xx	x	xx	x		
Closterium moniliferum														x
Closterium sp.		x	x	x	x		x		x	x	x	x		x
Coelastrum microporum										xx	xx	x	x	x
Coelastrum sp.														x
Colonial chlorophyta - type 2														x
Cosmarium sp.				x	x	xx	x	x	x	x	x	x		
Crucigenia quadrata														x
Crucigenia rectangularis														x
Crucigenia sp.	x		x	x	x	x	x	x		x	x	x		
Deasonia gigantica														x
Dictyosphaerium pulchellum		xx	x	xx	xx	xx	x	xx	x	x	xx	xx		xx
Elakatothrix viridis												x		
Eurastrum sp.														x

Table 8 (Cont.). Summary of Onondaga Lake phytoplankton, 1978 to 1994. x = present, xx = ≥ 1000 cells/ml (maximum density in 1994).

Taxon	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1994
BACILLARIOPHYTA														
Achnanthes deflexa														x
Asterionella formosa	x			x					x	x	x	x	x	x
Cocconeis sp.														x
Coscinodiscus sp.		x	x	x		x				x		x		
Cyclotella bodanica														x
Cyclotella meneghiniana	xx	xx	xx	xx	xx	xx	x	xx	xx	x	x	x	x	xx
Cyclotella sp.														x
Cyclotella sp. 2														x
Cyclotella sp. 3														x
Diatoma tenue	x	x	x	x	xx	x	xx	xx	x	x	x	x	x	
Diatoma vulgaris														xx
Entomoneis alata	x		x	x	x		x	x	x					
Fragilaria capucina														x
Fragilaria construens														x
Fragilaria crotonensis	x				x					x	x	xx	x	xx
Melosira granulata			x	x	x					x			x	
Melosira sp.														x
Navicula radiosa														x
Navicula sp.														x
Neidium sp.														x
Nitzschia acicularis														x
Nitzschia perminuta														x
Nitzschia sp.	x	x	x	x	x	x	x	x	x		x	x	x	x
Stephanodiscus hantzschii														xx
Stephanodiscus niagarae														x
Synedra gaillonii														x
Synedra radians														x
Synedra sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tabellaria fenestrata														x
other centric diatoms	xx	xx	xx	xx	xx	xx	xx	xx	xx	x	x	x	x	
other pennate diatoms	x	x		x			x	x	x		x			
CHLOROPHYTA														
Actinastrum hantzschii					x	x	x	xx	xx	x		x		
Ankistrodesmus falcatus	xx	xx	xx	xx	xx	x	xx	xx	xx	x	x	x	x	xx
Binuclearia tectorum					x	xx	xx	xx	xx	x				
Botryococcus braunii														x
Carteria platyrhyncha														x
Characium limnetcum														x
Characium sp.														x
Chlamydomonas globosa														xx
Chlamydomonas gloeopara														x
Chlamydomonas gracilis														x
Chlamydomonas incerta														x
Chlamydomonas platystigma														x
Chlamydomonas sp.	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx		x
Chlorella vulgaria	xx	xx	xx	xx	xx	xx	x	x	xx	x	xx	x		
Closterium moniliferum														x
Closterium sp.		x	x	x	x		x		x	x	x	x		x
Coelastrum microporum										xx	xx	x	x	x
Coelastrum sp.														x
Colonial chlorophyta - type 2														x
Cosmarium sp.				x	x	xx	x	x	x	x	x	x		
Crucigenia quadrata														x
Crucigenia rectangularis														x
Crucigenia sp.	x		x	x	x	x	x	x		x	x	x		
Deasonia gigantica														x
Dictyosphaerium pulchellum		xx	x	xx	xx	xx	x	xx	x	x	xx	xx		xx
Elakatothrix viridis												x		
Eurastrum sp.														x
Gloeocystis gigas														x
Gonium pectorale						x			x			x		
Heteromastix angulata				xx	x	xx	xx	x	xx	x	x			
Krichneriella elongate			x	x	xx	x	x	x	x	x	x			

Table 8 (Cont.). Summary of Onondaga Lake phytoplankton, 1978 to 1994. x = present, xx = ≥ 1000 cells/ml (maximum density in 1994).

Taxon	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1994
Lagerheimia quadriseta														x
Lobomonas sp.														x
Micractinium pusillum														x
Non-motile Chlorococcales														x
Oocystis borgei														x
Oocystis parva	xx	xx	xx	xx	xx	xx	xx	xx	x	xx	xx	xx	x	x
Pediastrum boryanum									x	x				
Pediastrum duplex	x	x		x	x	x		x	x	xx	xx	x	x	xx
Pediastrum simplex			x		x		x							
Pediastrum tetras					x									
Platymonas elliptica							x	x	x	x	x	x	xx	
Quadrigula lacustris										x	x			
Scenedesmus arcuatus v. platydisca														x
Scenedesmus dimorphus														xx
Scenedesmus obliquus	xx	xx	xx	xx	xx	xx	xx	x	xx	x	x	x	x	
Scenedesmus quadricauda	xx	xx	xx	xx	xx	xx	xx	x	x	x	x	x	x	x
Scenedesmus sp.														xx
Schroederia judayi														x
Schroederia setigera	x						x		x	x	x	x	x	
Selenastrum minutum														x
Selenastrum sp.											x			
Spermatozopsis exultans														x
Sphaerocystis schroeteri														xx
Staurastrum sp.										x	x			
Tetraedron minimum														x
Tetraedron sp.	x	x	x	x	x	x	x	x	x					
Ulothrix sp.														xx
CHRYSOPHYTA														
Chrysococcus sp.														x
Colonial Chrysophyte														x
Cyst (Chrysophyte)														x
Ochromonas sp.														x
Synura sp. (single)														x
CRYPTOPHYTA														
Chroomonas sp.	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	
Cryptomonas erosa	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Cryptomonas lucens														x
Cryptomonas ovata														x
Rhodomonas minuta														xx
R. minuta var. nannoplanctica														xx
CYANOPHYTA														
Anabaena flos-aquae														xx
Anabaena sp.					x	x	x	x		x		x	xx	
Aphanizomenon flos-aquae									x	x	x	x	xx	xx
Aphanocapsa elachista														xx
Chroococcus limneticus														x
Chroococcus prescottii														x
Coelosphaerium sp.					x	x	x	x	x	x	x	x	x	
Gomphosphaeria lacustris														xx
Merismopedia sp.		x	x	x	x	x	x	x						
Microcystis aeruginosa														x
Microcystis sp.			x	x						x		x	x	
Non-motile Blue-greens (>2 UM)														x
Oscillatoria limnetica														xx
CYANOPHYTA														
Oscillatoria sp.							x	x	x					x
Oscillatoria sp. 2														x
Synechococcus elongatus														xx
EUGLENOPHYTA														
Colacium sp.	x													
Euglena sp.	x	x	x	x	x	x	x	x	x	x	x			
Lepocynclis sp.		x	x			x		x	x					
PYRROPHYTA														

Table 8 (Cont.). Summary of Onondaga Lake phytoplankton, 1978 to 1994. x = present, xx = ≥ 1000 cells/ml (maximum density in 1994).

Ceratium hirundinella										x	x	x	x	x
Dinobryon sp.												x		
Gymnodinium sp.														x
Gymnodinium sp. 3														x
Peridinium umbonatum														x
other dinoflagellates	x	x	x	x	x	x	x	x	x	x	x	x	x	
UNIDENTIFIED														
Misc. microflagellate														xx

Table 9. Summary of common zooplankton species occurrence in Onondaga Lake in 1994. Species were arbitrarily classified as common if they accounted for ≥ 0.1% of the total abundance or ≥ 1.0% of the total biomass, with the exception of rotifers. Rotifer species were considered common if they accounted for ≥ 1.0% of the total abundance.

TAXON		MAXIMUM DENSITY (#/m^3)	AVERAGE DENSITY (#/m^3)	% OF TOTAL ABUNDANCE	MEAN BIOMASS (µg/m^3)	% OF TOTAL BIOMASS
COPEPODA						
Copepoda - nauplii		271,653	121,413.3	26.84	60,208	11.58
Cyclopoida						
Cyclopoid - copepodite		306,507	45,531.0	10.07	34,221	6.58
Cyclops bicuspidatus thomasi		15,801	3,415.4	0.76	20,565	3.96
Cyclops vernalis		13,379	2,794.1	0.62	17,193	3.31
Mesocyclops edax		8,370	1,415.2	0.31	12,851	2.47
Calanoida						
Diaptomus copepodite		89,800	24,624.6	5.44	46,369	8.92
Diaptomus siciloides		10,125	4,646.4	1.03	22,190	4.27
	Total			45.06		41.09
CLADOCERA						
Bosmina longirostris		62,820	14,406.3	3.18	12,498	2.40
Ceriodaphnia quadrangula		12,887	1,652.4	0.37	3,458	0.67
Daphnia ambigua		4,320	542.8	0.12	796	0.15
Daphnia catawba		27,180	3,660.0	0.81	25,044	4.82
Daphnia galeata mendotae		173,968	36,269.9	8.02	212,011	40.78
Daphnia pulex/pulicaria		11,418	1,510.6	0.33	39,219	7.54
Diaphanosoma leuchtenbergianum		15,026	1,559.0	0.34	4,881	0.94
	Total			13.18		57.30
ROTIFERA						
Brachionus angularis		55,673	7,438.6	1.64	204	0.04
Brachionus calyciflorus		66,796	5,152.5	1.14	2,658	0.51
Filinia terminalis		115,637	15,196.0	3.36	396	0.08
Keratella cochlearis		447,105	81,237.4	17.96	295	0.06
Keratella quadrata		178,124	39,155.6	8.66	2,544	0.49
Polyarthra vulgaris		25,857	4,683.3	1.04	256	0.05
Pompholyx sulcata		136,542	30,529.1	6.75	393	0.08
	Total			40.54		1.30
	Total			98.78		99.68

Table 10. Zooplankton assemblage of Onondaga Lake, 1969 - 1994 (r = rare, x = common). In 1994, species were arbitrarily classified as common if they accounted for ≥ 0.1% of the total abundance or ≥ 1.0% of the total biomass, with the exception of rotifers. Rotifer species were considered common if they accounted for ≥ 1.0% of the total abundance.

TAXON	1969[1]	1978[2]	1979-89[3]	1986-89[3]	1994[4]
CLADOCERA					
Alona affinis		r			
Bosmina longirostris	r	r	r	x	x
Ceriodaphnia quadrangula	x	x	x	x	x
Chydorus sphaericus	r	r			r
Daphnia ambigua					x
Daphnia catawba					x
Daphnia galaeta mendotae				x	x
Daphnia pulex (pulicaria)	x	x		x	x
Daphnia similis	x				
Diaphanosoma leuchtenbergianum				x	x
Eubosmina coregoni				r	
Leptodora kindtii				r	r
COPEPODA					
Cyclops bicuspidatus thomasi	x	x		r	x
Cyclops vernalis	x	x	x	x	x
Diaptomus sicilis	r	r			
Diaptomus siciloides				x	x
Mesocyclops edax	r				x
ROTIFERA					
Ascomorpha sp.			x		
Asplanchna sp.	r	x			r[5]
Brachionus angularis				x	x
Brachionus calycilflorus		x	x	x	x
Brachionus plicatus		r			
Brachionus sp.	x	x			
Brachionus variabilis				x	
Filinia longiseta	r	r		x	
Filinia terminalis				x	x
Hexarthra mira					r
Kellicottia bostoniensis			r	x	
Kellicottia longispina			x	x	
Keratella cochlearis					x
Keratella cochlearis c. cochlearis	r		r	r	
Keratella cochlearis c. robusta			r	x	
Keratella cochlearis c. tecta			r		
Keratella hiemalis	x	x			
Keratella quadrata		x	r	x	x
Keratella testudo			x	x	
Keratella valga		r			
Notholca acuminata					r
Notholca squamula				r	
Ploesoma truncatum				r	
Polyarthra dolichoptera					r
Polyarthra euryptera					r
Polyarthra major					r
Polyarthra remata			x	x	
Polyarthra sp.	x	x			
Polyarthra vulgaris					x
Pompholyx sulcata					x
Synchaeta sp.		x			r
Trichocerca multicrinis				r	r

1 - Waterman 1971 3 - UPI - 1994 5 - *A. priodonta*
2 - Meyer and Effler 1980 4 - This analysis

Table 11. Macrobenthos abundance at the epilimnetic site (Allied Waste Site) of Onondaga Lake for the sample dates 16 May, 18 July and 10 October 1994 and for four sites sampled in June 1989 (UFI 1994). Results are mean number/m^2 ± standard error (S.E.). In 1989, results are mean number/m^2 and the coefficient of variance (CV) range.

	P-1,P-2 1989 (#/m^2) Mean(CV range)	W-1,W-2 1989 (#/m^2) Mean(CV range)	16 May 1994 (#/m^2) Mean±S.E.	18 July 1994 (#/m^2) Mean±S.E.	10 October 94 (#/m^2) Mean±S.E.
Crustacea					
Gammaridae					
Gammarus fasciatus	546 (.13-.58)	245 (.64-.70)	21±21	296±154	62±32
Gammarus pseudolimnaeus	0	0	0	985±555	0
Total and [Relative] Abundance	546 [5%]	245 [3%]	21 [3%]	1,281 [65%]	62 [12%]
Isopoda					
Caecidotea sp.	0	0	0	55±55	0
Total and [Relative] Abundance	0 [0%]	0 [0%]	0 [0%]	55 [3%]	0 [0%]
Gastropoda					
Limnaeidae					
Fossaria sp.	0	0	0	14±14	0
Physidae					
Physella sp.	2 (0-2.24)	15 (.87-2.24)	69±48	89±14	7±7
Planorbidae					
Gyraulus sp.	5 (.82-2.24)	30 (0-1.05)	0	48±14	0
Total and [Relative] Abundance	7 [0.1%]	45 [1%]	69 [9%]	151 [8%]	7 [1%]
Annelida					
Oligochaeta					
Enchytraeidae	2916 (.46-.63)	186 (.74-1.14)	413±187	83±83	165±83
Tubificidae	0	0	21±12	0	7±7
Total and [Relative] Abundance	2,916 [27%]	186 [2%]	413 [56%]	83 [4%]	172 [34%]
Insecta					
Diptera					
Chironomidae					
Chironomus sp.	1602	3260	83±36	213±213	117±77
Cricotopus sylvestris	3150	2860	0	0	0
Dicrotendipes sp.	0	0	41±12	7±7	0
Glyptotendipes sp.	1944	1346	96±36	165±126	83±43
Procladius sp.	0	0	7±7	7±7	0
Cryptochironomus sp.	0	0	0	0	7±7
Rheotanytarsus sp.	0	0	0	0	7±7
Parachironomus sp.	154	16	0	0	48±48
Tanytarsus guerlus	141	252	0	0	0
Total and [Relative] Abundance	6,991 [66%]	7,734 [94%]	227 [31%]	392 [20%]	262 [52%]

Table 11. (Cont.) Macrobenthos abundance at the epilimnetic site (Allied Waste Site) of Onondaga Lake for the sample dates 16 May, 18 July and 10 October 1994 and for four sites sampled in June 1989 (UFI 1994). Results are mean number/m^2 ± standard error (S.E.). In 1989, results are mean number/m^2 and the coefficient of variance (CV) range.

Lepidoptera					
Pyralidae					
Acentria sp.	0	0	7±7	0	0
Total and [Relative] Abundance	0 [0%]	0 [0%]	7 [1%]	0 [0%]	0 [0%]
Bivalvia					
Dreissena polymorpha	0	0	0	14±14	0
Total and [Relative] Abundance	0 [0%]	0 [0%]	0 [0%]	14 [1%]	0 [0%]
Acarina	0	0	0	7±7	0
Total and [Relative] Abundance	0 [0%]	0 [0%]	0 [0%]	7 [0.4%]	0 [0%]
Nematoda	181(.89-1.03)	8 (0.75-2.24)	0	0	0
Total and [Relative] Abundance	181 [2%]	8 [0.1%]	0 [0%]	0 [0%]	0 [0%]
Hydrachnidia					
Limnesia	26 (.94-1)	4 (1.53-2.24)	0	0	0
Total and [Relative] Abundance	26 [0.2%]	4 [0.05%]	0 [0%]	0 [0%]	0 [0%]
Community Abundance	10,667	8,222	737	1,983	503

Table 12. Shannon diversity indices for benthic invertebrates, Onondaga and Cayuga Lakes. 1989 data are UFI (1994). Cayuga Lake data are from Ringler and Wagner (1988).

Lake	Site	Shannon-Weiner Index	Year
Onondaga	W-1	0.18	1989
	W-2	0.35	1989
	P-1	0.84	1989
	P-2	0.90	1989
	May	0.65	1994
	July	0.72	1994
	October	0.75	1994
Cayuga	Outfall		
	0-25cm	0.83	
	25-50cm	0.92	
	50-75cm	0.65	
	Reference		
	0-25cm	1.31	
	25-50cm	1.92	
	50-75cm	1.86	

Table 13. Results of Ichthyoplankton tows on Onondaga Lake from 11 April to 10 October 1994.

Date (1994)	Tow 1 (#/m^3)	Tow 2 (#/m^3)	Tow 3 (#/m^3)	Tow 4 (#/m^3)	Tow 5 (#/m^3)	Tow 6 (#/m^3)
11 April	0	0	0	0	0	0
18 April	0	0	0	0	0	0
25 April	0	0	0	0	0	0
2 May	0	0	0	0	0	0
9 May	0	0	0	0	0	0
16 May	0	0	0	0	0	0
23 May	0	0	0	0	0	0
31 May	0	0	0	0	0	0
06 June	0	0	0	0	0	0
13 June	0	0	0	0	0	0
13 June - Night	0	0	0	0	0	0.0019*
20 June	0	0	0	0	0	0
27 June	0	0	0	0	0	0
05 July	0	0	0	0	0	0
18 July	0	0	0	0	0	0
01 Aug	0	0	0	0	0	0
15 Aug	0	0	0	0	0	0
29 Aug	0	0	0	0	0	0
12 Sept	0	0	0	0	0	0
26 Sept	0	0	0	0	0	0
10 Oct	0	0	0	0	0	0

* One 10 mm log perch *(Percina caprodes)*, 288.5 m^3 filtered.

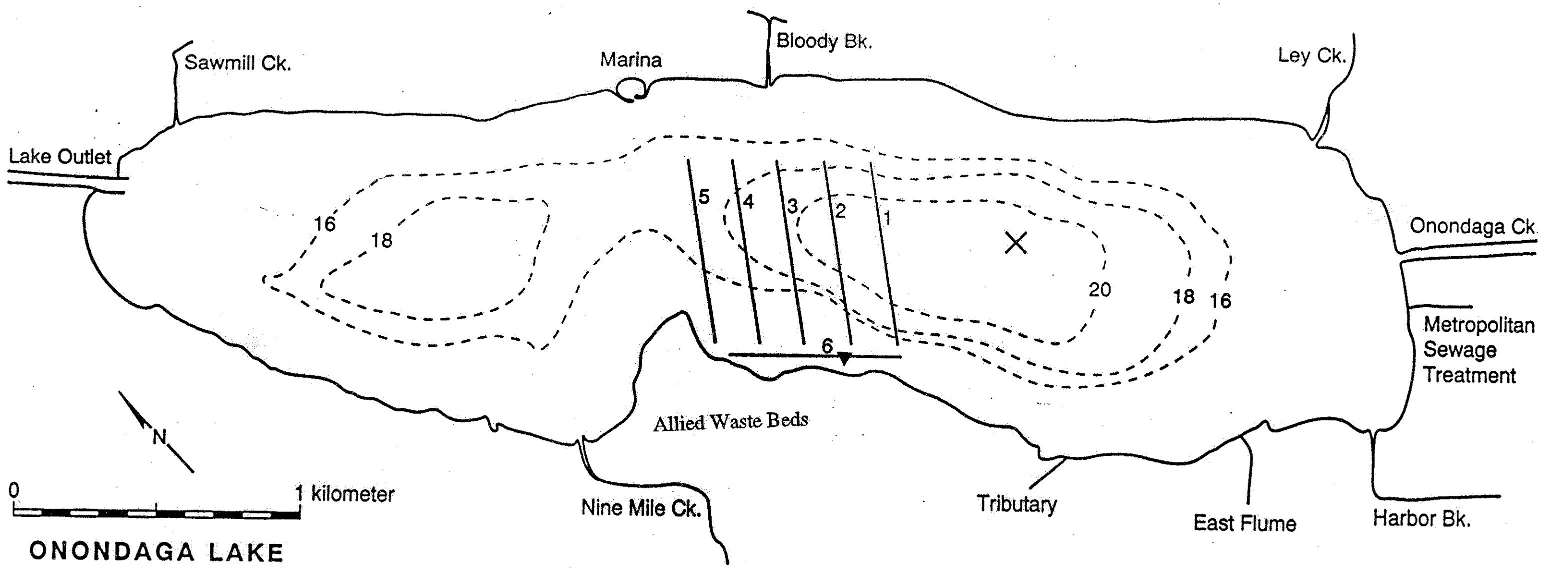


Figure 1. Map of Onondaga Lake showing sampling sites and icthyoplankton transects (1 through 6). X denotes the Main Lake Station. ▼ denotes the epilimnetic macrobenthos site.

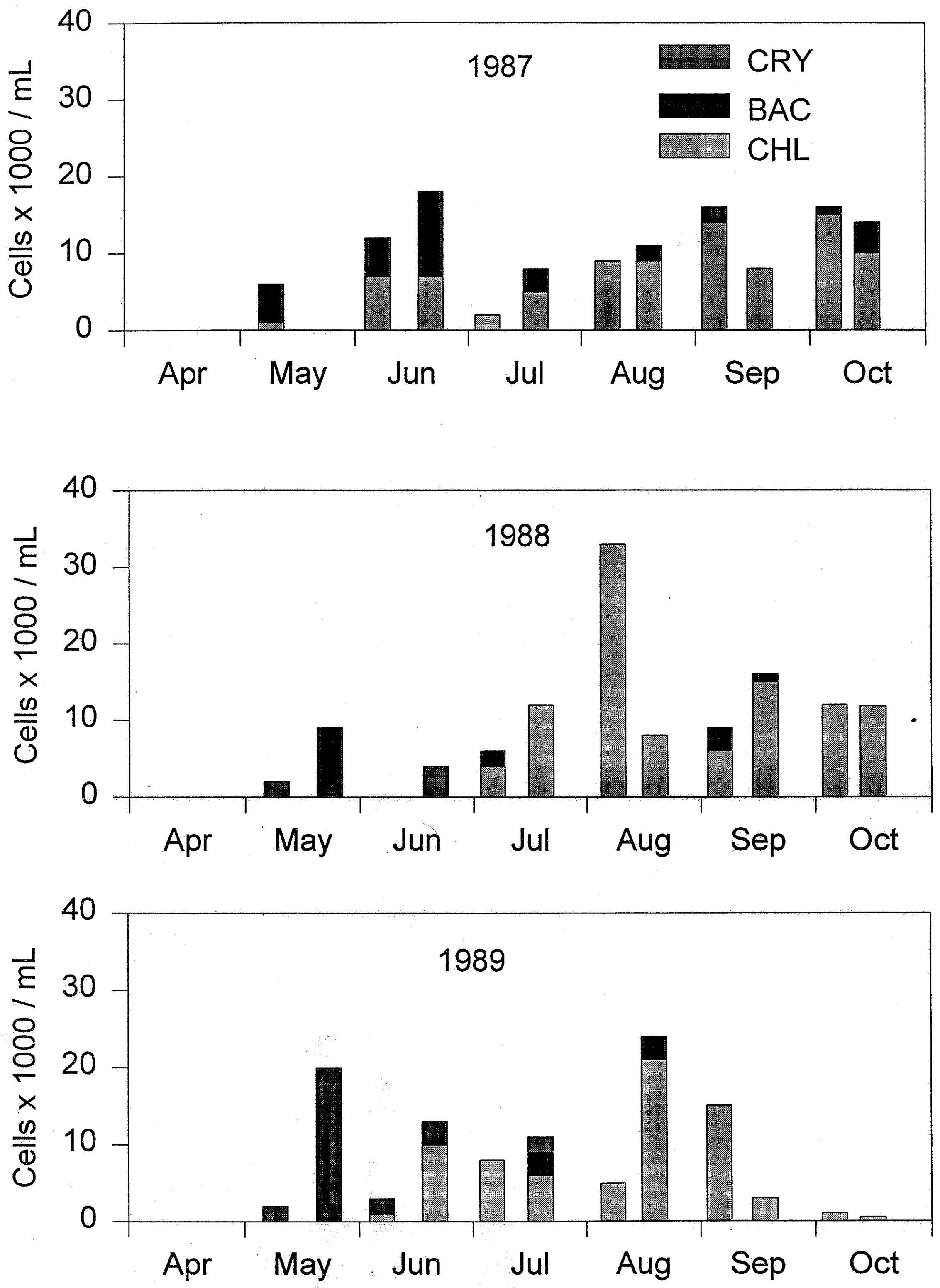


Figure 2. Seasonal abundance of Cryptophyta (CRY), Bacillariophyta (BAC) and Chlorophyta (CHL) from 1987 and 1994.

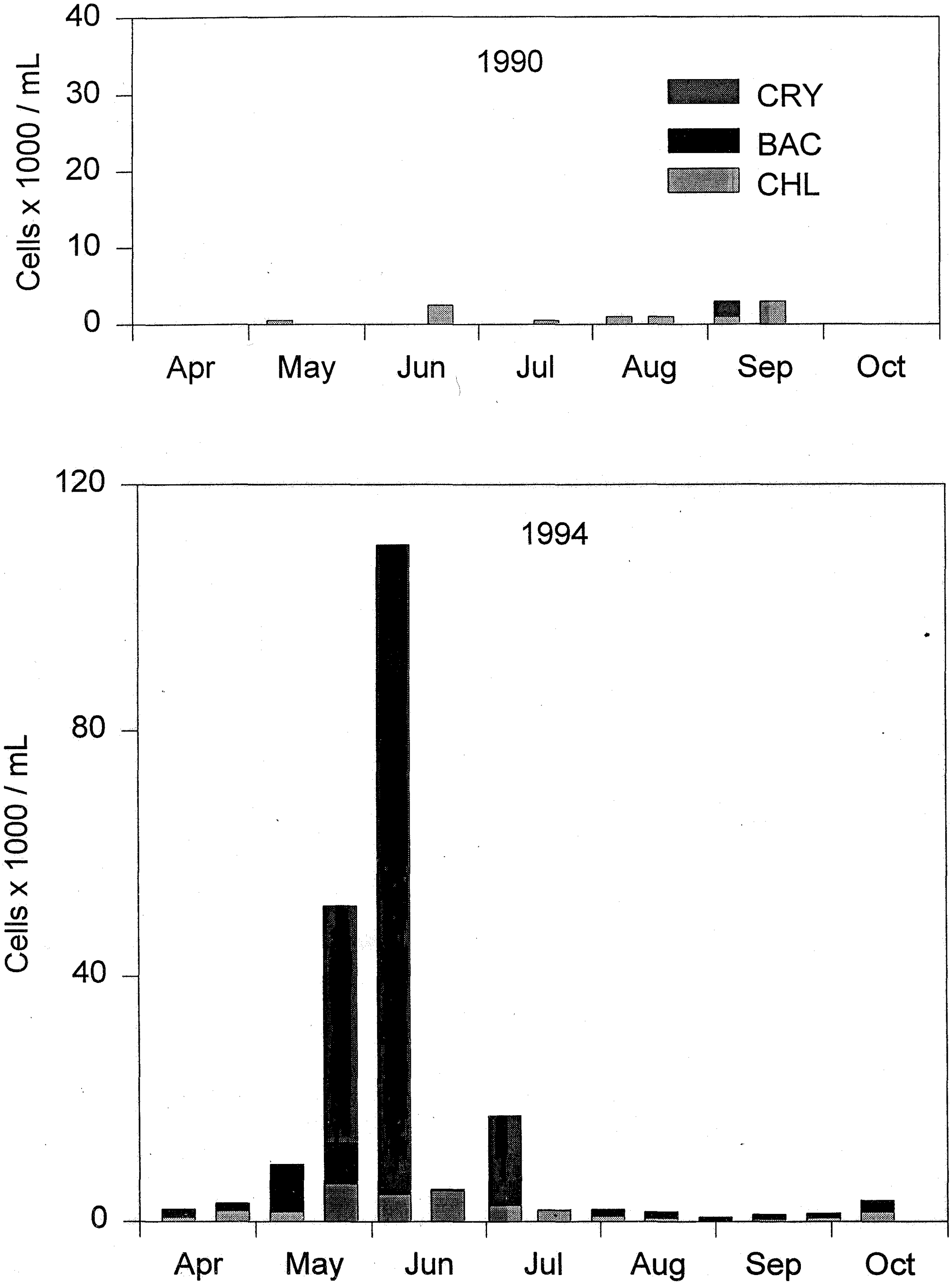


Figure 3. Seasonal abundance of Cryptophyta (CRY), Bacillariophyta (BAC) and Chlorophyta (CHL) from 1987-90 and 1994.

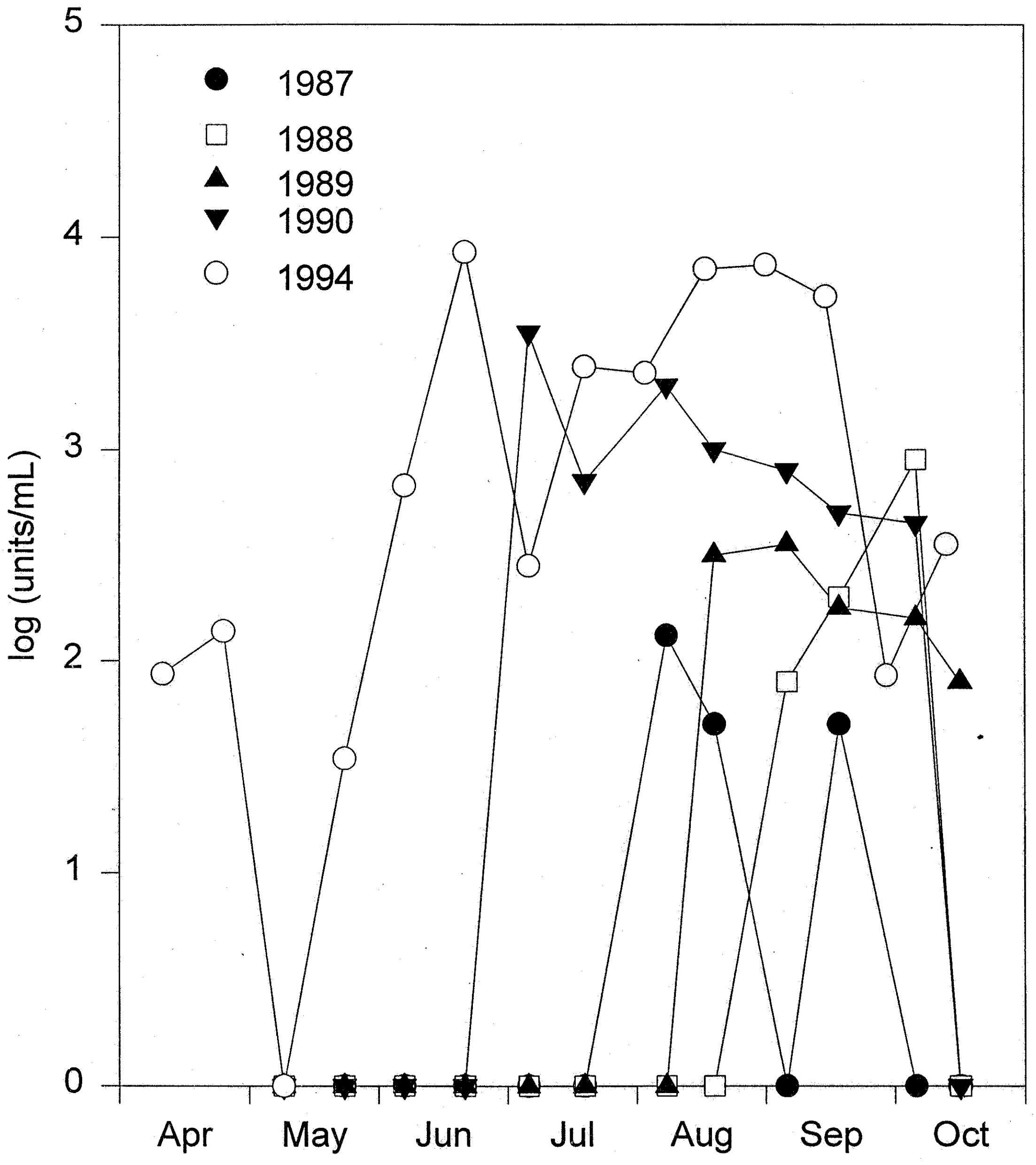


Figure **4**. Seasonal abundance of Cyanobacteria from 1987-90 and 1994. Modified from UFI (1994).

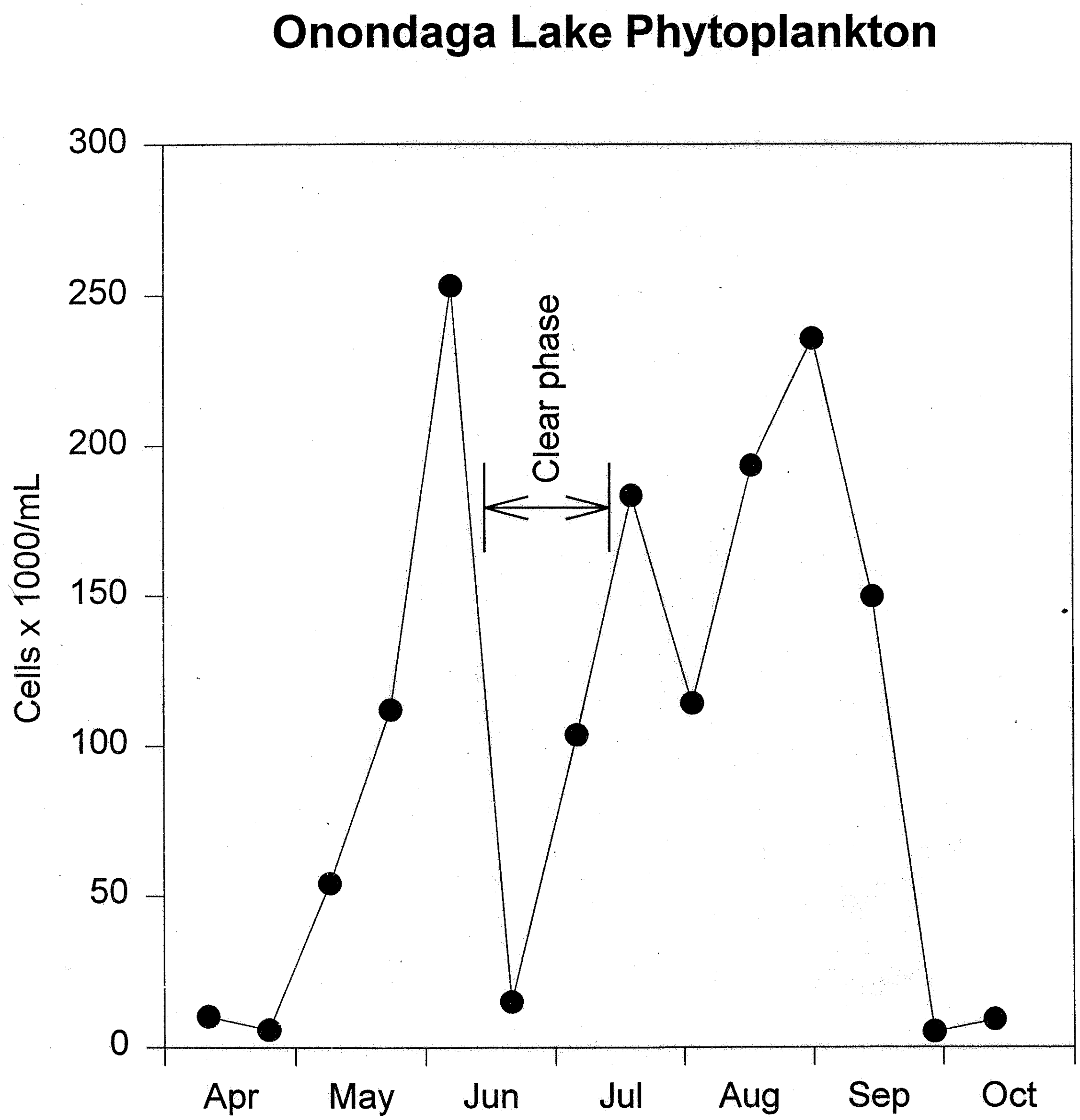
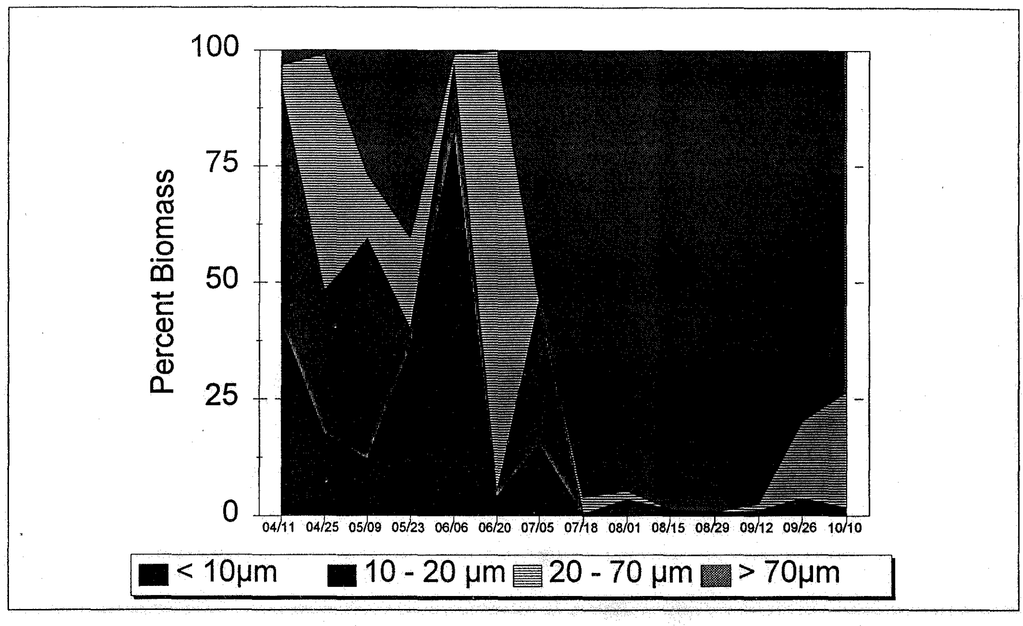


Figure 5. Seasonal abundance of the phytoplankton community of Onondaga Lake, 1994.



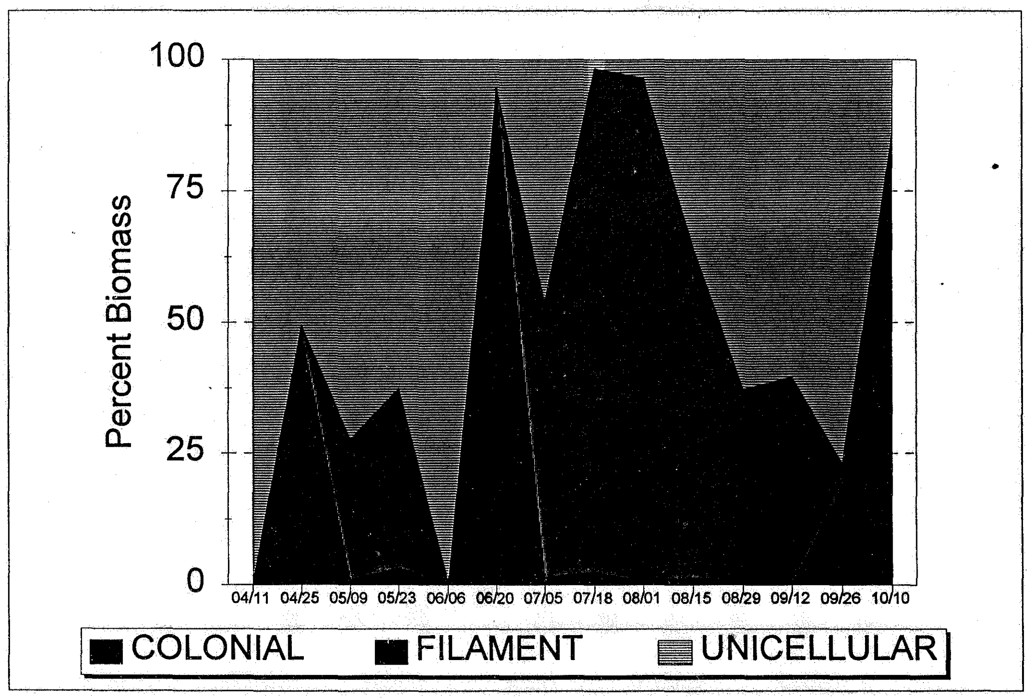


Figure 6. Seasonal phytoplankton distribution by size and growth form, Onondaga Lake, 1994.

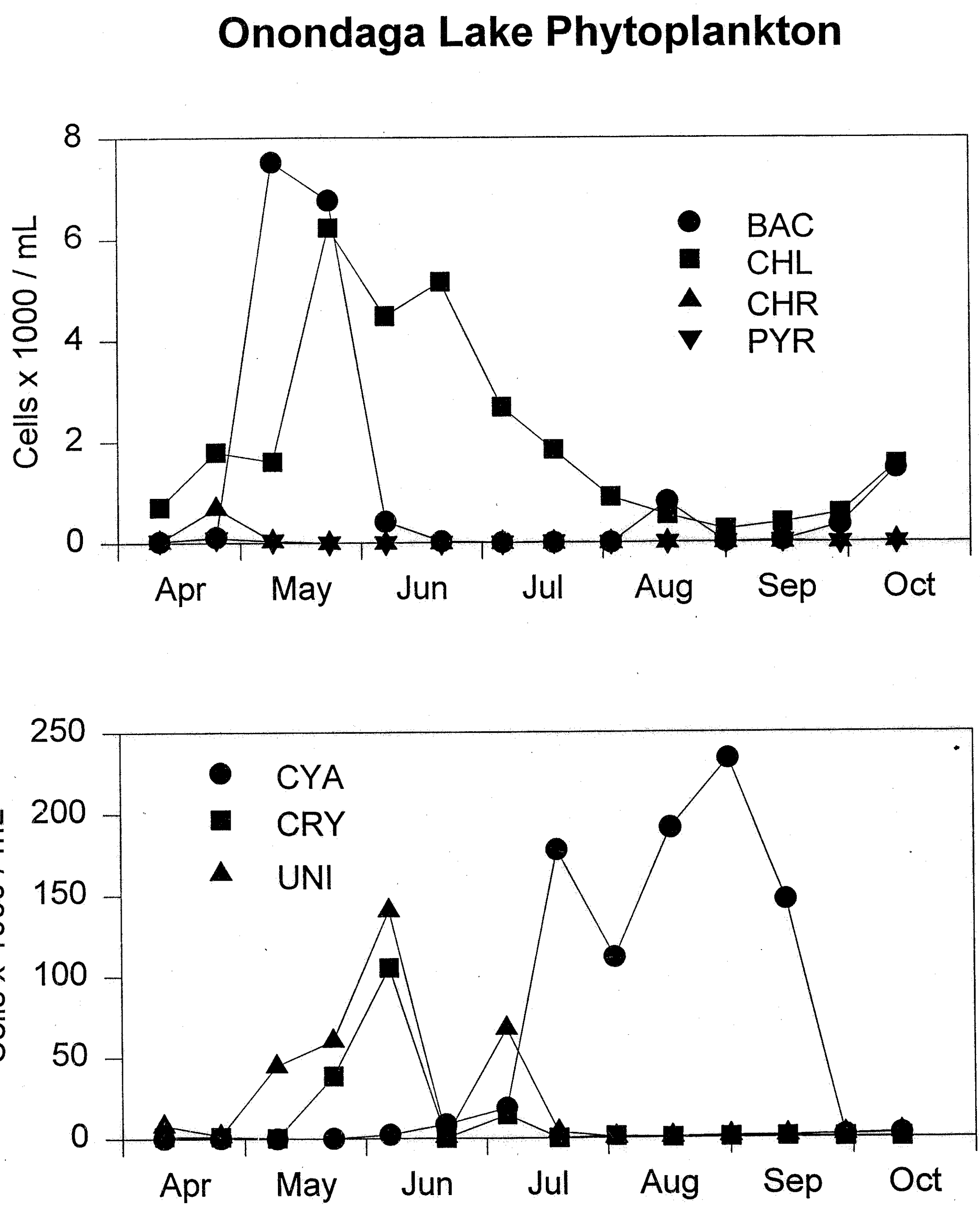


Figure 7. Seasonal abundance of various groupings of phytoplankton of Onondaga Lake, 1994. BAC=Bacillariphyta, CHL=Chlorophyta, CHR=Chrysophyta, PYR=Pyrrophyta, CYA=Cyanobacteria, CRy=Cryptophyta, UNI=Unidentified microflagellates.

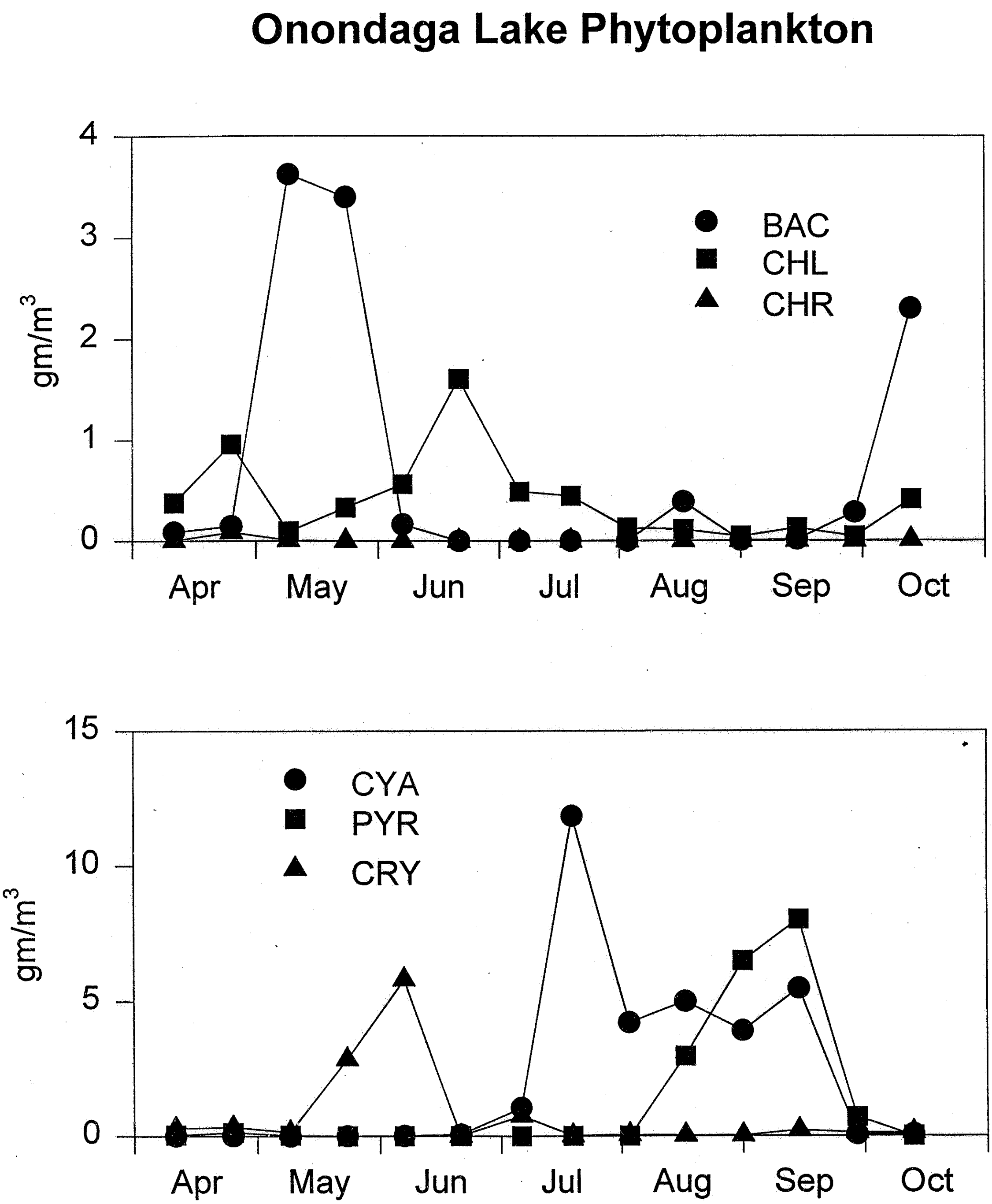


Figure 8. Seasonal biomass of various groupings of phytoplankton of Onondaga Lake, 1994. BAC=Bacillariophyta, CHL=Chlorophyta, CHR=Chrysophyta, PYR=Pyrrophyta, CYA=Cyanobacteria, CRy=Cryptophyta, UNI=Unidentified microflagellates.

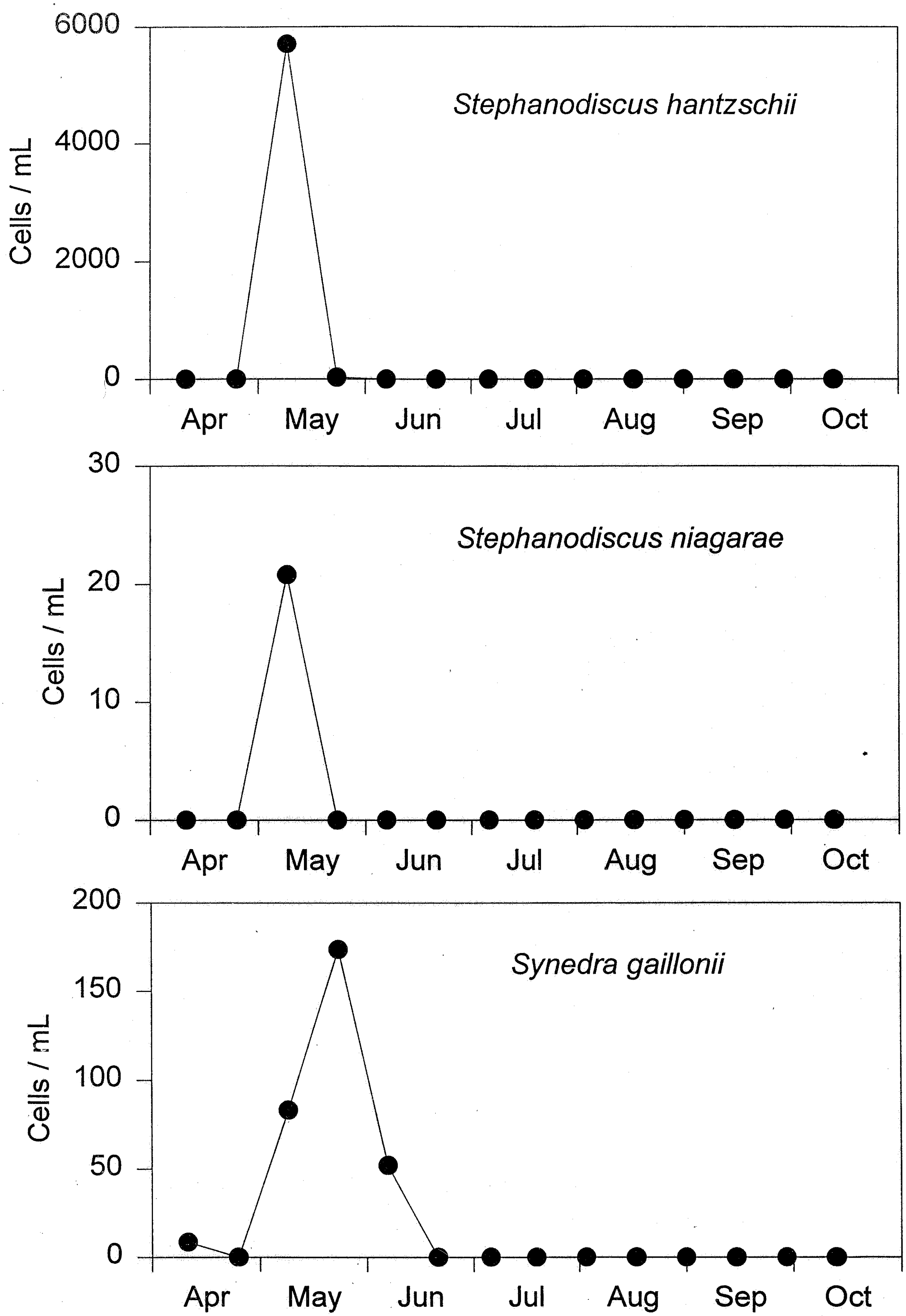


Figure 9. Seasonal abundance of common phytoplankton species (<u>Stephanodiscus hantzschii</u>, <u>S. niagarae</u>, <u>Synedra gaillonii</u>) of Onondaga Lake, 1994.

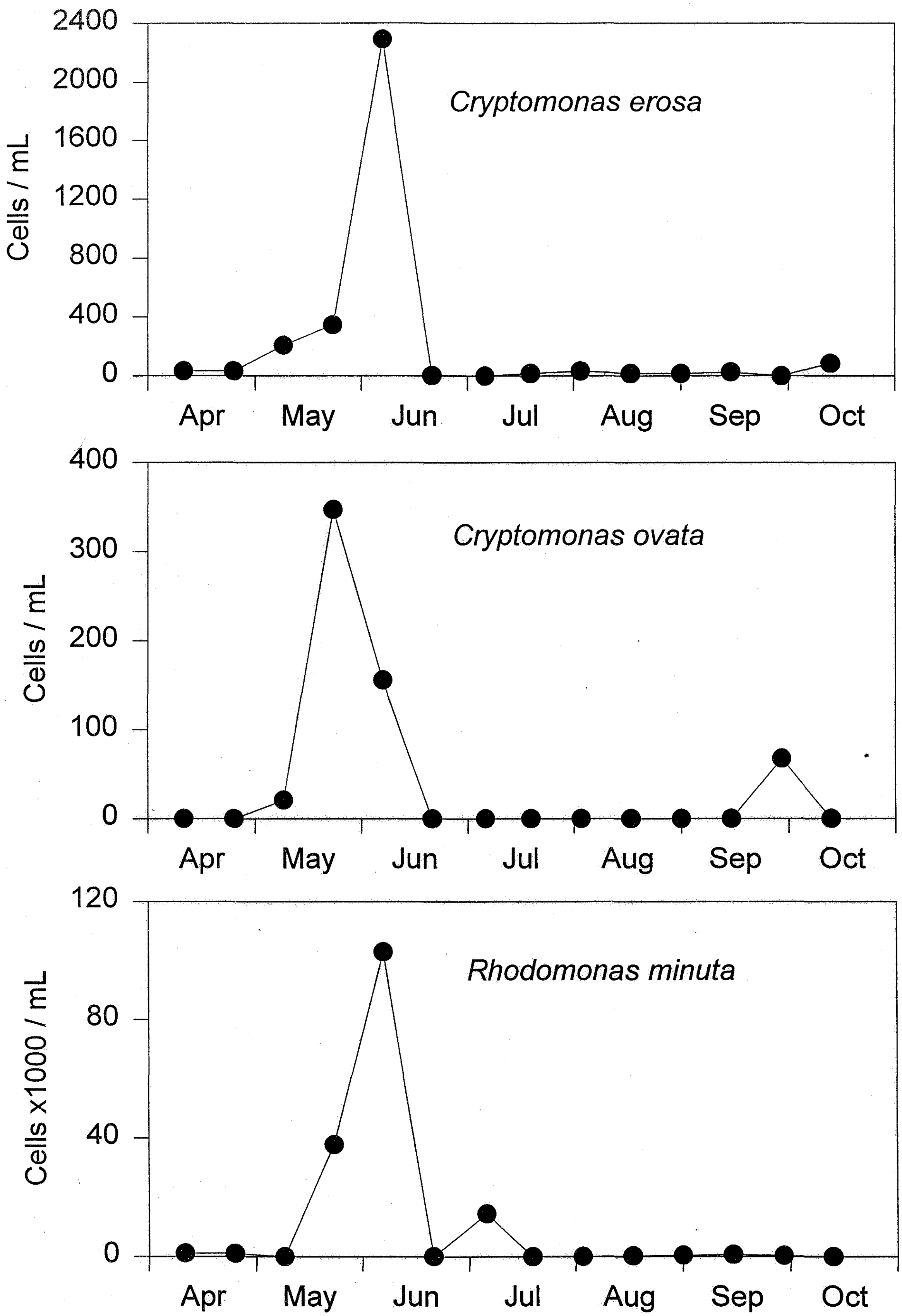


Figure 10. Seasonal abundance of common phytoplankton species (Cryptomonas erosa, Cryptomonas ovata, Rhodomonas minuta) of Onondaga Lake, 1994.

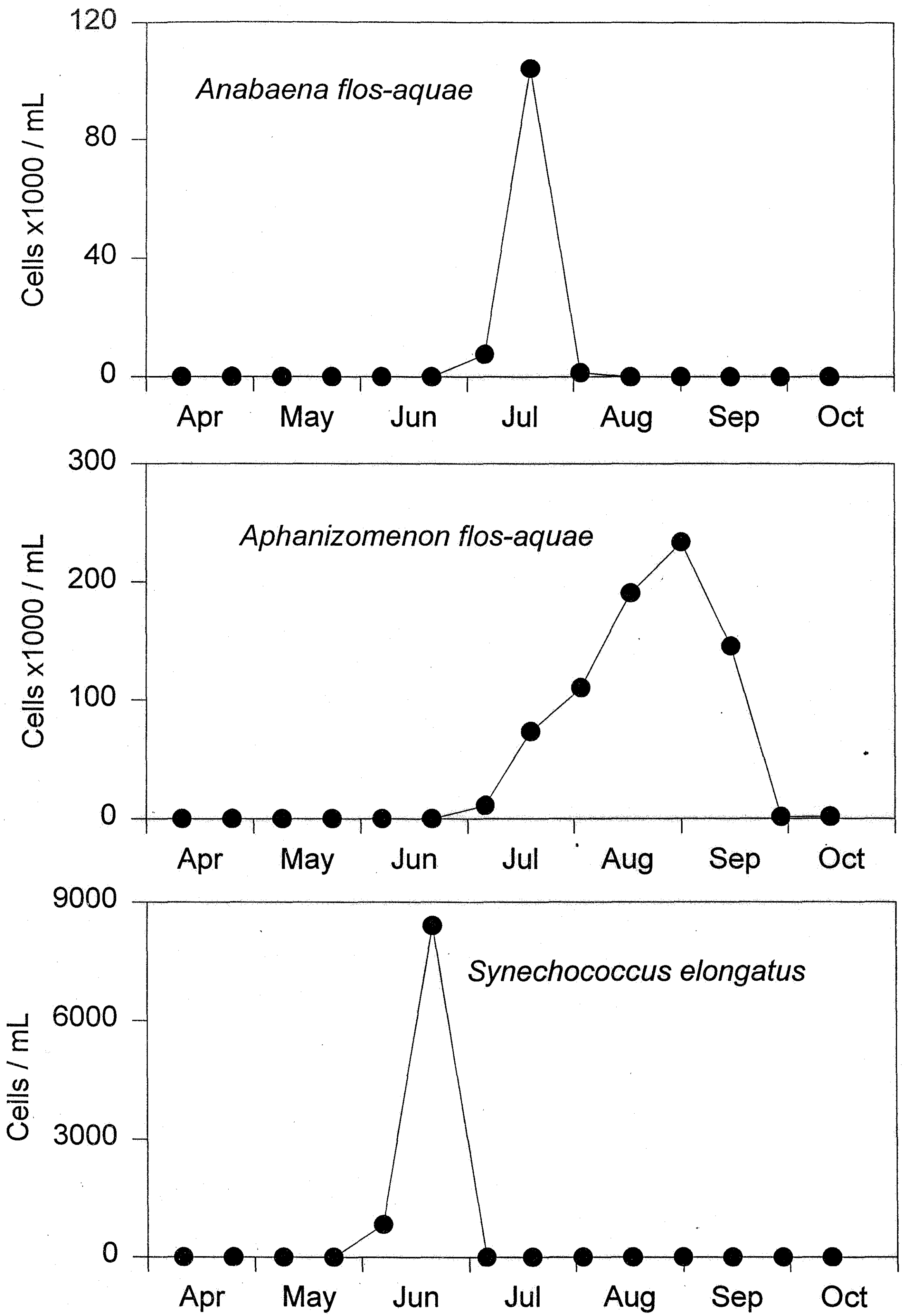


Figure **11**. Seasonal abundance of common phytoplankton species (Anabaena flos-aquae, Aphanizomenon flos-aquae, Synechococcus elongatus) of Onondaga Lake, 1994.

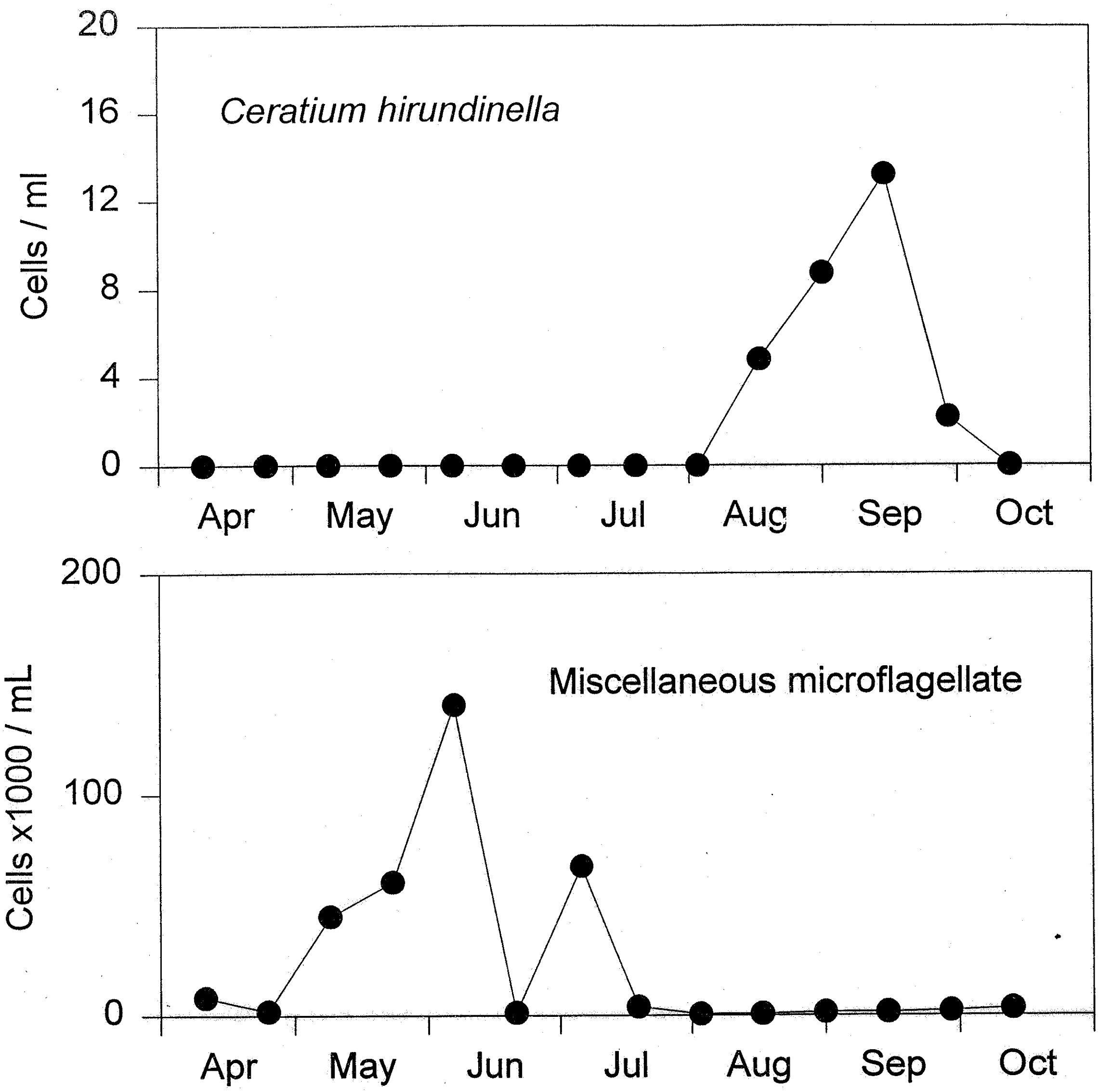


Figure **12.** Seasonal abundance of common phytoplankton species (Ceratium hirundinella, Miscellaneous microflagellates) of Onondaga Lake, 1994.

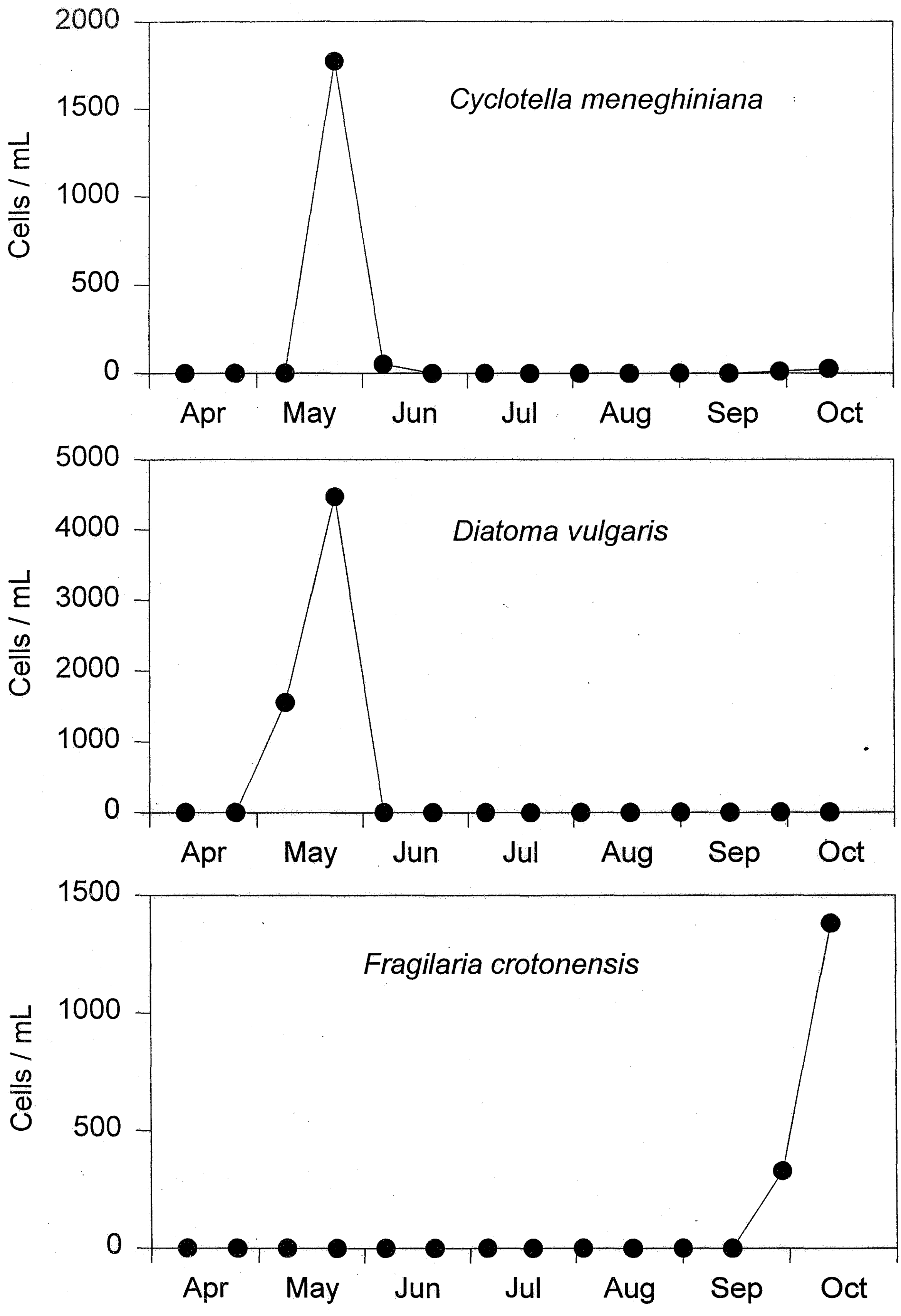


Figure **13**. Seasonal abundance of common phytoplankton species (Cyclotella meneghiniana, Diatoma vulgaris, Fragilaria crotonensis) of Onondaga Lake, 1994.

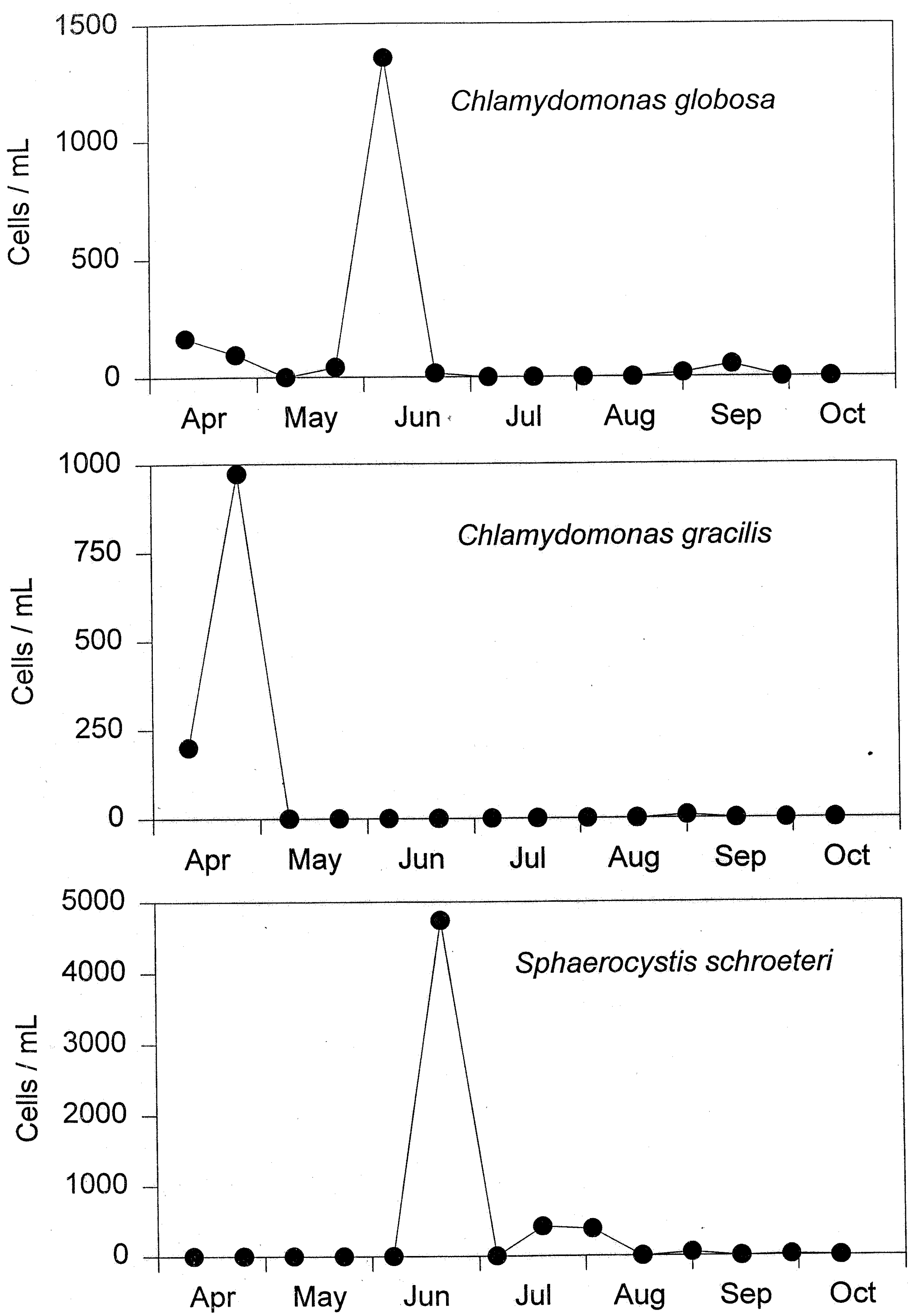


Figure **14.** Seasonal abundance of common phytoplankton species (Chlamydomonas globosa, Chlamydomonas gracilis, Sphaerocystis schroeteri) of Onondaga Lake, 1994.

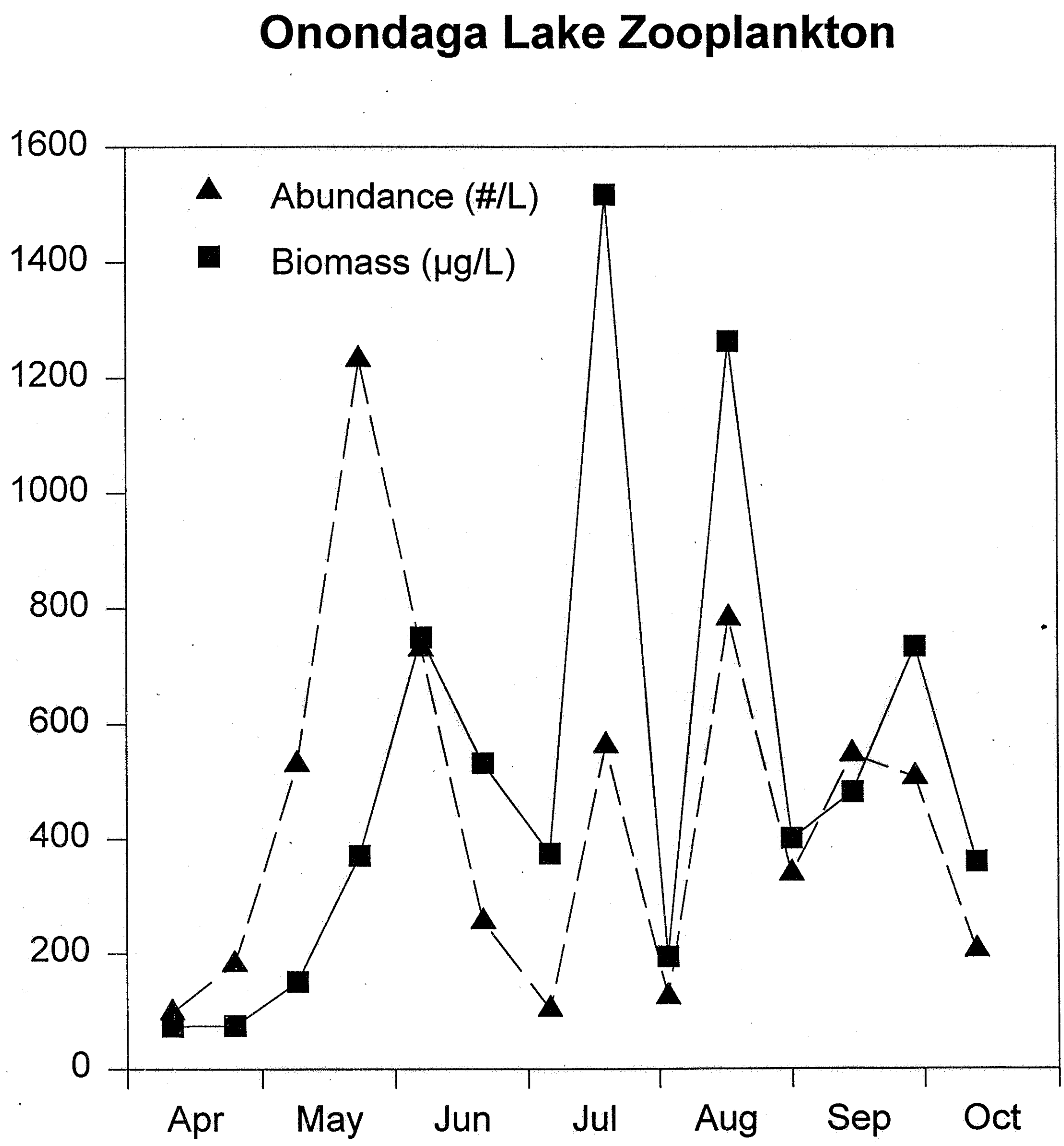


Figure 15. Seasonal abundance and biomass of zooplankton of Onondaga Lake, 1994.

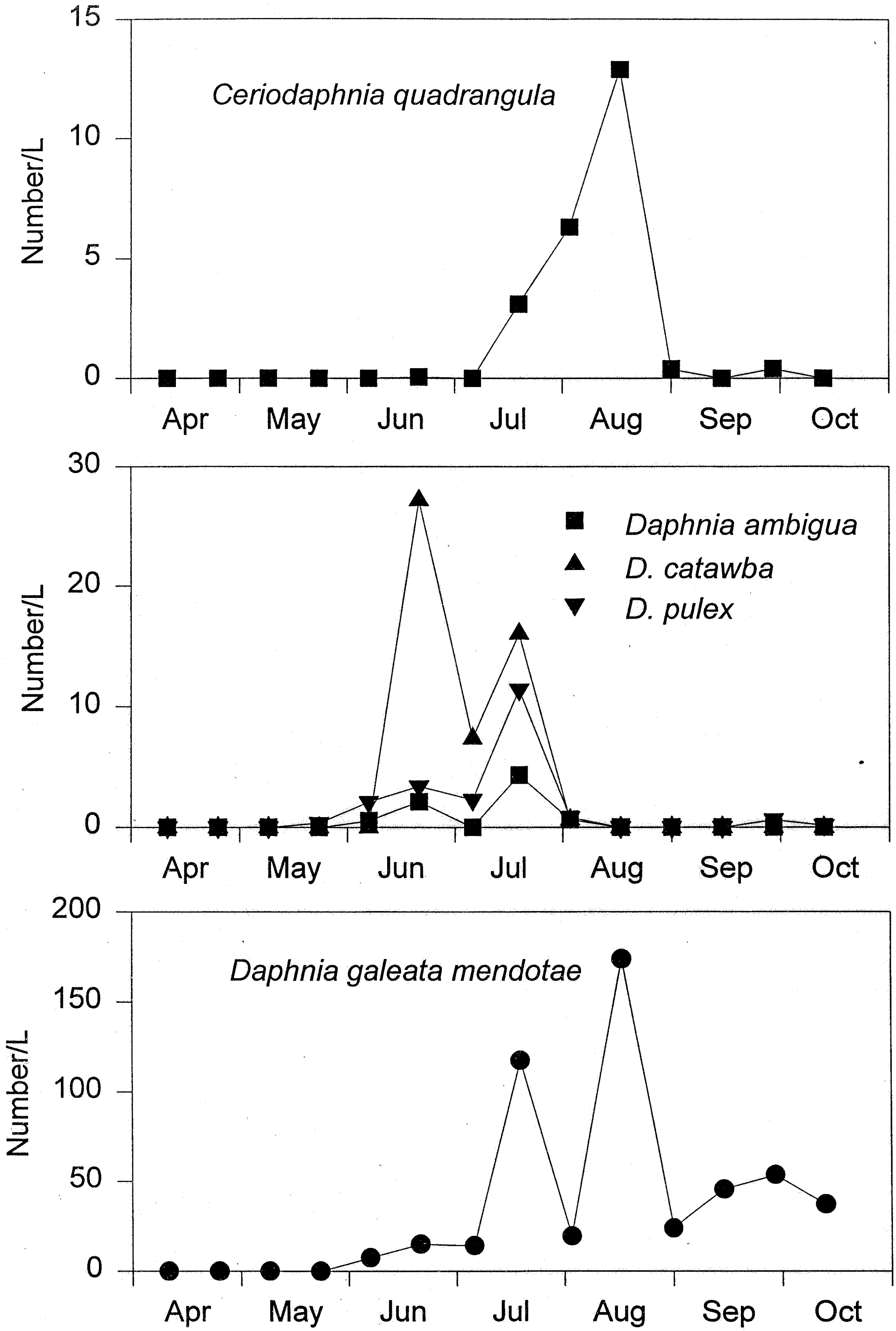


Figure **16**. Seasonal abundance of common zooplankton species (Ceriodaphnia quadrangula, Daphnia ambigua, D. catawba, D. pulex, D. galeata mendotae) of Onondaga Lake, 1994.

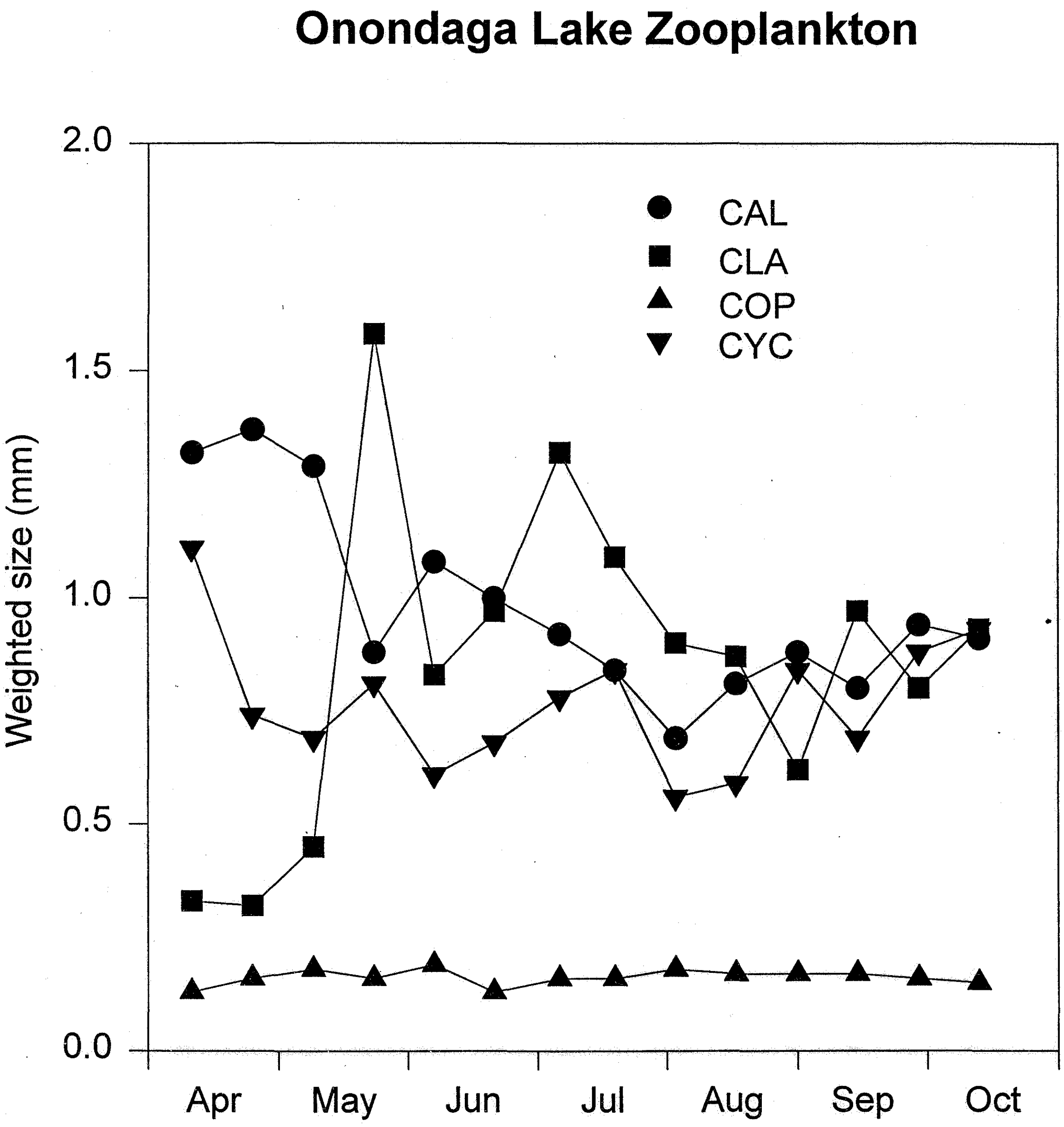


Figure 17. Seasonal size distribution of zooplankton in Onondaga Lake, 1994. CAL=Calanoida, CLA=Cladocera, COP=Copepoda nauplii, CYC=Cyclopoida.

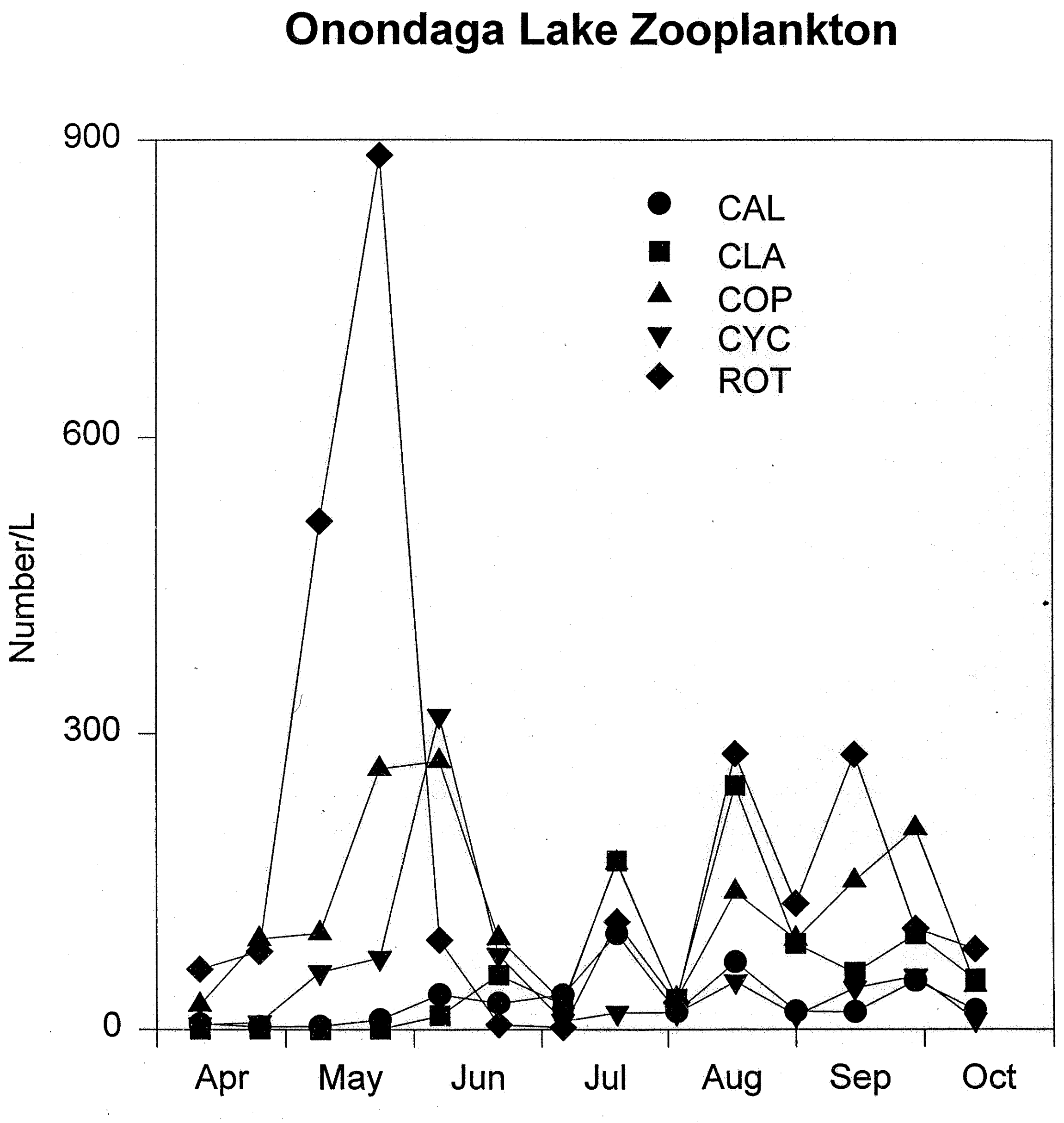


Figure 18. Seasonal abundance of various groups of zooplankton, Onondaga Lake, 1994. CAL=Calanoida, CLA=Cladocera, COP=Copepoda nauplii, CYC=Cyclopoida, ROT=Rotifera.

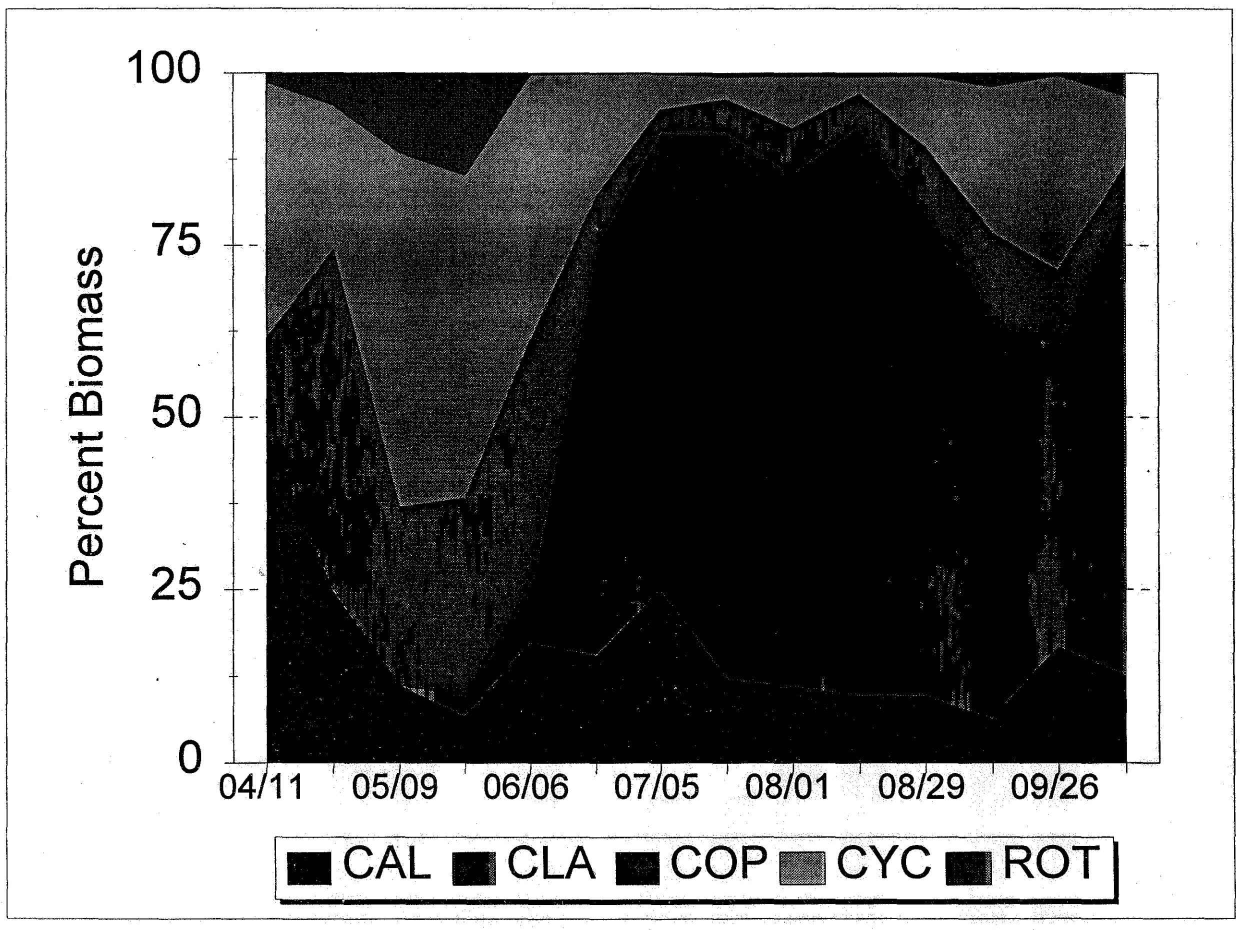


Figure 19. Relative biomass of various groups of zooplankton, Onondaga Lake, 1994. CAL=Calanoida, CLA=Cladocera, COP=Copepoda nauplii, CYC=Cyclopoida, ROT=Rotifera.

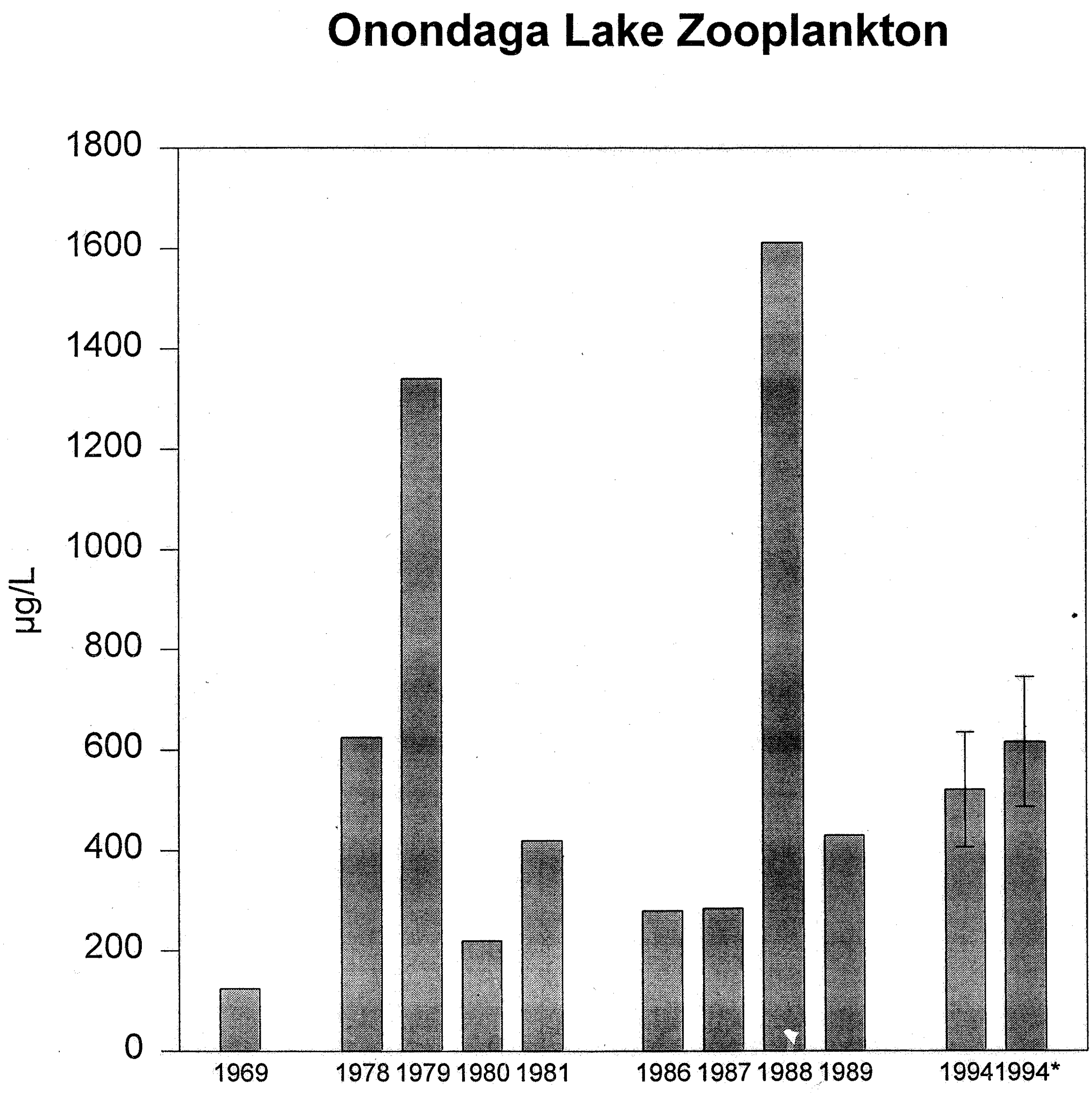


Figure 20. Seasonal biomass of zooplankton in Onondaga Lake. Data from UFI (1994) and this study.

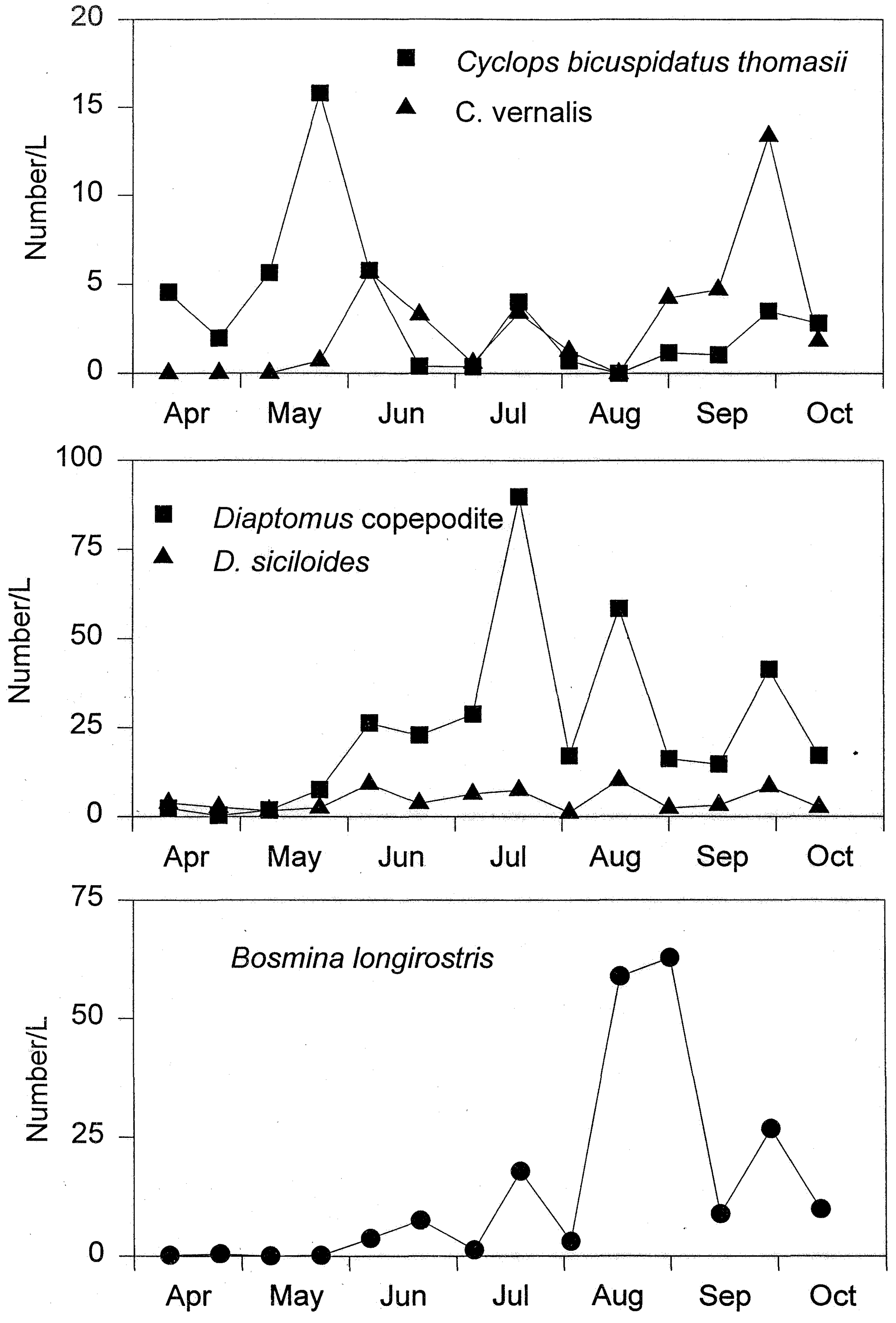


Figure **21**. Seasonal abundance of common zooplankton species (Cyclops bicuspidatus thomasii, C. vernalis, Diaptomus copepodite, D. siciloides, Bosmina longirostris) of Onondaga Lake, 1994.

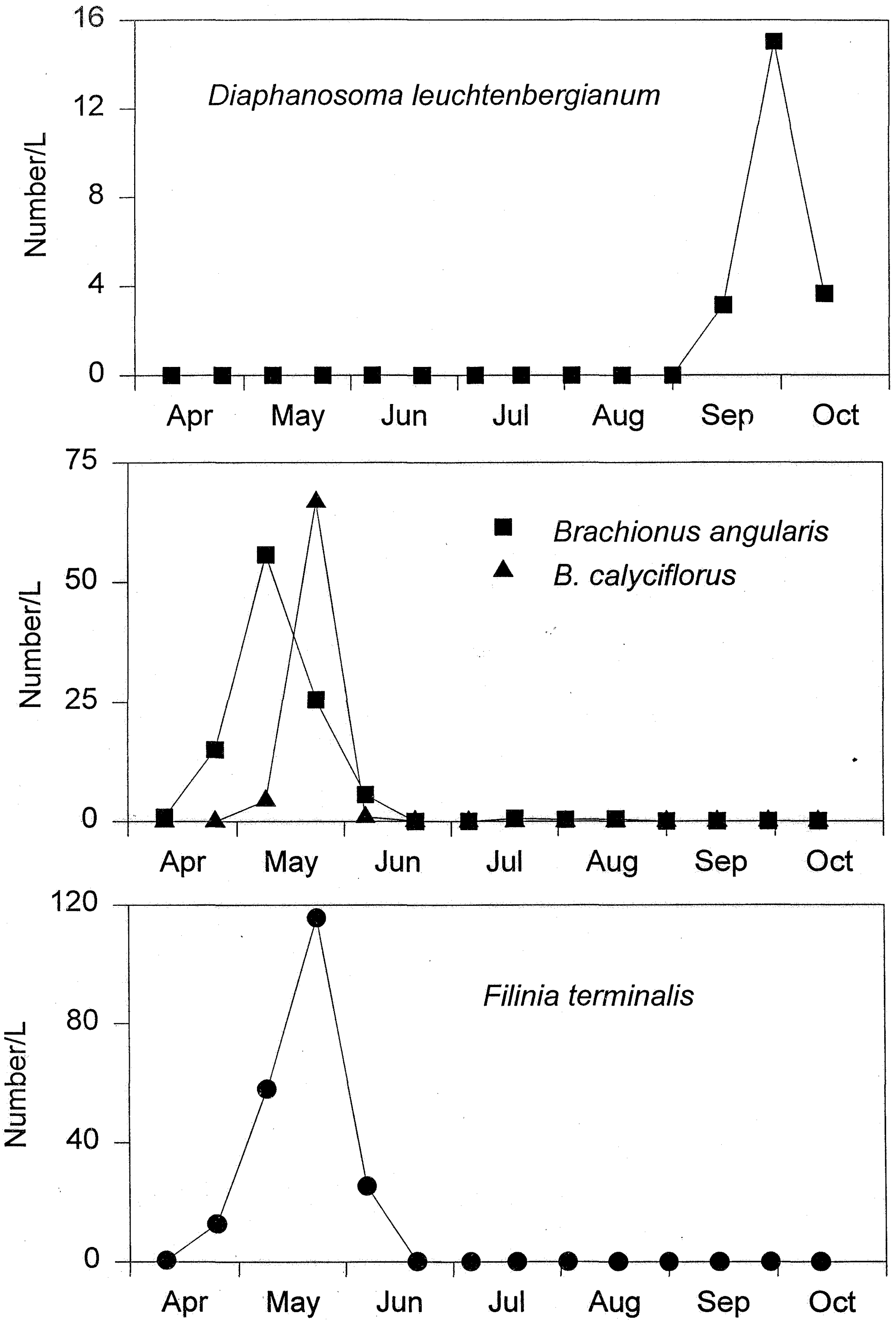


Figure **22**. Seasonal abundance of common zooplankton species (Diaphanosoma leuchtenbergianum, Brachious angularis, B. calyciflorus, Filinia terminalis) of Onondaga Lake, 1994.

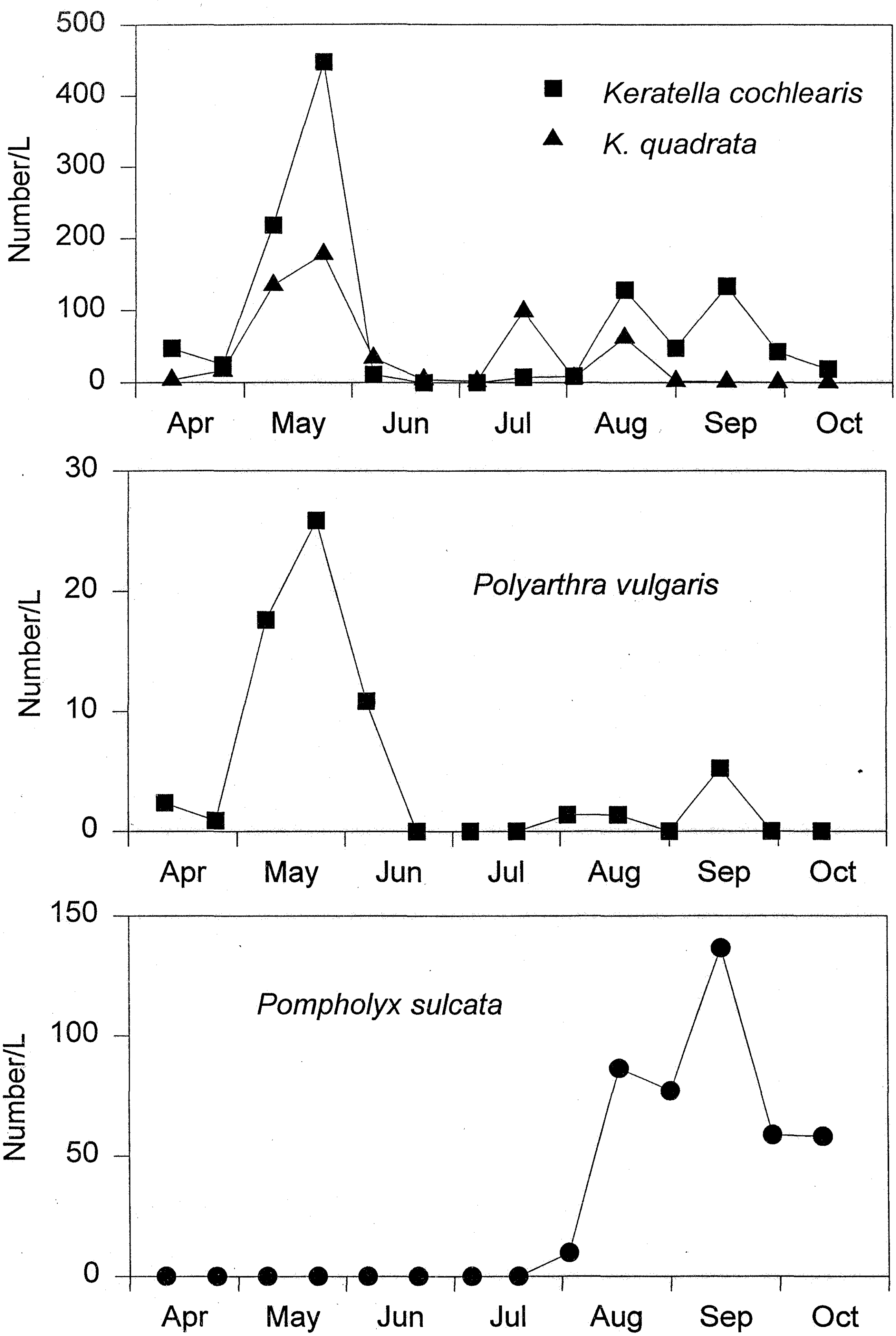


Figure 23. Seasonal abundance of common zooplankton species (Keratella cochlearis, K. quadrata, Polyarthra vulgaris, Pompholyx sulcata) of Onondaga Lake, 1994.

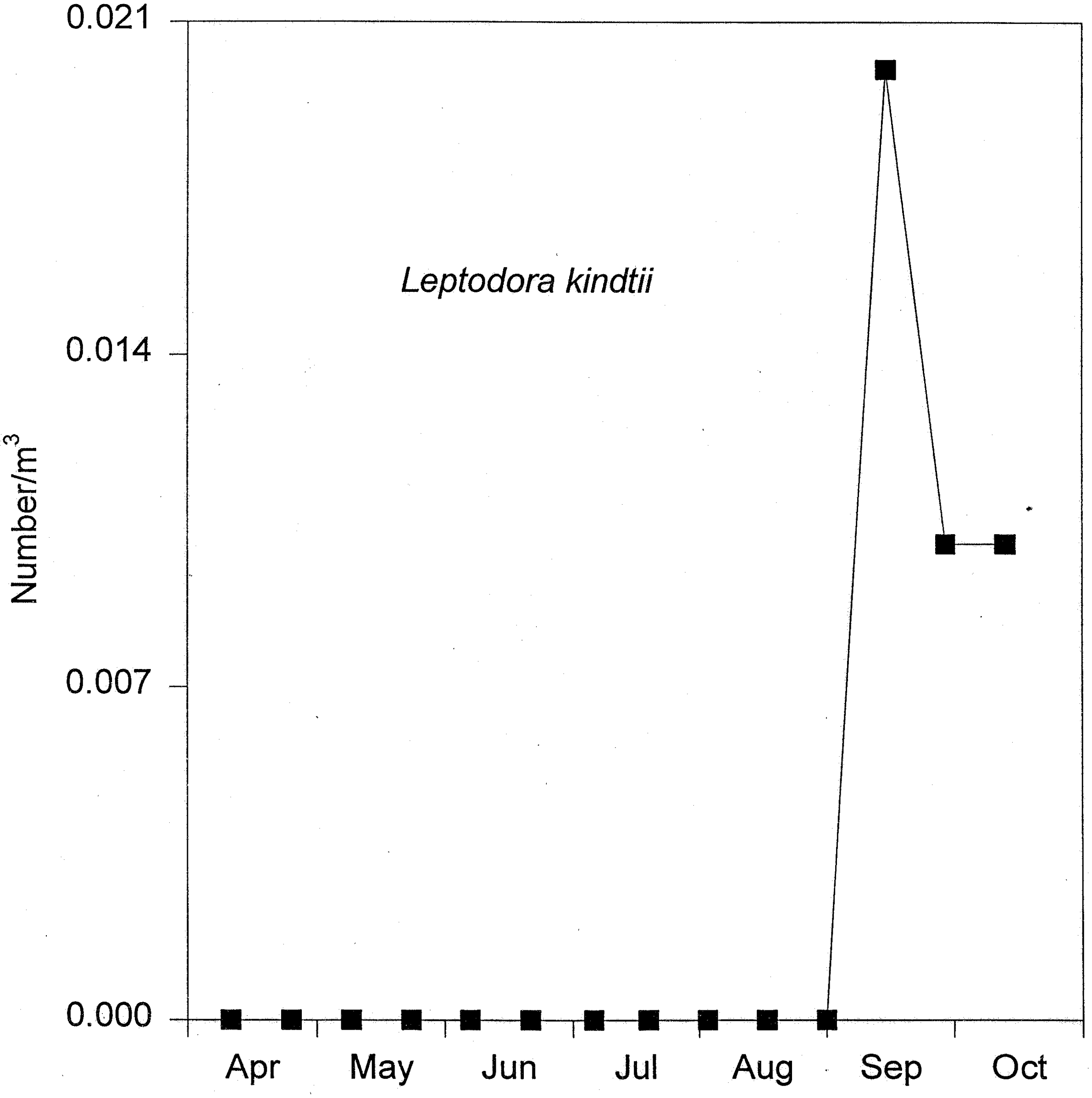


Figure **24.** Seasonal abundance of common zooplankton species (Leptodora kindtii) of Onondaga Lake, 1994.

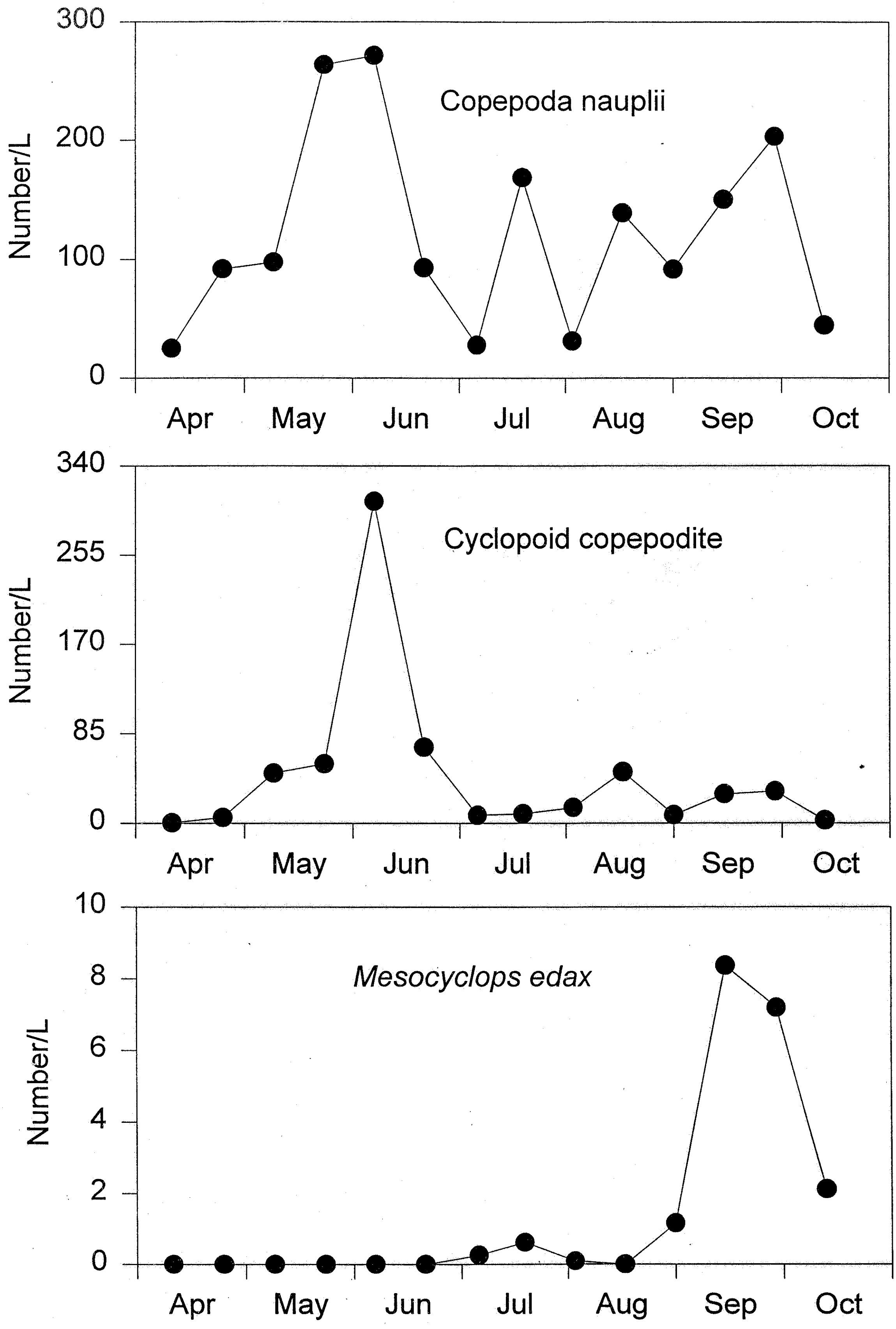


Figure **25.** Seasonal abundance of common zooplankton species (Copepoda nauplii, Cyclopoid copepodite, Mesocysclops edax) of Onondaga Lake, 1994.

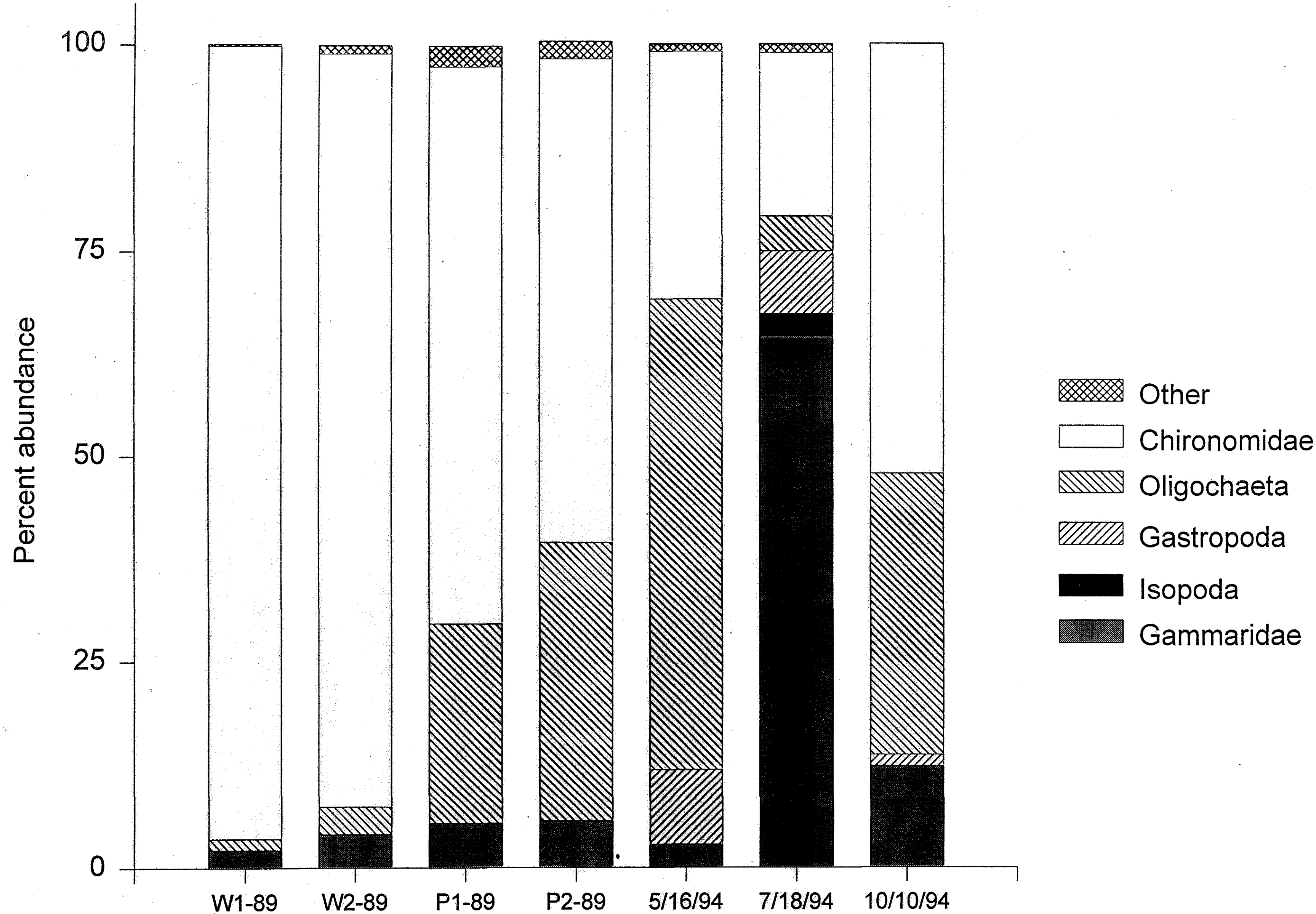


Figure **26**. Relative abundance of benthic macroinvertebrates in Onondaga Lake, 1989 and 1994. 1989 data are from UFI (1994). W1, W2 and the 1994 results are from sites on the west shore at the former Allied Waste Bed sites. P1 and P2 are on the east shore of the lake.

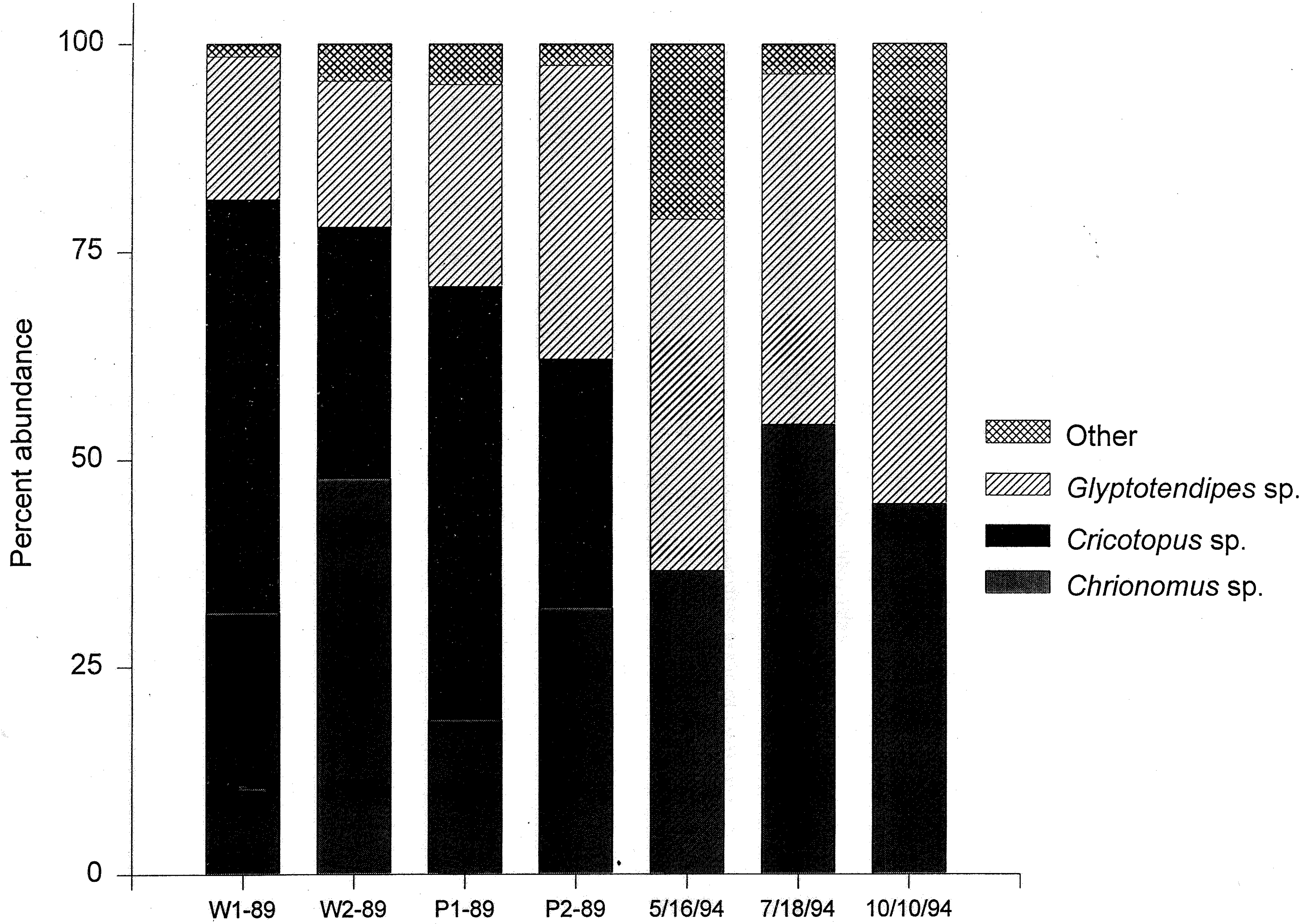


Figure **27.** Relative abundance of genera of Chironomidae in 1994 at the former Allied Waste Bed sites.

Appendix

Appendix 1. Seasonal phytoplankton data by species for Onondaga Lake, April -October, 1994.

Appendix 2. Seasonal zooplankton data by species for Onondaga Lake, April -October, 1994.

Appendix 3. Phytoplankton species list, Onondaga Lake, 1994.

Appendix 4. Zooplankton species list, Onondaga Lake, 1994.

Appendix 5. Letter from Phycotech, Inc. discussing possible areas of confusion in phytoplankton identification.

Appenix 1 . Onondaga Lake, 1994 phytoplankton abundance (cells/mL).

DATE	Achnanthes deflexa	Asterionella formosa	Cocconeis sp.	Cyclotella sp.	Cyclotella sp. 2	Cyclotella sp. 3	Cyclotella bodanica	Cyclotella meneghiniana	Diatoma vulgaris
04/11/94	0	0	0	0	0	0	0	0	0
04/25/94	17	0	0	17	0	0	0	0	0
05/09/94	0	0	0	21	0	0	42	0	1,558
05/23/94	0	0	0	139	0	0	0	1,771	4,473
06/06/94	0	0	0	0	208	0	0	52	0
06/20/94	0	0	0	0	0	29	0	0	0
07/05/94	0	0	0	0	0	6	0	0	0
07/18/94	0	0	0	0	0	0	0	0	0
08/01/94	0	0	0	0	0	0	0	0	0
08/15/94	0	0	0	0	0	0	0	0	0
08/29/94	0	0	0	9	0	0	0	0	0
09/12/94	0	0	35	0	0	0	0	0	0
09/26/94	0	0	0	0	0	0	0	11	0
10/10/94	0	46	0	0	0	0	0	26	0

DATE	Fragilaria crotonensis	Fragilaria capucina	Fragilaria construens	Melosira sp.	Navicula sp.	Navicula radiosa	Nitzschia sp.	Nitzschia acicularis	Nitzschia perminuta
04/11/94	0	0	0	0	9	0	0	0	0
04/25/94	0	0	0	0	0	43	9	0	0
05/09/94	0	21	21	0	0	0	0	21	0
05/23/94	0	0	0	0	0	0	0	35	69
06/06/94	0	0	0	0	0	0	0	52	52
06/20/94	0	0	0	0	0	0	0	0	0
07/05/94	0	0	0	0	0	0	0	0	0
07/18/94	0	0	0	0	0	0	0	0	0
08/01/94	0	0	0	0	0	0	0	0	0
08/15/94	0	4	0	800	0	0	0	0	0
08/29/94	0	0	0	0	0	0	0	0	0
09/12/94	0	0	0	0	0	0	0	0	0
09/26/94	329	0	7	0	0	0	0	0	0
10/10/94	1,381	0	0	0	0	0	0	0	0

Appenix 1 . Onondaga Lake, 1994 phytoplankton abundance (cells/mL).

DATE	Stephanodiscus niagarae	Stephanodiscus hantzschii	Synedra sp.	Synedra gaillonii	Synedra radians	Tabellaria fenestrata	Neidium sp.	Ankistrodesmus falcatus	Botryococcus braunii
04/11/94	0	0	0	9	0	0	9	9	0
04/25/94	0	0	9	0	0	17	0	26	0
05/09/94	21	5,709	21	83	0	0	0	313	0
05/23/94	0	35	0	174	70	0	0	1,979	0
06/06/94	0	0	0	52	0	0	0	417	0
06/20/94	0	0	0	0	0	0	0	23	0
07/05/94	0	0	0	0	0	0	0	0	0
07/18/94	0	0	0	0	0	0	0	17	0
08/01/94	0	0	0	0	0	0	0	0	0
08/15/94	0	0	0	0	0	0	0	0	0
08/29/94	0	0	0	0	0	0	0	0	0
09/12/94	0	0	0	0	0	0	0	0	0
09/26/94	0	0	0	0	0	0	0	0	0
10/10/94	0	0	0	0	0	0	0	9	710

DATE	Carteria platyrhyncha	Characium sp.	Characium limnetcum	Chlamydomonas sp.	Chlamydomonas globosa	Chlamydomonas incerta	Chlamydomonas gracilis	Chlamydomonas platystigma	Chlamydomonas gloeopara
04/11/94	0	0	0	0	165	113	200	130	0
04/25/94	35	0	0	69	96	35	972	330	0
05/09/94	0	0	0	0	0	0	0	0	0
05/23/94	0	0	0	0	42	35	0	0	0
06/06/94	52	0	0	0	1,354	0	0	52	0
06/20/94	0	0	0	0	17	0	0	0	93
07/05/94	0	0	0	0	0	0	0	0	52
07/18/94	0	0	0	0	0	0	0	0	0
08/01/94	35	0	0	0	0	0	0	0	0
08/15/94	0	104	0	0	0	0	0	0	0
08/29/94	0	0	0	0	17	0	9	0	0
09/12/94	92	0	0	0	52	0	0	17	0
09/26/94	0	0	20	0	0	0	0	0	0
10/10/94	0	0	0	0	0	0	0	0	0

Appenix 1 . Onondaga Lake, 1994 phytoplankton abundance (cells/mL).

DATE	Closterium sp.	Closterium moniliferum	Coelastrum sp.	Coelastrum microporum	Crucigenia rectangularis	Crucigenia quadrata	Dictyosphaerium pulchellum	Eurastrum sp.	Gloeocystis gigas
04/11/94	0	0	0	0	0	0	0	0	0
04/25/94	0	0	0	0	0	0	35	0	0
05/09/94	0	0	0	0	0	0	0	0	0
05/23/94	0	0	0	0	0	278	0	0	0
06/06/94	0	0	0	0	0	0	2,396	0	0
06/20/94	0	0	0	0	0	0	0	0	0
07/05/94	0	0	0	0	0	0	0	0	69
07/18/94	0	0	0	0	0	0	0	0	69
08/01/94	0	0	0	0	0	0	0	0	52
08/15/94	0	0	0	140	0	0	0	0	0
08/29/94	0	0	0	0	0	0	0	0	0
09/12/94	17	0	0	0	0	0	0	0	0
09/26/94	0	4	4	0	0	0	0	0	0
10/10/94	0	0	0	421	26	0	0	7	0

DATE	Micractinium pusillum	Oocystis parva	Oocystis borgei	Pediastrum duplex	Scenedesmus sp.	Scenedesmus dimorphus	Schroederia judayi	Selenastrum minutum	Tetraedron minimum
04/11/94	0	0	0	0	0	0	0	0	0
04/25/94	0	0	0	0	146	0	0	0	0
05/09/94	0	0	0	0	667	0	0	21	0
05/23/94	382	0	0	0	1,042	2,153	0	35	0
06/06/94	0	0	0	0	52	0	0	0	0
06/20/94	0	6	0	0	0	0	243	23	0
07/05/94	0	0	0	289	0	0	440	0	0
07/18/94	0	17	35	1,007	17	0	260	0	0
08/01/94	0	69	69	0	0	0	174	87	17
08/15/94	0	184	63	0	0	0	52	0	0
08/29/94	0	135	9	0	0	0	9	9	0
09/12/94	0	139	0	0	0	0	69	0	0
09/26/94	0	44	0	0	0	0	473	0	0
10/10/94	0	105	0	0	0	0	252	0	0

Appenix 1 . Onondaga Lake, 1994 phytoplankton abundance (cells/mL).

DATE	Ulothrix sp.	Sphaerocystis schroeteri	Colonial chlorophyta - type	Non-motile Chlorococcales	Lobomonas sp.	Lagerheimia quadriseta	Scenedesmus quadricauda	Scenedesmus arcuatus v. platydisca	Spermatozopsis exultans
04/11/94	0	0	35	17	0	0	35	0	0
04/25/94	0	0	35	0	9	0	0	0	0
05/09/94	0	0	0	104	0	0	0	500	0
05/23/94	0	0	0	0	0	0	278	0	0
06/06/94	0	0	0	156	0	0	0	0	0
06/20/94	0	4,740	0	6	0	0	0	0	6
07/05/94	1,788	0	0	12	0	6	0	0	0
07/18/94	0	417	0	0	0	0	0	0	0
08/01/94	0	382	0	17	0	0	0	0	0
08/15/94	0	0	0	0	0	0	0	0	0
08/29/94	0	52	0	17	0	0	0	0	0
09/12/94	0	0	0	0	0	0	0	0	0
09/26/94	0	18	0	11	0	0	0	0	0
10/10/94	0	0	0	0	0	0	7	0	0

DATE	Deasonia gigantica	Synura sp. (single)	Chrysococcus sp.	Ochromonas sp.	Cyst (Chrysophyte)	Colonial Chrysophyte	Anabaena flos-aquae	Aphanizomenon flos-aquae	Aphanocapsa elachista
04/11/94	0	0	9	0	17	0	0	0	0
04/25/94	0	17	0	0	9	655	0	0	0
05/09/94	0	0	21	21	0	0	0	0	0
05/23/94	0	0	0	0	0	0	0	0	0
06/06/94	0	0	0	0	0	0	0	0	0
06/20/94	0	0	0	0	0	0	0	0	0
07/05/94	23	0	0	0	0	0	7,673	11,144	0
07/18/94	0	0	0	0	0	0	104,288	73,199	0
08/01/94	0	0	0	0	0	0	1,435	110,307	0
08/15/94	0	0	0	0	0	0	0	190,450	0
08/29/94	0	0	0	0	0	0	0	233,547	0
09/12/94	0	0	0	0	0	0	0	145,322	1,250
09/26/94	0	0	0	0	0	0	0	1,491	66
10/10/94	0	0	0	17	0	0	0	1,556	0

Appenix 1 . Onondaga Lake, 1994 phytoplankton abundance (cells/mL).

DATE	Chroococcus limneticus	Chroococcus prescottii	Oscillatoria sp.	Oscillatoria sp. 2	Oscillatoria limnetica	Gomphosphaeria lacustris	Microcystis aeruginosa	Non-motile Blue-greens	Synechococcus elongatus
04/11/94	0	0	0	0	139	0	0	0	0
04/25/94	0	0	306	0	0	0	0	0	0
05/09/94	0	0	0	0	0	0	0	0	0
05/23/94	0	0	70	0	0	0	0	0	0
06/06/94	0	0	0	0	0	1,563	0	0	833
06/20/94	0	0	0	0	232	0	0	0	8,403
07/05/94	0	0	0	0	0	0	0	0	0
07/18/94	0	139	0	0	0	0	0	0	0
08/01/94	0	0	0	0	0	0	0	0	0
08/15/94	0	0	0	0	0	0	415	156	0
08/29/94	0	0	0	0	0	0	0	35	0
09/12/94	69	0	0	295	0	0	0	104	0
09/26/94	0	0	0	0	110	0	0	0	0
10/10/94	0	0	0	0	1,042	0	0	43	0

DATE	Ceratium hirundinella	Gymnodinium sp.	Gymnodinium sp. 3	Peridinium umbonatum	Cryptomonas erosa	Cryptomonas lucens	Rhodomonas minuta	R. minuta var. nannoplanctica	Cryptomonas ovata
04/11/94	0	43	0	0	35	0	1,181	78	0
04/25/94	0	43	0	52	35	0	1,068	26	0
05/09/94	0	0	0	42	208	0	0	42	21
05/23/94	0	0	0	0	347	35	37,815	0	347
06/06/94	0	0	0	0	2,292	0	102,900	0	156
06/20/94	0	0	0	0	6	0	93	0	0
07/05/94	0	0	0	0	0	0	14,584	0	0
07/18/94	0	0	17	0	17	0	0	35	0
08/01/94	0	0	0	0	35	0	0	1,059	0
08/15/94	5	0	0	0	18	0	208	0	0
08/29/94	9	0	0	0	17	0	469	0	0
09/12/94	13	17	0	0	26	0	712	0	0
09/26/94	2	0	0	0	0	2	357	0	68
10/10/94	0	0	0	0	86	0	0	330	0

Appenix 1 . Onondaga Lake, 1994 phytoplankton abundance (cells/mL).

DATE	Misc. microflagellate
04/11/94	8,074
04/25/94	1,771
05/09/94	44,795
05/23/94	60,421
06/06/94	140,600
06/20/94	1,215
07/05/94	67,713
07/18/94	3,907
08/01/94	521
08/15/94	729
08/29/94	1,354
09/12/94	1,458
09/26/94	2,170
10/10/94	3,125

Appendix 2. Onondaga Lake, 1994 zooplankton abundance (#/m^3).

DATE	*Cyclops bicuspidatus thomasi*	*Cyclops vernalis*	*Diaptomus siciloides*	Cyclopoid - copepodite	Copepoda - nauplii	*Bosmina longirostris*	*Daphnia galeata mendotae*	*Asplanchna priodonta*
04/11/94	4,562	0	3,832	547	25,182	182	0	0
04/25/94	1,972	0	2,629	5,478	91,917	438	0	0
05/09/94	5,638	0	1,674	47,745	97,605	0	0	1,674
05/23/94	15,801	718	2,514	56,382	263,953	180	0	718
06/06/94	5,780	5,692	9,195	306,507	271,653	3,766	7,531	0
06/20/94	411	3,287	3,757	72,207	92,812	7,573	15,028	0
07/05/94	392	587	6,395	7,569	27,798	1,305	14,160	0
07/18/94	4,012	3,394	7,406	8,949	168,799	17,898	117,573	0
08/01/94	731	1,279	1,097	14,897	31,347	3,107	19,558	0
08/15/94	0	0	10,125	48,785	138,990	58,910	173,968	0
08/29/94	1,156	4,239	2,312	7,708	91,725	62,820	23,895	0
09/12/94	1,046	4,708	3,139	27,727	150,144	8,894	45,514	2,093
09/26/94	3,499	13,379	8,439	30,257	203,363	26,758	53,516	412
10/10/94	2,816	1,831	2,535	2,676	44,499	9,857	37,036	3,802

DATE	*Keratella cochlearis*	*Keratella quadrata*	*Notholca acuminata*	*Polyarthra dolichoptera*	*Polyarthra major*	*Polyarthra vulgaris*	*Synchaeta sp.*	*Trichocerca multicrinis*
04/11/94	47,627	4,015	365	1,095	730	2,372	1,642	730
04/25/94	24,760	16,652	3,725	4,930	329	876	110	0
05/09/94	218,289	135,308	441	5,814	1,145	17,618	16,033	0
05/23/94	447,105	178,124	0	22,265	2,155	25,857	180	0
06/06/94	11,209	34,416	0	2,277	0	10,859	0	0
06/20/94	176	4,814	0	0	0	0	0	0
07/05/94	131	2,153	0	0	0	0	0	0
07/18/94	7,715	99,057	0	0	0	0	0	0
08/01/94	8,956	6,854	0	0	0	1,371	0	0
08/15/94	128,405	62,592	0	0	0	1,381	0	0
08/29/94	47,789	2,312	0	0	385	0	0	0
09/12/94	133,403	1,046	0	0	0	5,232	0	0
09/26/94	42,607	412	0	0	0	0	0	0
10/10/94	19,151	422	0	0	0	0	0	0

Appendix 2 (cont.). Onondaga Lake, 1994 zooplankton abundance (#/m^3).

DATE	*Trichocerca sp.*	*Mesocyclops edax*	*Leptodora kindtii*	*Daphnia catawba*	Unknown rotifer sp.	*Diaphanosoma leuchtenbergianum*	*Ceriodaphnia quadrangula*	*Pompholyx sulcata*
04/11/94	365	0	0.00	0	0	0	0	0
04/25/94	0	0	0.00	0	110	0	0	0
05/09/94	0	0	0.00	0	0	0	0	0
05/23/94	0	0	0.00	0	0	0	0	0
06/06/94	0	0	0.00	0	0	0	0	0
06/20/94	0	0	0.00	27,180	0	0	59	0
07/05/94	0	261	0.00	7,374	0	0	0	0
07/18/94	0	617	0.00	16,047	0	0	3,086	0
08/01/94	0	91	0.00	640	0	0	6,306	9,870
08/15/94	0	0	0.00	0	0	0	12,886	86,524
08/29/94	0	1,156	0.00	0	0	0	385	77,079
09/12/94	0	8,370	0.02	0	0	3,139	0	136,542
09/26/94	0	7,204	0.01	0	0	15,026	412	58,868
10/10/94	0	2,112	0.01	0	0	3,661	0	58,159

DATE	Chydoridae	*Polyarthra euryptera*	*Pompholyx sulcata*	*Diaptomus copepodite*	*Brachionus angularis*	*Brachionus calyciflorus*	*Daphnia ambigua*	*Hexarthra mira*
04/11/94	0	547	365	2,372	912	0	0	0
04/25/94	0	219	0	329	15,009	0	0	0
05/09/94	0	0	0	1,762	55,673	4,405	0	0
05/23/94	0	0	0	7,542	25,498	66,796	0	0
06/06/94	175	0	0	26,360	5,605	876	525	0
06/20/94	0	0	0	22,953	0	59	2,113	0
07/05/94	0	0	0	28,842	0	0	0	0
07/18/94	0	0	0	89,800	617	0	4,320	1,543
08/01/94	0	0	0	17,090	366	0	640	91
08/15/94	920	0	0	58,449	460	0	0	0
08/29/94	0	0	0	16,187	0	0	0	0
09/12/94	0	0	0	14,648	0	0	0	0
09/26/94	0	0	0	41,372	0	0	0	0
10/10/94	0	0	0	17,039	0	0	0	0

Appendix 2 (cont.). Onondaga Lake, 1994 zooplankton abundance (#/m^3).

DATE	*Filinia terminalis*	*Daphnia pulex*
04/11/94	547	0
04/25/94	12,818	0
05/09/94	58,140	0
05/23/94	115,637	359
06/06/94	25,484	2,102
06/20/94	117	3,405
07/05/94	0	2,284
07/18/94	0	11,418
08/01/94	0	823
08/15/94	0	0
08/29/94	0	0
09/12/94	0	0
09/26/94	0	618
10/10/94	0	141

Appendix 3. Onondaga Lake phytoplankton species list 1994.

TAXON		AUTHORITY
BACILLARIOPHYTA		
	Achnanthes deflexa	Reimer
	Asterionella formosa	Hassall
	Cocconeis sp.	Ehrenberg
	Cyclotella bodanica	Grunow
	Cyclotella meneghiniana	Kutzing
	Cyclotella sp.	(Kutzing) de Brbisson
	Cyclotella sp. 2	(Kutzing) de Brbisson
	Cyclotella sp. 3	(Kutzing) de Brbisson
	Diatoma vulgaris	Bory
	Fragilaria capucina	Desmazieres
	Fragilaria construens	(Ehrenberg) Grunow
	Fragilaria crotonensis	Kitton
	Melosira sp.	Agardh
	Navicula radiosa	Kutzing
	Navicula sp.	Bory
	Neidium sp.	Pfitzer
	Nitzschia acicularis	(Kutzing) W. Smith
	Nitzschia perminuta	(Grunow) M. Peragallow
	Nitzschia sp.	Hassal
	Stephanodiscus hantzschii	Grunow
	Stephanodiscus niagarae	Ehrenberg
	Synedra gaillonii	(Bory) Ehrenberg
	Synedra radians	Kutzing
	Synedra sp.	Ehrenberg
	Tabellaria fenestrata	(Lyngbye) Kutzing
CHLOROPHYTA		
	Ankistrodesmus falcatus	(Corda) Ralfs
	Botryococcus braunii	Kutzing
	Carteria platyrhyncha	Ettl
	Characium limnetcum	Lemmermann
	Characium sp.	A.Braun
	Chlamydomonas globosa	Snow
	Chlamydomonas gloeopara	Rodhe et Skuja
	Chlamydomonas gracilis	Snow
	Chlamydomonas incerta	Pascher
	Chlamydomonas platystigma	(Korschikoff) Pascher
	Chlamydomonas sp.	Ehrenberg
	Closterium moniliferum	(Bory) Ehrenberg
	Closterium sp.	Nitzch
	Coelastrum microporum	Naegeli
	Coelastrum sp.	Naegeli
	Colonial chlorophyta - type 2	N/A
	Crucigenia quadrata	Morren
	Crucigenia rectangularis	(A. Braun) Gay
	Deasonia gigantica	(Deason) Ettl et Komare
	Dictyosphaerium pulchellum	Wood
	Eurastrum sp.	Ehrenberg
	Gloeocystis gigas	(Kutz.) Lagerheim
	Lagerheimia quadriseta	(Lemm.) G.M. Smith
	Lobomonas sp.	Dangeard
	Micractinium pusillum	Fresenius
	Non-motile Chlorococcales	N/A
	Oocystis borgei	Snow
	Oocystis parva	West & West
	Pediastrum duplex	Meyen
	Scenedesmus arcuatus v. platydisca	G. M. Smith
	Scenedesmus dimorphus	(Turp.) Kutzing
	Scenedesmus quadricauda	(Turp.)de Brbisson
	Scenedesmus sp.	Meyen
	Schroederia judayi	Lemmermann
	Selenastrum minutum	(Naeg.) Collins
	Spermatozopsis exultans	Korschikoff
	Sphaerocystis schroeteri	Chodat
	Tetraedron minimum	(A. Braun) Hansgirg
	Ulothrix sp.	Kutzing

Appendix 3 (cont.). Onondaga Lake phytoplankton species list 1994.

	TAXON	AUTHORITY
CHRYSOPHYTA		
	Chrysococcus sp.	Klebs
	Colonial Chrysophyte	N/A
	Cyst (Chrysophyte)	N/A
	Ochromonas sp.	Wyssotzki
	Synura sp. (single)	Ehrenberg
CRYPTOPHYTA		
	Cryptomonas erosa	Ehrenberg
	Cryptomonas lucens	Skuja
	Cryptomonas ovata	Ehrenberg
	R. minuta var. nannoplanctica	Skuja
	Rhodomonas minuta	Skuja
CYANOPHYTA		
	Anabaena flos-aquae	(Lyngbye)de Brbisson
	Aphanizomenon flos-aquae	(L) Ralfs
	Aphanocapsa elachista	West & West
	Chroococcus limneticus	Lemmermann
	Chroococcus prescottii	Drouet & Daily
	Gomphosphaeria lacustris	Chodat
	Microcystis aeruginosa	Kutzing
	Non-motile Blue-greens (>2 UM)	N/A
	Oscillatoria limnetica	Lemmermann
	Oscillatoria sp.	Vaucher
	Oscillatoria sp. 2	Vaucher
	Synechococcus elongatus	Naegeli
PYRROPHYTA		
	Ceratium hirundinella	(O.F. Muell.) Dujardin
	Gymnodinium sp.	(Stein) Kofoid & Swezy
	Gymnodinium sp. 3	(Stein) Kofoid & Swezy
	Peridinium umbonatum	Stein
UNIDENTIFIED		
	Misc. microflagellate	N/A

Appendix 4. Onondaga Lake zooplankton species list, 1994.

COPEPODA

Copepoda - nauplii

Cyclopoida

Cyclopoid - copepodite

Cyclops bicuspidatus thomasi

Cyclops vernalis

Mesocyclops edax

Calanoida

Diaptomus copepodite

Diaptomus siciloides

CLADOCERA

Bosmina longirostris

Ceriodaphnia reticulata

Chydoridae

Daphnia ambigua

Daphnia catawba

Daphnia galeata mendotae

Daphnia pulex

Diaphanosoma leuchtenbergianum

Leptodora kindtii

ROTIFERA

Asplanchna priodonta

Brachionus angularis

Brachionus calyciflorus

Filinia terminalis

Hexarthra mira

Keratella cochlearis

Keratella quadrata

Notholca laurentiae

Polyarthra dolichoptera

Polyarthra euryptera

Polyarthra major

Polyarthra vulgaris

Pompholyx sulcata

Pompholyx sulcata

Synchaeta sp.

Trichocerca multicrinis

Trichocerca sp.

Unknown rotifer sp.

Appendix 5

Letter from Phycotech, Inc. discussing phytoplankton taxonomy

PhycoTech

February 2, 1995

Dr. Joseph C. Makarewicz
Professor of Biological Sciences
State University of New York
College at Brockport
Brockport, NY 14420

Dear Joe:

Per our telephone conversation, please find below the information we discussed.

1. *Rhodamonas* - 2 pt pyrenoid is solid and the gullet is present and strong. *Chroomonas* - 4 pt pyrenoid (hollow in the center), gullet is vague. Determining the difference between *Rhodamonas* and *Chroomonas* is difficult in preserved material. These are probably the same taxa.

2. *Platymonas*, possibly confused with *Carteria* sp. Both have 4 flagella, *Carteria* has a more defined cell wall and a larger pyrenoid. I used Ettle 1983 to make the identification.

3. *Coelosphaerium* vs. *Gomphosphaeria*. Cells in *Gomphosphaeria* are connected by gelatinous tendrils and usually have cells without gas vacuoles. *Coelosphaerium* and *Gomphosphaeria*, though, have similar sized cells (for some species) and both have hollow colonies. These two could be confused, but I find the difference obvious.

4. *Scenedesmus dimorphus* vs. *S. obliquus*. *S. obliquus* does not have lunate cells and does have small spines on terminal cells. *S. dimorphus* has lunate terminal cells and no spines. They are very unlikely to be confused.

Sincerely,

Ann St. Amand

Dr. Ann St. Amand

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