LAKE WAYNEWOOD

REPORT ON LIMNOLOGICAL CONDITIONS IN 1993

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POCONO COMPARATIVE LAKES PROGRAM

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INTRODUCTION

Personnel from Lehigh University visited Lake Waynewood on 12 dates throughout 1993 as part of a routine monitoring program of three lakes. These lakes were selected to span a trophic gradient, Lake Waynewood lying at the nutrient-rich, productive ("eutrophic") end of the gradient. Similar reports will be submitted to the owners of Lake Giles, an acidic, unproductive ("oligotrophic") lake, and Lake Lacawac, a well protected lake of intermediate productivity ("mesotrophic").

The monitoring of these lakes in the Pocono region of northeastern Pennsylvania is a key component of Lehigh's Pocono Comparative Lakes Program (PCLP). This program aims to better understand the natural functioning of lakes, differences in lakes that arise through natural or man-made differences in their watersheds, and long-term trends that may be occurring in northeastern Pennsylvania. Through the cooperation of lake owners, scientists from Lehigh and other institutions are obtaining basic information that provides objective documentation of current lake conditions as well as a context for more intensive studies. Financial support from the Andrew W. Mellon Foundation has made these studies possible.

1993 was the sixth consecutive year of the monitoring program. The spring sampling in May completed the fourth full year of monthly sampling. With pending exhaustion of the Mellon grant, we initiated some changes beginning with the summer 1993 sampling (the sixth consecutive summer) to reduce sampling costs and to acquire additional data more closely tailored to continuing research efforts of the Lehigh investigators. These changes will be listed below, and in the **METHODS** section. They include reducing the non-summer sampling frequency (Waynewood was sampled only once after the end of August). The present report summarizes conditions in Lake Waynewood over the full twelve-month period for 1993.

The format closely follows that of the previous four years. Physical/chemical data are presented as tables for each date, and are summarized in figures. The following parameters were measured: **TEMPERATURE**, **LIGHT PENETRATION**, **SECCHI DEPTH**, **DISSOLVED OXYGEN**, **ALKALINITY**, **pH**, and algal **CHLOROPHYLL-a**. **ZOOPLANKTON DATA** are presented as graphs that give the concentration (number of individuals per liter) averaged over the entire water column. This report also includes a test of the sampling effectiveness of the 202-μm and 48-μm mesh plankton nets for the major large zooplankton. The nets are compared side-by-side to collections with a Schindler trap **(APPENDIX III)**.

Samples of the algal **PHYTOPLANKTON** have been routinely collected but not usually analyzed. We did, however, prepare seasonal composite samples for three years (summer 1989 through spring 1992). These twelve samples have now been counted for us by algal specialists at PhycoTech (Baroda, MI). The results are tabulated in **APPENDIX II**.

Also included with the 1993 report is a table of chemical data from 1991-92 (**APPENDIX I**). Waynewood was sampled at 5-6 depths on 6 dates (in April, July, September, and November 1991, plus February and April 1992). Values were obtained for **major cations (Ca, Mg, Na, K)** and for **chloride (Cl)** -- results for sulfate are not yet available. Nutrient analyses included (on most dates): **soluble reactive phosphorus (SRP)**, **total dissolved plus particulate phosphorus (TP)**, **ammonium (NH_4)**, **nitrate (NO_3)**, and (on 2 dates only) **particulate carbon and nitrogen**. These analyses were supervised by Dr. Nina Caraco and Dr. Jonathan Cole at the Institute of Ecosystem Studies in Millbrook, NY. Dr. Robert Moeller also analyzed **total dissolved inorganic carbon (DIC)** and **pH** from each sample. Analyses from the second year of sampling (April 1992 through February 1993) have been suspended because of lack of funding, but the samples will be stored in case new support becomes available. Methods for the 1989 and 1991-92 analyses are summarized in **APPENDIX I**.

Changes effective in June 1993 included deleting the nighttime zooplankton sampling, adding a suite of chemical analyses of the regular water bottle collections from three depths, and changing the analytical procedure for chlorophyll analysis. The chemical analyses include **dissolved organic carbon (DOC)** as well as nutrients: **soluble reactive phosphorus (SRP)**, **total dissolved phosphorus (TDP)**, **total particulate phosphorus (TPP)**, **ammonium (NH_4)** and **nitrate (NO_3)**. Also, **total particulate matter** was measured as dry mass of seston per liter of water filtered. These analyses were performed at Lehigh under the supervision of Dr. Donald Morris.

A new research focus for investigators at Lehigh is the role of ultraviolet radiation in lakes. Lehigh has purchased instruments that measure ultraviolet radiation in addition to the visible wavelengths of solar radiation that we have monitored during the routine sampling. These data will be compiled within the electronic database at Lehigh.

We would like to acknowledge the interest and encouragement of the Lake Waynewood Association, which has been responsible for the inclusion of Lake Waynewood in this long-term study. In particular we thank Dave Westpfahl and family, as well as the Barron's and Bovard's, for facilitating access to the lake for the routine sampling. The Lacawac Sanctuary continues to play a major role in this program as field laboratory and summer residence for the investigators. We especially appreciate the cheerful assistance of its Director, Sally Jones, and the long-term interest and encouragement of Arthur Watres and Clyde Goulden.

1993 METHODS AND RESULTS

Data included in this report are extracted from an electronic database maintained at Lehigh University by Dr. Craig Williamson. The field sampling, laboratory analyses, and computer data entry were supervised by Gina Brockway, in collaboration with Dr. Robert Moeller, Dr. Donald Morris, and Dr. Bruce Hargreaves. Gina Brockway and Timothy Vail carried out most of the field sampling and laboratory analyses. Gina and Tim determined alkalinity and pH, and along with Yin Zhong analyzed chlorophyll samples. Gina analyzed most of the nutrient samples. Macrozooplankton were counted by Paul Stutzman (Jan.--May), Natasha Vinogradova (June--mid-Aug.), and Gina Brockway (mid-Aug.--Nov.). Microzooplankton were counted by Natasha Vinogradova (Jan.--July) and Gina Brockway (Aug.--Nov.). Gina managed all aspects of the computer database including data entry, data analysis, and printing of zooplankton graphs. Dr. Bruce Hargreaves has continued to oversee maintenance of the computerized database, which he and Scott Carpenter developed. Gina entered the physical/chemical data, which Robert Moeller checked and abstracted as tables and graphs.

Although efforts have been made to assure the accuracy of data included in the database, and compiled in this report, we cannot guarantee complete accuracy and do not claim specific levels of accuracy or precision. The data have been collected as part of a lake characterization program and may not be suitable for uses not envisioned by the investigators. A brief description of sampling and analytical techniques is included here. A more complete description was distributed in 1993:

Moeller, R.E., C.E. Williamson, J. A. Aufderheide and E. M. Novak. 1993. Sampling Protocols (1988-1993) of the Pocono Comparative Lakes Program. Unpublished Report, Lehigh University. (Available on loan through the Lehigh University Library System as part of the 1992 Annual Reports to lake owners.)

Information acquired through the Pocono Comparative Lakes Program is to be shared among scientists desiring to make broad comparative studies or considering research projects in these lakes. Inquiries to examine or use the data are invited. Of course, the primary right to publish extensive extracts from the database, or from this unpublished report to the lake owners, resides with the PCLP cooperating investigators and students who generated the data. As of October, 1994, most of the existing information is accessible through the software program Reflex™ (version 2, Borland International, copyright 1989) running on IBM PC-type microcomputers.

SAMPLING PROGRAM

On each sampling occasion, Lake Waynewood was visited during the day. The January through May sampling included a second visit after dark, following the 1989-1993 protocol. The night-time visit was required for optimal sampling of certain migrating zooplankton. Other parameters were measured, and samples were collected, during the day. Sampling was carried out at a fixed station (site "A") near the deepest part of the lake (about 12.5 meters or 41 feet). The thermal stratification existing on any date dictated the depths from which other samples were collected **(Figure 1)**. The lake was sampled monthly until June (5 dates), then biweekly through August (6 dates) when surficial water temperature stayed above 20°C, then once during the autumn (mid-November).

TEMPERATURE AND PHYSICAL STRATIFICATION

Temperature was measured at 1-meter intervals with the thermister of a YSI™ oxygen meter, in degrees Celsius. Accuracy should be within 1 degree. (This is **Method #10**.)

Figure 2 shows the thermal stratification that develops during late spring and summer, then breaks down in the autumn. On day 20 (20 January) the lake was ice-covered, and displayed a weak "reverse stratification", which was also evident near the end of ice cover on day 81 (22 March). After ice-out (10 April at Lacawac), the water column briefly circulated from top to bottom during "spring turnover", as evident in the nearly isothermal 5-7°C water column on day 109 (19 April). Although the lake was weakly stratified on day 109, it apparently circulated again before day 133, since temperature at the bottom of the lake increased from 5.1 to 6.1°C. By day 187 (6 July) the surface water had warmed to 26.5°C. The water column was strongly stratified, consisting of three layers: an upper warm water layer, periodically circulating in contact with the atmosphere (the **EPILIMNION**, 0-3 meters, temperature 23-26.5°C); an intermediate layer of rapid

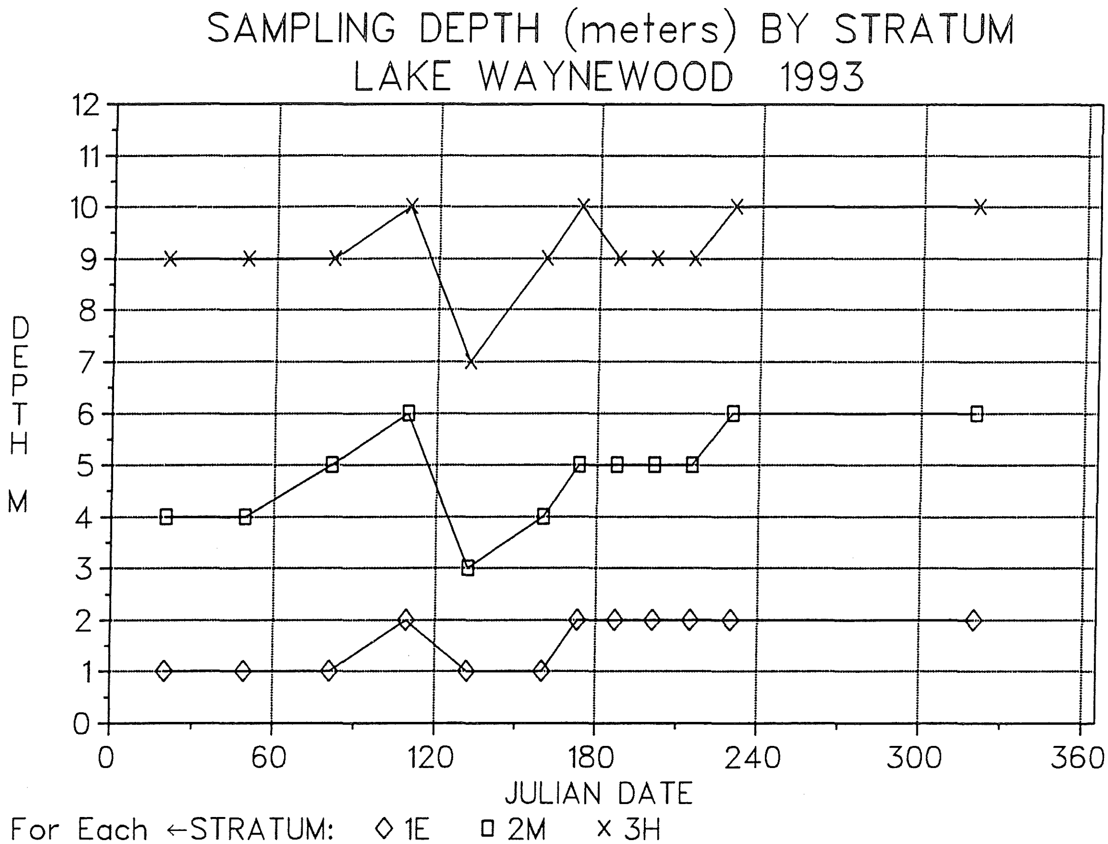


Figure 1. Depths of "EPI", "META", and "HYPO" samples from Lake Waynewood, 1993.

Sampling depths were selected by the field sampling crew based on the temperature profile on each date (see text for discussion).

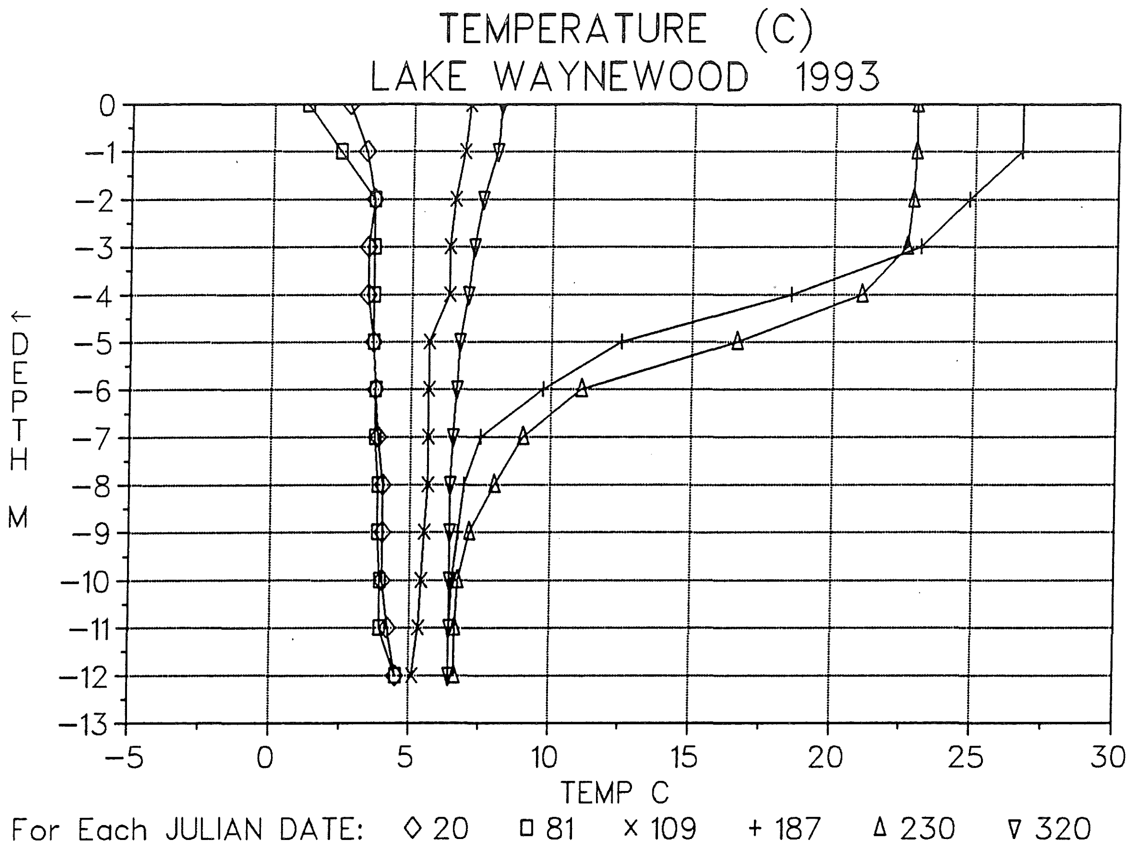


Figure 2. Temperature profiles in Lake Waynewood, 1993.

Values (°C) are plotted for six dates: **20 January** (day 20 --early winter ice cover), **22 March** (day 81 --late ice cover), **19 April** (day 109 --during spring turnover), **6 July** (day 187 --summer stratification), **18 August** (day 230 --later stratification), **16 November** (day 320 --fall turnover).

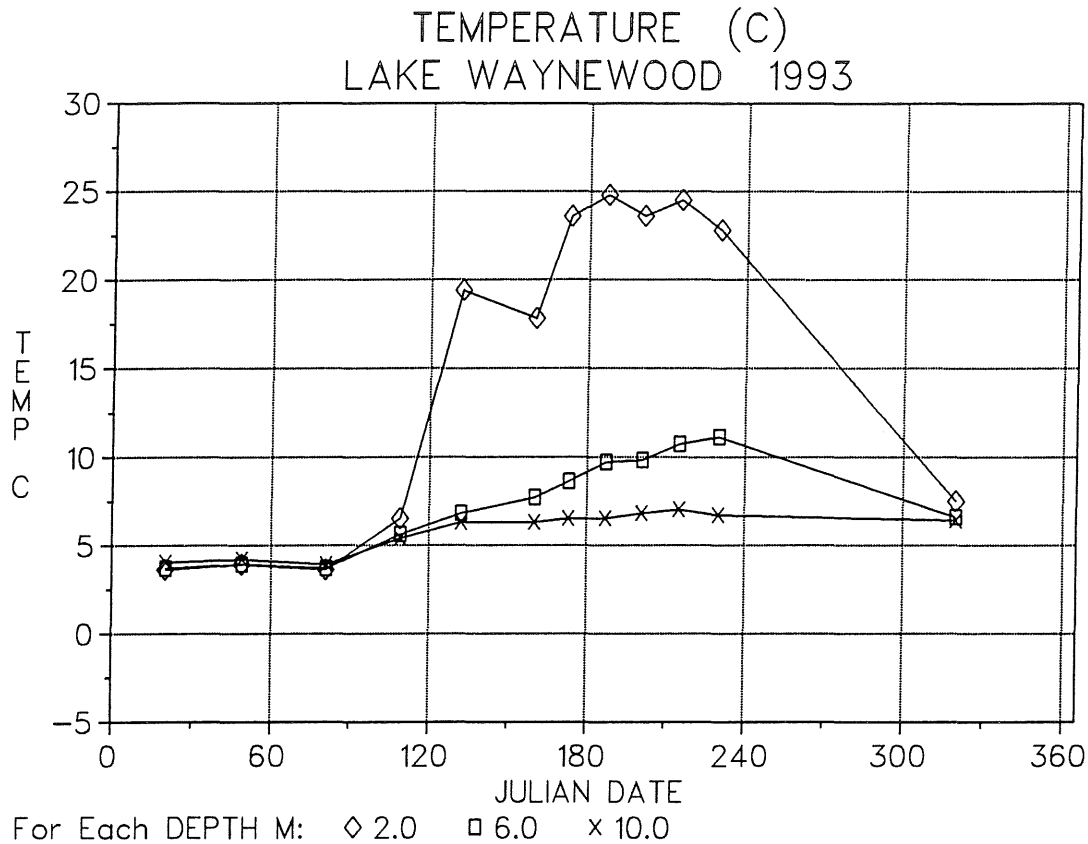


Figure 3. Temperature trends within Lake Waynewood, 1993.

Values (°C) are plotted for three fixed depths.

temperature decrease with depth (the **METALIMNION**, 3-7 meters, temperature changing >1°C per meter); and a deep layer of cold water (the **HYPOLIMNION**, 7-12 meters, temperature 6.5-8°C). Lake heating during midsummer occurred mainly in the metalimnion; epilimnial temperature was highest early in July.

The usual course of thermal stratification is that of slow, gradual thickening of an epilimnion during the summer. By day 230 (18 August) the epilimnion extended to almost 4 meters. As the lake cooled during the autumn, the epilimnion thickened more rapidly until the lakewater was circulating from top to bottom. This period of full circulation, or "fall turnover", was in progress by day 320 (16 November), although the lake showed a slight ephemeral stratification on the warm, calm day it was sampled.

The 1992-93 winter ice cover began in late December (12 cm of ice on December 29, 1992). Ice thickness increased through the winter, exceeding 50 cm on 22 March. Ice did not go out until about 10 April, the recorded date at Lake Lacawac (Sally Jones, pers. comm.).

The temperature pattern in the lake is controlled by climate, and will differ only slightly from year to year. Two major variables are the durations of winter ice-cover (ca. 14-15 weeks in 1992-93) and the completeness of spring turnover. Spring turnover was complete in 1993, judging from the well oxygenated conditions encountered at 10-12 meter depths on day 110 (20 April).

Although December 1992 and early January 1993 were relatively warm, air temperatures during February and March were colder than normal (**Figure 10**), accounting for the thickness of the ice. Summer was again warmer than usual, returning to a climatic trend that had been interrupted by a "normal" summer in 1992. **Figure 3** presents the detailed trends of water temperature at three fixed depths (2,6,10 meters) for comparison with other years.

Water samples for **pH**, **alkalinity**, **chlorophyll**, **algae**, and -- starting in June -- **dissolved organic carbon**, **sestonic particulate matter**, and **nutrients** were collected from mid-depths of the three layers when thermal stratification was well developed. During turnover periods, the lake was divided into three equal layers. Under ice-cover (e.g. 20 January), the topmost layer was 0-1m, and the remaining depths were divided at the Secchi depth (see **SECCHI DEPTH** below).

LIGHT PENETRATION

Light intensity at 1-meter intervals was calculated as a percentage of the light just below the lake surface (10 cm). Since 1988, four slightly different methods have been used to construct a 0-12 m profile of light penetration; method #12 (numbers correspond to codes from data tables) was used in 1993 through August, then method #13 was introduced.

Method 12. Two sensors, mounted 1-m apart on a common line, electronically computed the ratio of light intensities between the nominal depth and the depth above it. The percentage penetration profile was constructed from these ratios. The sensors are Licor™ submersible flat cosine-corrected sensors filtered to give a quantum response to photosynthetically available radiation ("PAR"). Units are microeinsteins per square meter per second ($\mu E/m^2.sec$).

Method 13. A single sensor, separately measuring both UV wavelengths and PAR,

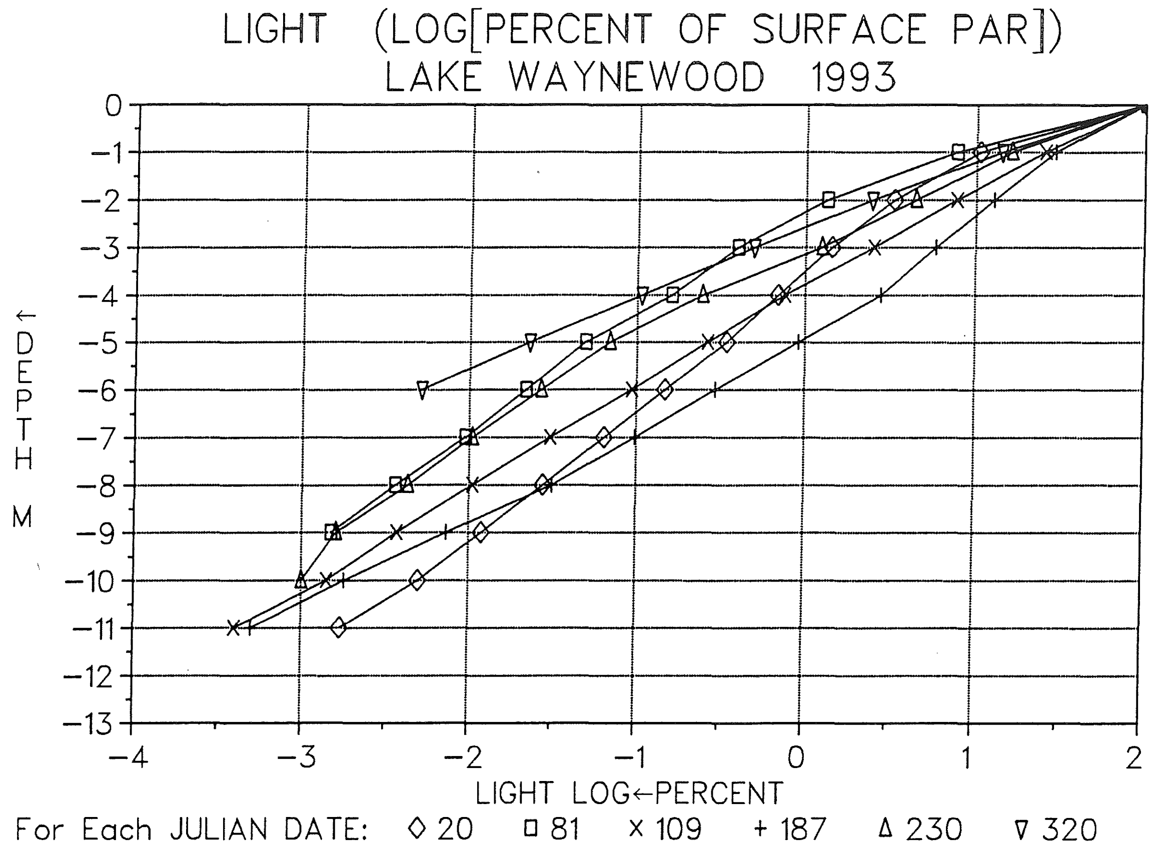


Figure 4. Light penetration in Lake Waynewood, 1993.

Values are percentages of the light at 0.1 m depth and are graphed on a logarithmic scale (i.e., 100% ="2", 10% ="1", 1% ="0", etc.) for six dates: **20 January** (day 20 --early winter ice cover), **22 March** (day 81 --late ice cover), **19 April** (day 109 --during spring turnover), **6 July** (day 187 --summer stratification), **18 August** (day 230 --later stratification), **16 November** (day 320 --fall turnover).

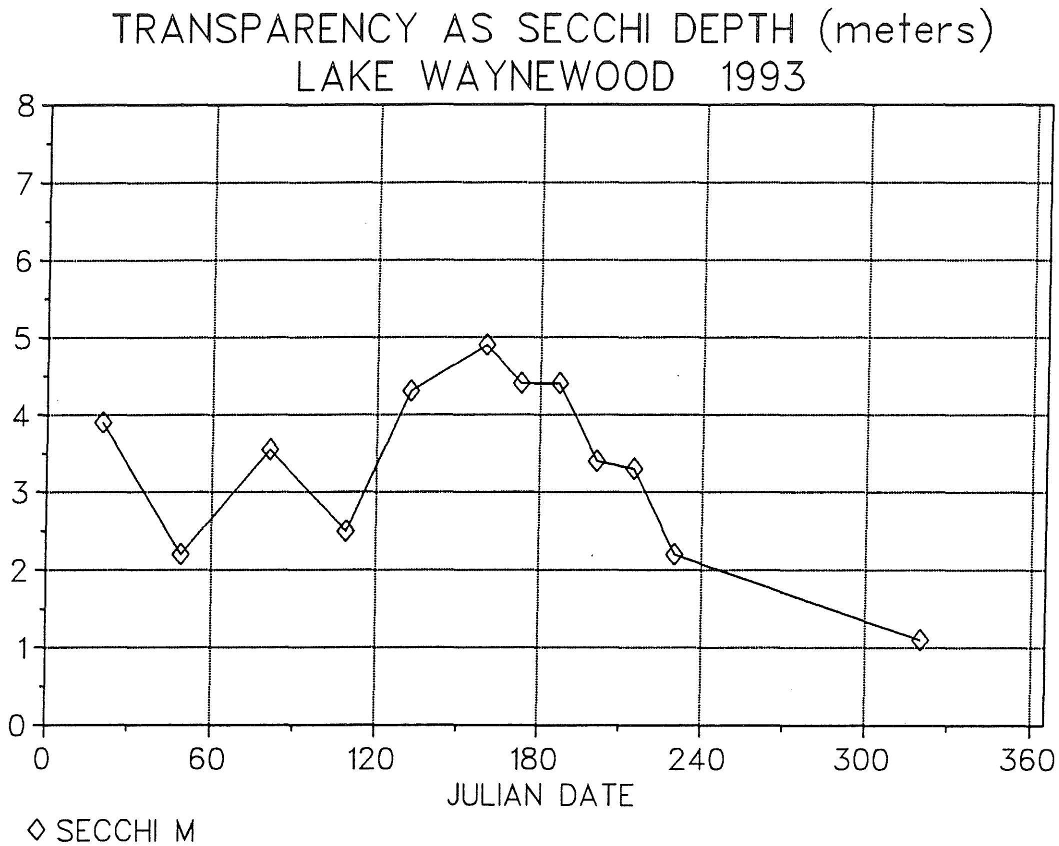


Figure 5. Transparency in Lake Waynewood, 1993.

Values plotted are the Secchi depths, in meters.

is lowered 1-several times from a boom extending beyond the side of the boat. Water depth, temperature, and irradiance in 5 wavebands are logged automatically and continuously to a microcomputer disk for later data reduction. The instrument is a Biospherical Instruments PUV-500™ fitted with a high-resolution depth sensor. Like the Licor instrument, the sensor is calibrated to give a cosine response for measurement of downwelling radiation. It measures PAR (400-700 nm) as well as UV irradiance in ca. 10-nm bands around 380, 340, 320 and roughly 305 nm. Profiles with this instrument are more prone to noise from changing cloudiness than the dual-Licor unit used in Method 12, but we attempt to minimize problems by averaging or combining multiple profiles.

Light ("PAR") penetration is plotted on a logarithmic scale for six dates (**Figure 4**). The lake was relatively clear in early summer (day 187), with the 1% light level lying at 5 m, well into the metalimnion. During the summer, depths above 3 m (i.e. most of the epilimnion) received at least 1% of the light penetrating the lake surface. Although the upper metalimnion received enough light to support some algal growth, the lower metalimnion and the hypolimnion received too little light to support algae. Transparency was even more reduced during fall turnover (day 320), when the water column supported high algal populations (see chlorophyll values in **Figure 9**). Under thick ice and snow cover on 22 March (day 81), light was strongly attenuated both through the ice/snow and in the upper 2 m of the water column.

SECCHI DEPTH

Secchi depth is the depth, in meters, at which a white-and-black quartered disk 20 cm in diameter just ceases to be visible to an observer lowering it from a boat. It is a measure of water transparency. We observed the Secchi disk with a small glass-bottomed viewing box to reduce glare from the lake surface.

The pattern of Secchi transparency (**Figure 5**) showed the late-spring or early summer "clear water" period (Secchi depth 4-5 m) that has been evident every year (1989-93). Transparency decreased steadily during the summer, reaching 2 m by the end of August. This pattern has been typical, although the rapidity of the decline varies. Only in 1990 was midsummer transparency consistently less than 2 m. The pattern in late summer and fall has been quite variable, especially during full turnover in November, when transparency has varied from a low of 1.1 m (this year--1993) to a high of 4.5 m (in 1991).

OXYGEN CONTENT OF THE LAKEWATER

Dissolved oxygen was measured polarographically using a YSI™ submersible temperature-compensating oxygen meter. The meter was calibrated in air to 100% saturation immediately before use in the lake. The effect of Lake Waynewood's elevation above sea-level (1381 feet) was not taken into account when calibrating the meter, so compiled values are roughly 5% too high. Units are mg O_2 per liter. (This is **Method #10.**).

Often the meter did not give a true "zero" when dropped into definitely anoxic (oxygen-free) water. Values flagged with error code "4" in the data tables should be treated as true zeros.

Oxygen became moderately depleted below 7 meters during the relatively long

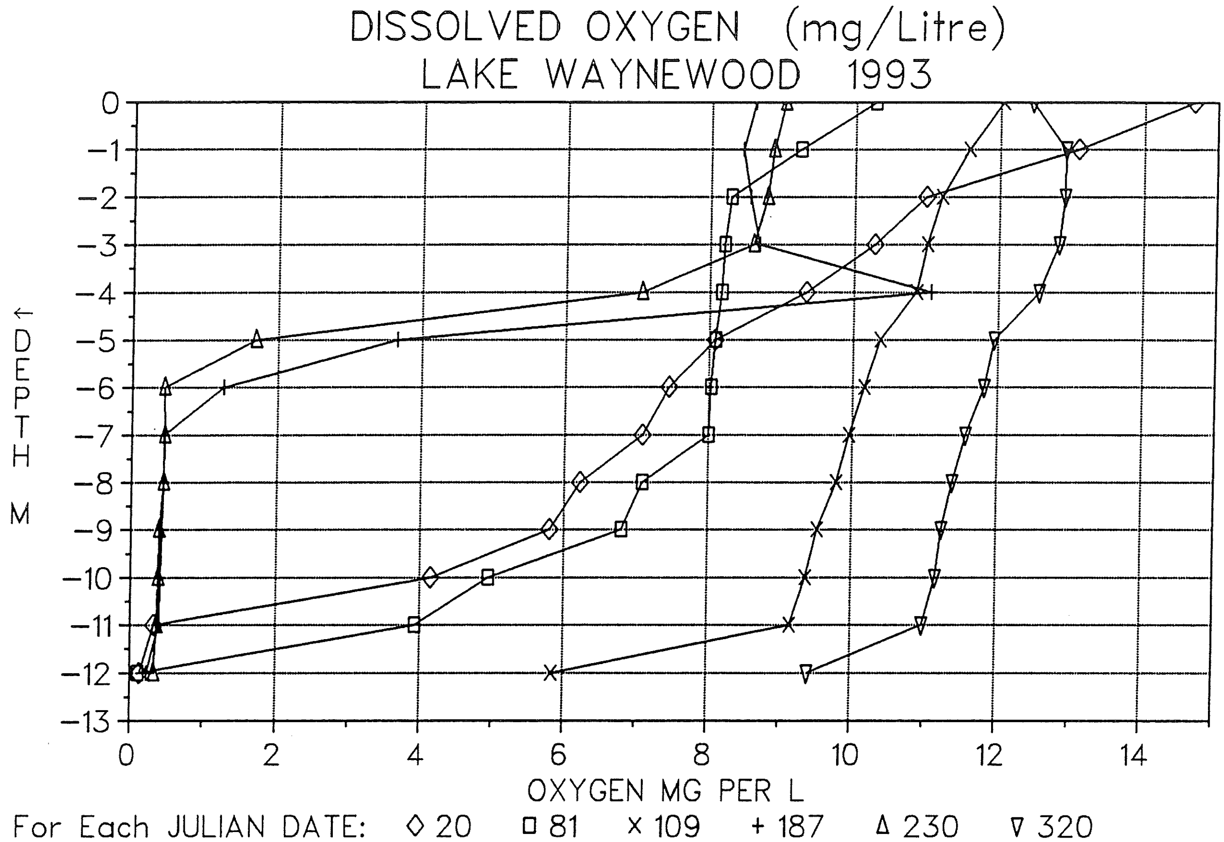


Figure 6. Dissolved oxygen in Lake Waynewood, 1993.

Values (mg oxygen per liter) are plotted for six dates: **20 January** (day 20 --early winter ice cover), **22 March** (day 81 --late ice cover), **19 April** (day 109 --during spring turnover), **6 July** (day 187 --summer stratification), **18 August** (day 230 --later stratification), **16 November** (day 320 --fall turnover). Values less than 0.5 mg/L should be interpreted as "zero" dissolved oxygen.

winter ice/snow cover. It is remarkable that the greatest reduction occurred during the first month of ice-cover. Oxygen concentration was reset close to atmospheric saturation during spring turnover, when the lake was still cold. During summer stratification, oxygen was again consumed within the deeper hypolimnion, and lost from the warming epilimnion via outgassing to the atmosphere. These processes contributed to the metalimnetic oxygen maximum that was evident in early summer **(Figure 6)**. Algal photosynthesis in the top of the metalimnion would have contributed to the effect (note the sharp peak of 11 mg O_2/L at 4 m depth on 6 July, coincident with very high levels of metalimnetic chlorophyll --**Figure 9**). Already by 6 July, oxygen had been eliminated from the hypolimnion and was depleted in the lower metalimnion. These patterns have been very consistent from year to year. Reoxygenation took place during fall turnover.

ALKALINITY AND pH

Alkalinity is a measure of the acid neutralizing, or buffering capacity. Alkalinity was determined by potentiometric titration of a 100-ml sample using 0.1 N sulfuric acid as titrant and monitoring pH change with an Orion™ model SA250 pH meter and Ross™ epoxy-body combination electrode. Titration points between pH 4.4 and 3.7 were plotted, after Gran transformation, to give alkalinity in microequivalents per liter (μeq./L). (This is **Method #11**.) Alkalinity was analyzed monthly, on alternate sampling dates during summer.

Samples for alkalinity and pH were taken from duplicate water collections (acrylic plastic Van Dorn bottle) at three depths, designated "**E**" (epilimnion), "**M**" (metalimnion), and "**H**" (hypolimnion). Selection of these depths is described in the section **TEMPERATURE AND THERMAL STRATIFICATION**. Samples were stored in air-tight polypropylene bottles for up to 24 hr (refrigerated) before analysis, or, more usually, analyzed within a few hours of collection. Samples were warmed to room temperature before analysis. The pH meter and electrode described above were calibrated with commercial high ionic strength buffers. The pH was measured in 50-ml aliquots of sample, usually with gentle mixing. The following variant of the method was employed on all dates on 1993:

Method 12. As above, with 0.5 ml salt solution (Orion™ pHisa™ solution) added to increase ionic strength. Usually, this had little or no effect on the sample (pH change <0.1 unit). Also, a quality assurance protocol was followed, verifying electrode performance in distilled water and the stability of calibration.

Trends of pH are plotted for each layer in **Figure 7**. In the absence of intense biological activity, the pH of Waynewood would be about 6.5-7 with an alkalinity of about 300 μeq/L **(Figure 8)**, judging from values in late spring. These values portray a softwater lake with moderate bicarbonate buffering capacity. High pH values from August (pH >8.5) reflect intense algal photosynthesis and uptake of dissolved carbon dioxide. True *in situ* pH values at this time probably reached 9-10, our samples having been analyzed several hours after collection. Microbial metabolism generated substantial alkalinity in the anoxic hypolimnion **(Figure 8)**, but this was lost upon reoxidation of the water column during fall turnover and subsequent winter stratification. Levels and seasonal trends of both pH and alkalinity have been highly similar during the past 4.5 years of regular monitoring.

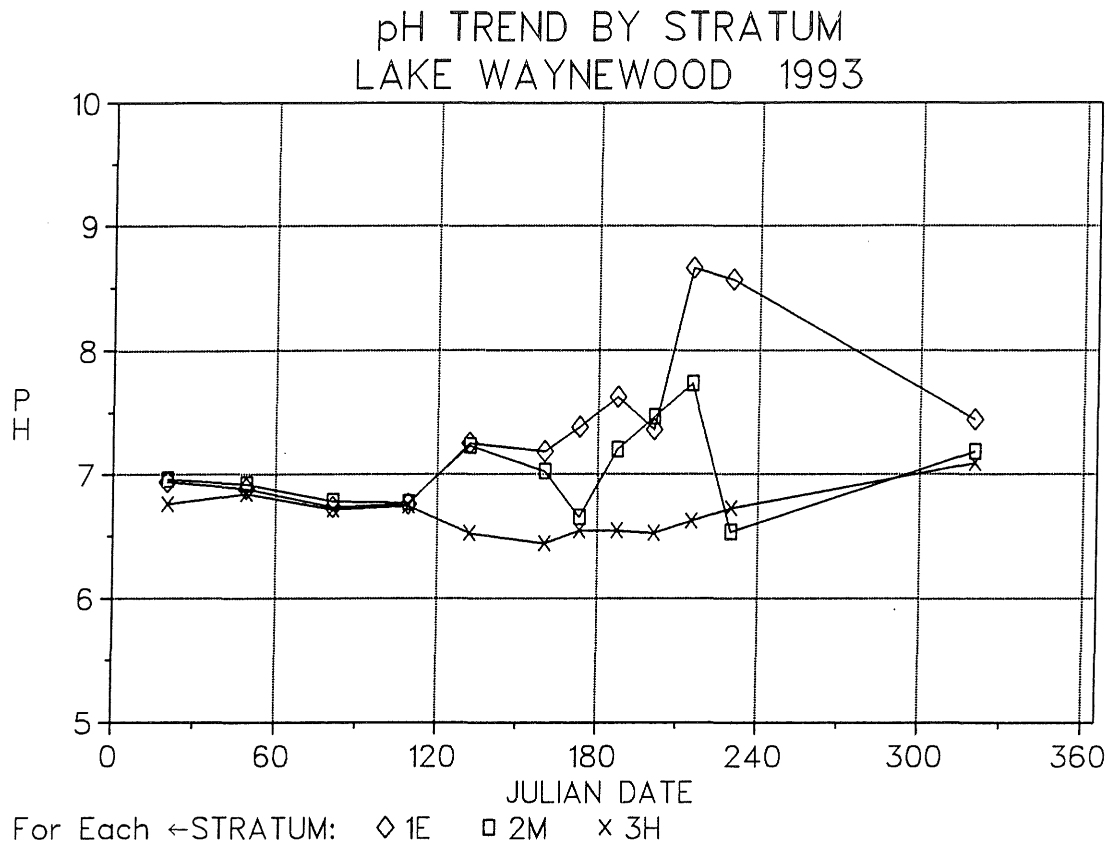


Figure 7. Trends of pH in Lake Waynewood, 1993.

Values are plotted for the mid-depths of the three layers, Epilimnion (**1E**), Metalimnion (**2M**), and Hypolimnion (**3H**). In autumn and winter, when these layers are not developed, samples are collected as described in **RESULTS AND METHODS**.

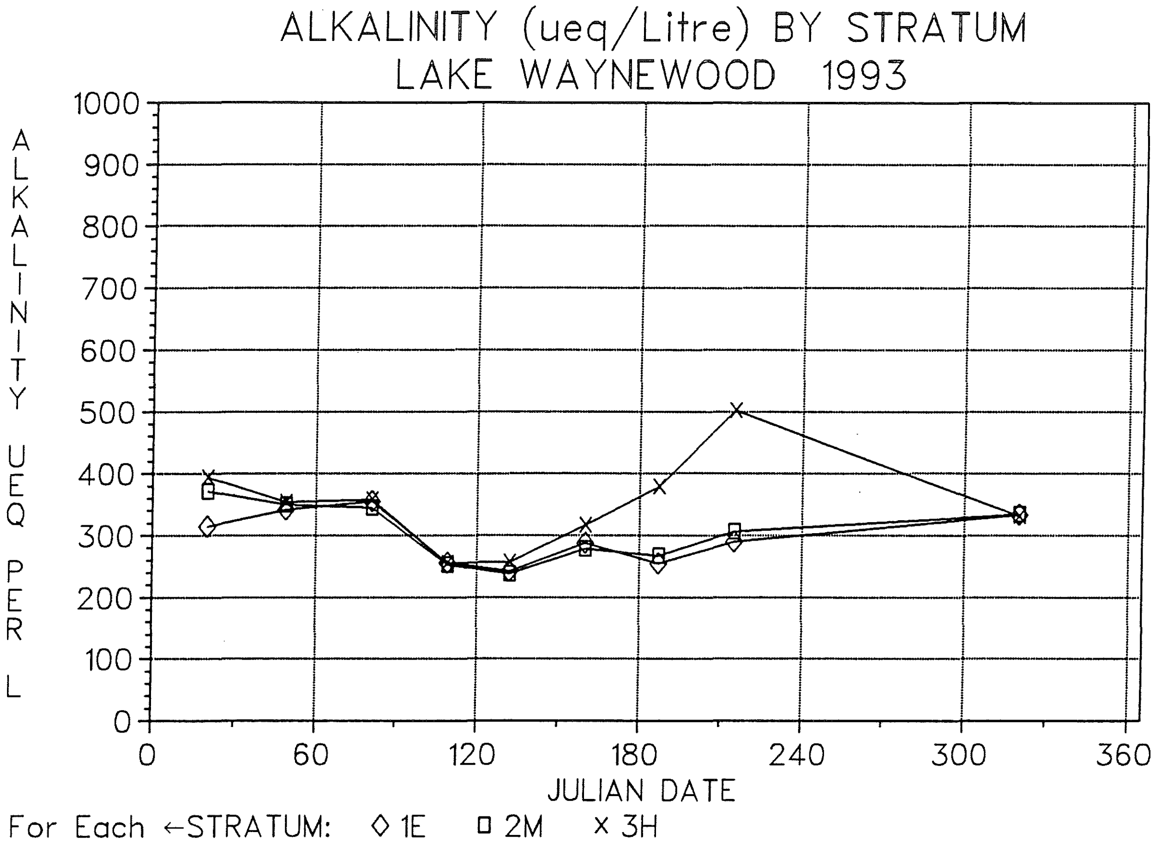


Figure 8. Trends of Alkalinity in Lake Waynewood, 1993.

Values are plotted for the mid-depths of the three layers, Epilimnion (**1E**), Metalimnion (**2M**), and Hypolimnion (**3H**). In autumn and winter, when these layers were not developed, samples were collected as described in **RESULTS AND METHODS**.

CHEMISTRY

Data from the 1991-92 chemical samplings are presented in **APPENDIX I**. Six depths were sampled on each of five dates distributed throughout the year. The 1989 data were included in the 1990 Annual Report. The sampling and analytical methods for both series are summarized in **APPENDIX I**.

Cation concentrations were similar in 1989 and 1991-92, though a little higher in 1991-92. By combining 1989 sulfate with 1991-92 chloride data, averaging other ion concentrations, calculating H^+ concentration from pH, and calculating bicarbonate (HCO_3^-) from pH and total dissolved inorganic carbon (DIC), we have derived a generalized ion balance for Lake Waynewood water. These averages were not weighted for volume differences at different depths. Depths with reduced oxygen ($\leq$ 3 mg/L) were excluded from the depth-integrated means, however. Additional parameters were extracted from the chemical database to more broadly characterize the lake **(Table 1)**.

Table 1. Chemical Characterization of Lake Waynewood.

		micromoles/L		microequivalents/L	
Anions					
Sulfate	SO_4^{-2}	122.	μM	244.	μeq/L
Chloride	Cl^{-1}	180.		180.	
Bicarbonate	HCO_3^{-1}	295.		295.	
Nitrate	NO_3^{-1}	4.		4.	
Cations					
Sodium	Na^{+1}	166.	μM	166.	μeq/L
Calcium	Ca^{+2}	207.		414.	
Magnesium	Mg^{+2}	54.7		109.	
Potassium	K^{+1}	34.0		34.0	
Hydrogen ion	H^+	<0.01		<0.01	
Ammonium	NH_4^{+1}	7.		7.	
Other Chemical Parameters					
pH[1]		7.27			
Alkalinity		303.	μeq/L		
Conductivity (1989 data)		72.	μmho/cm		
Dissolved Inorganic Carbon (DIC)		327.	μM		
Dissolved Organic Carbon (DOC)		440.	μM		
Total Phosphorus (totP)		0.78	μM		

[1] IES *in situ* pH in 1989, PCLP lab pH in 1991-92

The ion balance is excellent (723 μeq/L for anions, 730 μeq/L for cations). Calcium is the dominant cation, bicarbonate and sulfate are co-dominant anions. Sodium and chloride are fairly abundant, and at nearly equal molar concentrations. This may reflect human activities of the drainage basin. At Lake Waynewood's pH of 7.3, bicarbonate provides a moderate buffering capacity (alkalinity 303 μeq/L). Bicarbonate makes up ca. 90% of the total dissolved inorganic carbon. Waynewood is, however, a fairly softwater lake, and dissolved organic carbon (DOC) somewhat exceeds the dissolved inorganic carbon (DIC). Dissolved organic carbon is relatively high (440 μM).

Chemical analyses from 1993, which emphasized nutrients and dissolved organic carbon, are presented in **Table 2**. Dissolved organic carbon was consistently near 5.3 mg C/L (i.e. 440 μM, as cited above) from June through November. Concentrations of DOC varied little with depth. Phosphate was released into the anoxic hypolimnion, but was at low levels (<3 μg/L) in "EPI" depths --where there was enough light for phytoplankton growth-- during the summer. Ammonium followed the same pattern as phosphate, accumulating in the hypolimnion but being reduced to low levels (3-10 μg N/L) in the better lighted depths during summer. During June the epilimnetic phytoplankton were more likely limited by phosphorus than nitrogen, since ammonium and nitrate were present at appreciable levels. These nutrients were subsequently depleted, so that by mid-July the epilimneti cphytoplankton may have become co-limited by nitrogen as well as phosphorus.

ALGAL CHLOROPHYLL-a

Chlorophyll-a is a measure of algal mass, since all algae contain this pigment. It is a widely used parameter for comparisons of lake trophic conditions. Chlorophyll samples came from the same Van Dorn collections used for pH and alkalinity. Samples were stored in 1-L polyethylene bottles for 2-12 hr (cool in darkness) before being filtered. Two analytical methods were used in 1993, both giving presumably comparable values for chlorophyll-a corrected for pheopigments (**CHLAC** in data tables and **Figure 9**), and chlorophyll-a including pheopigments (**CHLASUM** in data tables).

Method 12 (January-May). Subsamples were filtered and stored frozen (0.5 L onto Gelman™ A/E filters). Two samples were filtered from each depth: a whole-water sample (for total chlorophyll-a) and a sample fractionated with a 22-μm nitex net. Often the sum of fractions was less than the total. This sum was only treated as a replicate for total chlorophyll-a if it was greater than or equal to 85% of the whole sample. The percentage of chlorophyll passing the 22μm net (percent of the summed fractions) is presented in the data tables (**CHLAC P**). Intact filters were extracted overnight at 2-4°C, in darkness, in 12 ml of a 5:1 (vol/vol) mixture of 90% basic acetone and methanol. Extracts were centrifuged and read in a Sequoia-Turner™ model 112 fluorometer equipped with F4T5/B lamp, red-sensitive photomultiplier, 5-60 excitation filter and 2-64 emission filter. The meter was calibrated with dilutions of pure chlorophyll-a or chlorophyll-a,b extracts from higher plants; these were assayed first by standard spectrophotometric techniques. Each sample was reread after acidification (to 0.03 N) to allow correction for pheopigments. We verified that chlorophyll behaves virtually the same in the mixed solvent as in 90% acetone alone, and that the mixed solvent extraction gave results that were the same as or greater than those from parallel extraction in 90% acetone with grinding.

Method 13 (June-November). Samples were filtered onto glass fiber filters (Whatman GF/F). These were immediately placed in 10 ml of 90% ethanol, heated to boiling, extracted overnight in a freezer, and analyzed spectrophotometrically for chlorophyll-a and pheopigment [see citations in D.P. Morris and W.M. Lewis, Jr. 1992. Limnology and Oceanography 37(6):1179-1192]. No size-partitioning was performed.

In Lake Waynewood there was a distinct seasonal pattern of chlorophyll-a (**Figure 9**) that was broadly consistent with previous years. Values were low (less than 6 μg/L) under the ice in January, but subsequently increased to >80 μg/L in the upper 2 meters under the snow-covered ice. This dense algal population crashed during the later winter: by 22 March, still under the snow-covered ice, chlorophyll-a levels had declined to <1 ug/L at all three depths. Algal populations remained small throughout the spring. During July a

Table 2. Lake Waynewood: Chemical Parameters in 1993.

Abbreviations: dissolved organic carbon (DOC), chlorophyll-a (Chl-a), pheophytin-a (Pheo-a), soluble reactive phosphorus (SRP), total dissolved phosphorus (TDP), total particulate phosphorus (TPP), ammonium (NH3), nitrate (NO3), particulate matter. Chlorophyll-a values are corrected for pheopigment.

Date	Stratum	Depth (m)	DOC (mg C/L)	Chl-a (ug/L)	Pheo-a (ug/L)	SRP (ug P/L)	TDP (ug P/L)	TPP (ug P/L)	NH3 (ug N/L)	NO3 (ug N/L)	Part. Matter (mg/L)
09 Jun 93	E	1	5.45	2.4	1.2	2.4	8.8	5.2		26.1	0.91
	M	4	5.32	1.8	3.1	2.1	8.8	7.1		<0.1	1.55
	H	9	5.08	0.7	0.8	9.8	18.1	10.4		94.6	1.21
22 Jun 93	E	2	5.41	4.6	-1.3	0.4	9.7	5.9	24.6	25.1	0.31
	M	5	5.45	6.6	2.0	2.7	14.8	9.6	16.1	84.3	0.79
	H	10	5.23	1.9	1.8	29.8	43.0	20.2	285.	84.9	1.29
06 Jul 93	E	2	5.51	2.4	0.7	0.7	6.7	5.6	9.8	12.7	1.00
	M	5	4.71	26.4	2.1	2.2	12.6	12.3	7.4	8.5	1.69
	H	9	4.43	6.3	5.8	22.1	34.2	29.9	308.	75.5	2.48
20 Jul 93	E	2	4.54	5.0	1.8	1.0	5.5	9.8	5.0	<0.1	1.50
	M	5	5.09	56.2	10.8	6.4	15.2	27.0	3.9	<0.1	5.25
	H	9	4.88	3.2	5.6	39.1	48.9	53.4	365.	2.2	3.87
03 Aug 93	E	2	5.27	8.8	1.9	2.5	8.2	9.5	5.0	1.6	1.55
	M	5	6.82	41.4	2.8	3.9	12.3		3.8	<0.1	2.95
	H	9	5.30	11.5	8.2	39.4	66.6		286.	4.4	
18 Aug 93	E	2	5.24	14.8	2.6	0.9	9.5	12.0	7.8		2.55
	M	6	5.12	15.6	10.5	7.3	18.9	7.5	10.9		
	H	10	5.20	3.2	3.8	24.1	25.2	21.2	843.		2.37
16 Nov 93	E	2	5.68	39.2	6.5	7.2	22.3		9.9		5.67
	M	6	5.55	25.8	4.0	7.5	21.0		9.3		3.40
	H	10	5.72	41.4	2.7	8.1	16.7		20.5		2.96

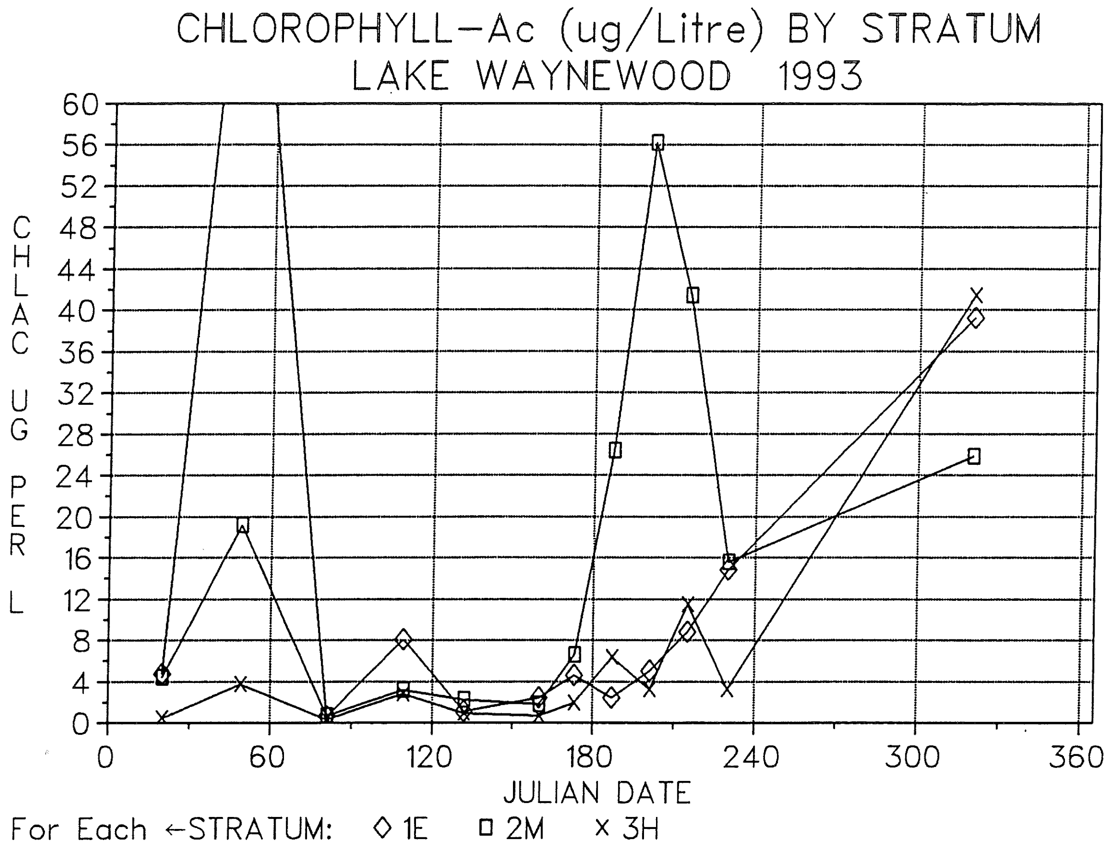


Figure 9. Trends of Chlorophyll-a in Lake Waynewood, 1993.

Values are plotted for the mid-depths of the three layers, Epilimnion (**1E**), Metalimnion (**2M**), and Hypolimnion (**3H**). In autumn and winter, when these layers were not developed, samples were collected as described in **RESULTS AND METHODS**. Chlorophyll-a values are corrected for pheopigments.

large metalimnetic population developed, as in all five years sampled. Epilimnetic algae increased gradually during the summer as the metalimnetic peak declined. The lake was not sampled in September-October, typically a time of maximal algal concentrations in Waynewood. Algal levels were very high during fall turnover, as in 1990, but unlike 1991-92. This year-to-year variability in fall chlorophyll concentration in the deeply circulating water column is a striking feature of our 5-year data set.

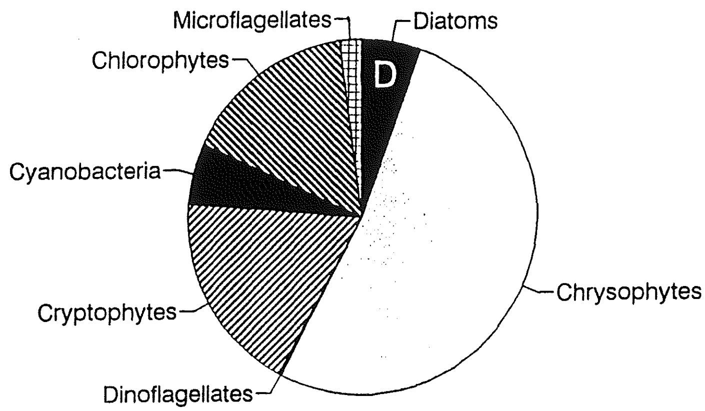
PHYTOPLANKTON

Phytoplankton subsamples (100 ml) were preserved from the EPI, META, and HYPO samples with acid Lugol's solution (to 1% vol/vol). These have not been routinely analyzed because of the effort required. To provide some idea of the algal communities prevalent at different seasons in the three study lakes, we prepared composite seasonal samples for three separate years (summer 1989 through spring 1992), which were submitted to a subcontractor (PhycoTech, Baroda, Michigan) for analysis. The original acid-Lugol's preserved samples are archived at Lehigh.

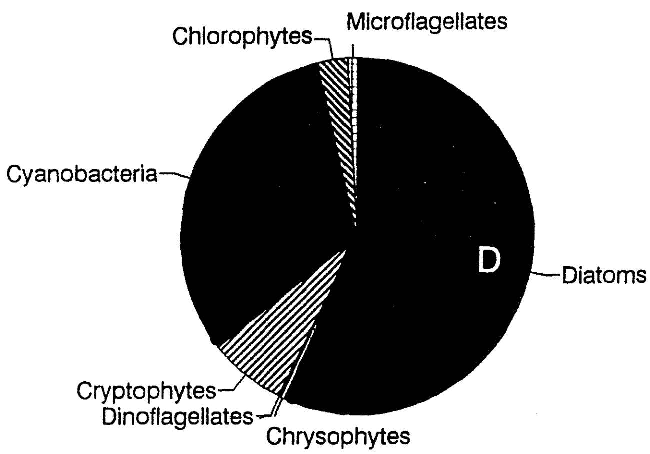
At PhycoTech, an appropriate volume was filtered onto a membrane filter, mounted on a microscope slide in resin (HPMA), and counted at 200x magnification. The count included a minimum of 300 cells/colonies. In most samples, an additional 100 cells of the smallest types were counted at 400x. For a few very large types the whole slide was scanned. Biovolumes were estimated from simple geometric shapes fitted to 1-several dimensions of the cells encountered.

The analyses are presented as species biovolumes in **APPENDIX II**. Identifications at the genus or species level were directed by Ann St Amand at PhycoTech. These counts should include the several most abundant taxa, with a scattered inclusion of less common types. A summary of the seasonal representation of the main groups of algae is given as pie charts on the next page, along with the total algal biovolume for each season. Note that all depths (EPI, META, HYPO) contributed to each sample. "Winter" samples were collected beneath ice cover in January and February, "Spring" samples after ice-out in March through May, "Summer" samples during thermal stratification of June through September, and "Autumn" samples late in stratification (October) or during fall turnover in November or December.

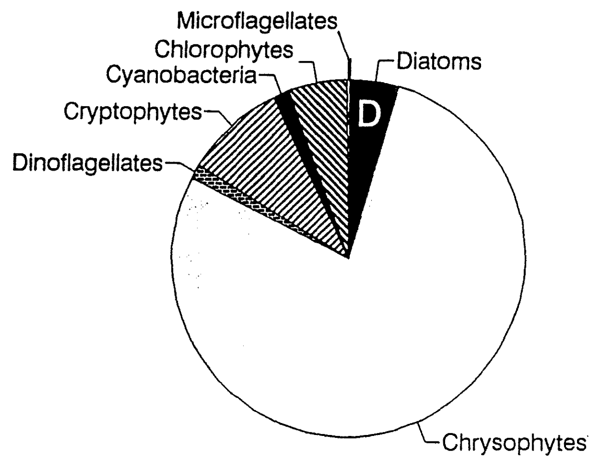
The biovolume data for the composite samples (see pie charts) show a major seasonal shift from chrysophyte (mainly *Synura*) dominance in winter and spring to cyanobacterial (mainly *Aphanizomenon*) dominance in summer, and mixed diatom and cyanobacterial dominance in the autumn. The autumn community is quite variable from year to year, both in abundance and in relative dominance of cyanobacteria vs diatoms. In 1989 *Aphanizomenon* dominated and diatoms were sparse, but in 1990 a massive multi-specific diatom community replaced the summer's dense *Aphanizomenon* population. In 1991, algae in general were less abundant, and diatoms, *Aphanizomenon*, and cryptophytes all played important roles. Similar year-to-year variability occurred in spring. The chrysophyte *Synura* strongly dominated the community in 1990 and 1991, but was absent from the counts in 1992, when cryptophytes and green algae dominated. The summer community was somewhat more consistent over the three years, with strong dominance by the filamentous cyanobacteria *Aphanizomenon flos-aquae* and *Anabaena macrospora*, two notorious species of eutrophic lakes.



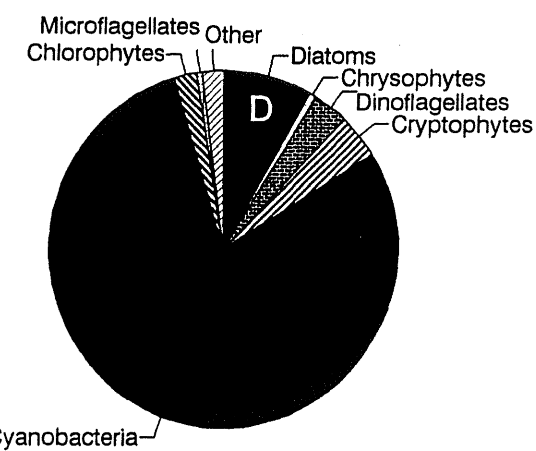
WAYNEWOOD (WINTER 690 x10^3 um^3/mL)



WAYNEWOOD (AUTUMN 1094 x 10^3 um^3/mL)



WAYNEWOOD (SPRING 1940 x10^3 um^3/mL)



WAYNEWOOD (SUMMER 1363 x 10^3 um^3 /mL)

ZOOPLANKTON

Zooplankton receive a major emphasis in the PCLP program. These animals represent the key link between algal primary producers and fish populations. The intensity of grazing by herbivorous zooplankton strongly affects the kind of algae that dominate, and potentially can control (i.e. reduce) algal populations even in the face of abundant nutrient supply. Consequently the kinds and abundances of zooplankton have important implications for the water quality of a lake.

Zooplankton were sampled at day and night (January-May) or only during the day (June-November). The data presented here include nighttime samples when available, for consistency with previous years. Some species avoid the water column during the day, especially *Chaoborus*; for these taxa concentrations from summer and fall 1993 may not be comparable to earlier data. Hopefully for most species, including copepods, Cladocera, and certainly rotifers, the whole water-column means were little affected by sampling time. Zooplankton were collected with closing-style plankton nets that could be pulled through part of the water column open, collecting animals, then closed and pulled the rest of the way to the surface. In this way the water column was sampled as the three layers defined by temperature. In the present report, data are given as mean concentrations (numbers of individuals per liter) over the entire ca 12-m water column. Details of the depth-distributions, and daily patterns of vertical movement, are still being analyzed.

Two sizes of nets were used: a 30-cm diameter net with a mesh of 202 μm, for some macrozooplankton, and a 15-cm diameter Wisconsin-style net with a 48-μm mesh for microzooplankton as well as other macrozooplankton. These were mounted side-by-side in "bongo" configuration.

The effectiveness of these nets for sampling macrozooplankton was checked on 16 June 1993 in lakes Giles, Lacawac, and Waynewood. Each lake was visited after dark. At five stations the nets were hauled from 5 meter depth to the surface, and a parallel composite Schindler trap sample was collected from 0.5, 1.5, 2.5, 3.5, and 4.5 meters. Dr. Peter Schulze and Gaby Grad collected and preserved the samples. Gaby Grad later subsampled and counted the samples. The Schindler trap is a quick-closing transparent box (here 25-L in volume) that should minimize avoidance-responses of some zooplankton to the hydrodynamic effects of nets. The results for all three lakes are presented in **APPENDIX III**. Both nets performed well, the 48-μm net apparently somewhat better than the 202-μm net in lakes Giles and Lacawac. There may have been some underestimation of *Daphnia* even with the 48-μm net, but the pattern was not consistent across all three lakes. Basically, the 48-μm mesh Wisconsin net gave mean concentrations within 25% of those calculated from the Schindler trap series, with no compelling evidence of any serious systematic underrepresentation caused by net clogging or avoidance.

Microzooplankton includes mainly rotifers, but some copepods and small Cladocera also were counted from these samples. Our counting strategy was somewhat different in 1991-93 from that used in 1989 or 1990, with *Chaoborus* and some copepods (e.g. cyclopoid males and copepodids) being counted from the 48-μm sample that had been counted from 202-μm samples in 1989-90 samples. This change was made to increase collection efficiency of forms (e.g. small instar *Chaoborus*, copepodids, male copepods, etc.) that were going through the 202-μm mesh net. In addition, starting in June 1993 we only sampled during the day, potentially missing plankton that congregated within a meter of the lake bottom during daylight. Collections were duplicated for each depth range. Mean values are presented.

Seasonal trends in abundance are presented as a series of graphs for the most frequently encountered zooplankton, identified to genus and sometimes to species **(Figures 11-37)**. **Table 3** lists the zooplankton identified to date. Updating some of the major features of Lake Waynewood's zooplankton community:

(1) As usual, the cladoceran *Daphnia* (several species) was apparently the dominant grazer during spring and fall (5-15/L), and was reduced to low levels during summer. Levels in midsummer (<1/L) were especially low, following a population crash in mid-July. Somewhat higher concentrations prevailed in the summers of 1989 and 1991, but 1990 and 1992 were similar to 1993.

(2) The calanoid copepod *Diaptomus oregonensis* has tended to be relatively common throughout the year (0.5-2 adult females/L), especially during the late summer. *Diaptomus* was at exceptionally low density, however, from March through July this year (<0.2 adult females/L), reinforcing the 1992 pattern. Like 1992, there was some apparent inverse relationship seasonally with the *Daphnia* population, with low *Diaptomus* concentrations during the spring and early summer period of abundant *Daphnia*. *Diaptomus* recovered in August from its low spring and early summer level, a few weeks after the *Daphnia* decline. Both populations overwinter as non-reproducing adults.

(3) The various rotifers displayed pronounced seasonalities, which differed among species. There were also pronounced differences in distribution among the three layers. Densities were quite high but variable in summer (200-1500/L), which imply densities of twice this in the upper water layers where they mainly occurred. Rotifers were less abundant during the winter and spring (200-500/L), but not as strongly reduced as in 1992 (<50/L). Winter/spring is a time of relatively few species, while the strong late August peak in abundance was associated with the appearance of additional species of restricted summer occurrence (e.g. *Ascomorpha, Collotheca, Conochilus*). It is interesting that the August peak shortly succeeded the crash in *Daphnia*, perhaps suggesting a competitive interaction.

(4) In general hard-bodied rotifers (e.g. *Keratella*, especially *K. cochlearis*), those with swift escape reactions (e.g. *Polyarthra*), and those forming large colonies (e.g. *Conochilus*) or individual gelatinous tubes (e.g. *Collotheca*) were most common during the summer, perhaps implying heavy predation pressure that these protective growth forms might resist. One potential predators was quite common in summer: the large dipteran *Chaoborus* (0.2-0.4/L, as in previous years). Our switch to daytime sampling after May had no obvious effect on the size of the summer *Chaoborus* collection, probably because the animals do not migrate all the way to the sediments through Waynewood's relatively dark, anoxic hypolimnion. Another group of predators, cyclopoid copepods, tended to be low throughout the year in comparison to most previous years.

(5) In general, 1993 was a poor year for cyclopoid copepods in Lake Waynewood. *Mesocyclops edax*, the main summer cyclopoid in 1989-1991, was uncommon in 1992-93. In spring, *Diacyclops thomasi* was present, though at even lower concentration (ca 0.4/L on one date) than in 1990-92. *Orthocyclops modestus* similarly had a weak spring population, but no late summer population. This taxon appeared or was first recognized by the zooplankton counters in 1992, when it was relatively common in late summer (0.2-1/L). *Cyclops scutifer* briefly reached ca. 1 adult/L in late summer, but has never been

Table 3. Zooplankton species recorded from open-water samples in Lake Waynewood 1988-1993. Seasons of especially high or low abundance in 1993 are indicated.

	Taxon	Seasonal Abundance in 1993 High	Low
Diptera			
**	*Chaoborus* spp.	late Sp,Su	[F]
	C. flavicans		
	C. punctipennis		
Cyclopoid Copepoda			
*	*Diacyclops thomasi*	W,Sp	[Su,F]
*	*Cyclops scutifer*	late Su	
	Macrocyclops albidus (rare)		
*	*Mesocyclops edax*		
*	*Orthocyclops modestus*		
	Tropocyclops prasinus		
Calanoid Copepoda			
**	*Diaptomus oregonensis*		[Sp,early Su]
Cladocera			
	Bosmina		
	Ceriodaphnia spp.		
	Chydorus spp.		
**	*Daphnia* spp.	Sp,F	[Su]
	D. pulex/pulicaria		
	D. laevis		
	Diaphanosoma spp.		
	Holopedium gibberum		
	Leptodora kindtii		
Rotifera			
	Anuraeopsis spp.		
*	*Ascomorpha* spp.	Su	[F,W,Sp]
	A. ovalis		
*	*Asplanchna* spp.	late Sp	[W,F]
**	*Collotheca* spp.	mid-Su	[F,W,Sp]
*	*C. mutabilis*		
	Colurella spp.		
**	*Conochilus* spp.	Su	[F,W,Sp]
*	*Filinia longiseta*		
	Gastropus spp.		
*	*G. hyptopus*	late Sp,Su	[F]
*	*G. stylifer*	late Sp,Su	[F]

continued next page

Table 3. Zooplankton in Lake Waynewood, 1993 (continued)

	Taxon	Seasonal Abundance in 1993 High	Low
	Kellicottia spp.		
*	*K. bostoniensis*		[early Su]
*	*K. longispina*		
	Keratella spp.		
**	*K. cochlearis*	early Su,F	[W,Sp]
*	*K. crassa*		[W,Sp]
*	*K. earlinae*		[Su]
	K. hiemalis		
	K. serrulata f. *curvicornis*		
	K. taurocephala		
	Lecane spp.		
	L. luna		
	Monostyla spp.		
	Notholca spp.		
	N. acuminata		
	Notommata spp.		
	Ploesoma spp.		
*	*P. truncatum*		[mid-Su]
**	*Polyarthra* spp.	late Sp	
	P. dolichoptera		
	P. euryptera		
	P. remata		
	P. vulgaris		
*	*Pompholyx* spp.		
*	*Synchaeta* spp.	late Sp, early Su	[F]
	Trichocerca spp.		
	Trichocerca ("small")		
*	*T. cylindrica*	late Su	[W,Sp]
	T. lophoessa		
*	*T. multicrinus*		
*	*T. rousseleti*		
*	*T. similis*	Su	[W,Sp]
	Trichotria spp.		
	Wolga spp.		

Abbreviations for seasons of maximal or [minimal] abundance:
W (winter), Sp (spring), Su (summer), F (fall).

** Dominant species included in Figures
* Other common species included in Figures

common. And finally *Tropocyclops prasinus*, which had developed abundant late summer and fall populations in 1989-91 (10-20 adults/L), failed in 1993 as also in 1992.

(6) Concerning cyclopoid copepods: we are having some difficulty assigning immature cyclopoids (the "copepodids") to species. We have continued to present graphs for copepodids of each genus, but have discovered year-to-year confusion in how copepodids of *Cyclops scutifer* and *Orthocyclops modestus* were separated in Lake Lacawac, and related problems may occur in the Lake Waynewood database. A more conservative strategy would be to lump all cyclopoid copepodids.

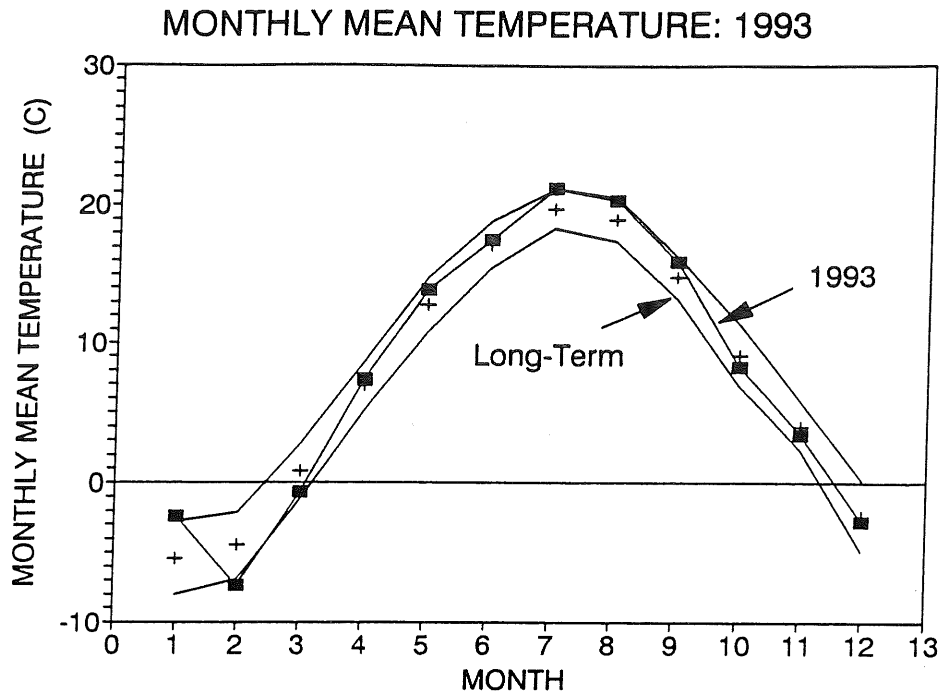
CLIMATE IN 1993

Weather data were again obtained from NOAA for the cooperator's station at Hawley, PA (ca. 20 km N of Lake Lacawac). The monthly mean temperatures (monthly means of daily means) are plotted along with total monthly rainfall for 1993 versus the average of the previous 31 years (**Figure 10**). The year included both relatively cold (February) and warm months (January, July, August). The summer was slightly warmer and drier than usual. The winter was cold enough for a long ice cover (late December to 10 April), and fairly snowy. A week after the major snowstorm of 14-15 March, we encountered melting snow on top of >50 cm of still-solid ice -- quite a contrast with the poor ice conditions of preceding winters.

DISCUSSION

In 1993 Lake Waynewood went through a seasonal pattern similar to those of previous years. The eutrophic nature of the lake was evident in the often high chlorophyll levels and the early-summer onset of anoxic conditions throughout the hypolimnion. As in previous years, high chlorophyll levels developed within the metalimnion in June and July, before increasing in the epilimnion. In fact, Lake Waynewood had relatively low epilimnetic algal populations from May through July (< 8 μg Chl-a/L), but increased to ca. 16 μg Chl-a/L by the end of August. High chlorophyll levels prevailed during fall turnover in November (ca. 30 μg/L).

Water transparency was relatively high in late spring and early summer (Secchi depth 4-5 m through early July). This has been the general pattern for Waynewood, though the timing of the late summer increase of epilimnetic algae creates some variability in how far into the summer such relatively high transparency persists. In 1993, transparency declined steadily from 4.5 to 2 meters during July and August. In some years (1989-90), a slightly greater decline occurred more rapidly during July, corresponding to high epilimnetic algal populations during late July and into August. The better water transparency during late July and August 1992-93 might represent a long-term trend of decreasing eutrophication. On the other hand, the very high algal populations encountered during fall turnover in November, 1993 (ca. 30 μg Chl-a/L throughout the 0-12 meter water column; Secchi depth only 1.1 meter) was one of the highest we have encountered during the 5-year study. Water quality in midsummer is probably a delicate balance of a variety of biological and chemical factors that determine the depth-distribution of the algae, with massive algal populations developing in the metalimnion when transparency of the upper water column allows sufficient light to reach the 3.5-6 meter depths of the metalimnion. Algal populations in autumn are remarkably variable; sometimes --as in 1993-- they have been quite dense.



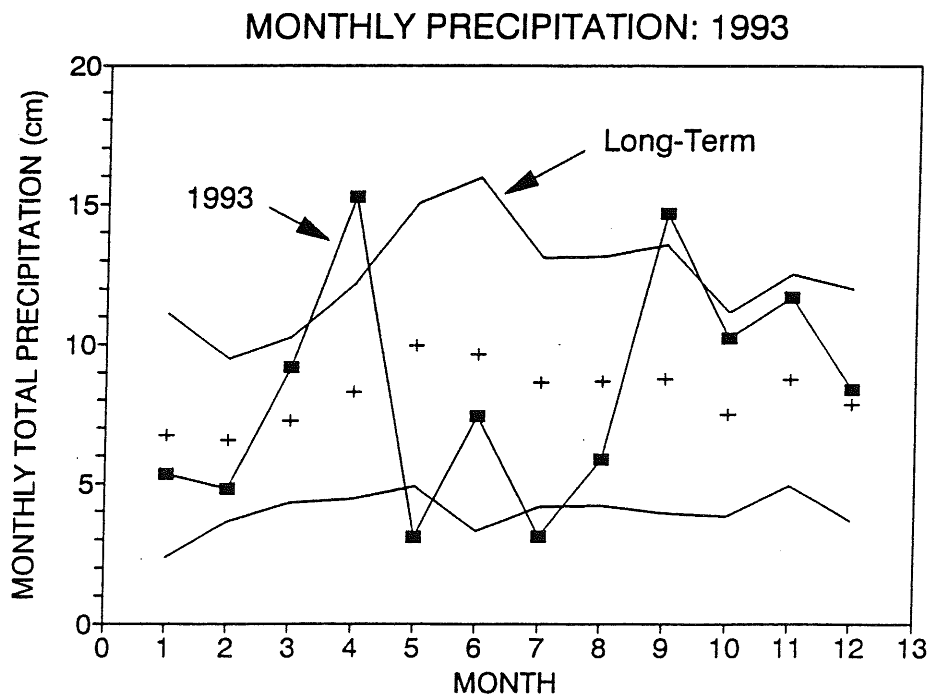


Figure 10. Monthly climate in 1993 compared to the 31-year averages.

(Top) Mean temperature (degrees Celsius). **(Bottom)** Monthly mean precipitation (cm rain or thawed snow). Data are from the NOAA cooperator's station at Hawley, PA. Long-term values (+) are enclosed in an envelope defined by one standard deviation of the monthly values. Data were not reported for July, so values from the Lacawac weather station were substituted. Lacawac values of temperature were adjusted down 0.7°C and precipitation was adjusted up by a factor of 1.32 to match average May, June, and August differences between the stations.

The phytoplankton counts from 1989-1992 identify two filamentous cyanobacteria (blue-green algae) as dominants of the summer phytoplankton: *Aphanizomenon flos-aquae* and *Anabaena macrospora*. These are notorious species of eutrophic lakes. In winter and spring, species of the colonial flagellated chrysophyte, *Synura*, dominated, as in the less productive lakes. In autumn, the phytoplankton was variably dominated by diatoms and cyanobacteria, the latter persisting-- sometimes at very high levels --from their summer populations. Autumnal abundance of diatoms is a common pattern in productive lakes that have adequate concentrations of dissolved silicon.

The winter of 1992-93 was cold and long, reversing for a second year the climatic warming trend of the recent past. Ice cover was in place from late December to mid-April at Lake Lacawac, and was often snow-covered. Algae were abundant right beneath the ice in early winter, but had been strongly reduced under the half-meter of snow-covered ice when we sampled in March. Despite the long ice cover, and the poor light conditions under the snow-covered ice, there was only moderate oxygen depletion within the water column. Anoxia only developed below 10 meters.

The chemical data from 1991-92, in combination with that collected in 1989, allowed us to calculate an ion balance for the lake water. Calcium was the dominant cation, and bicarbonate and sulfate were co-dominant anions. The relative abundance of sodium and chloride, and their equi-molar concentrations, probably reflects human activities, including road salting, within the drainage basin. Data on the algal nutrients phosphorus and nitrogen in 1993 again demonstrated high levels of regenerated ammonium and phosphate within the anoxic summer hypolimnion. These nutrients supported high algal populations during fall turnover. In spring, nitrogen (ammonium and nitrate) were depleted more slowly than phosphate, so the epilimnetic algae may have shifted from a phosphorus limitation in May-June to a nitrogen and phosphorus co-limitation in July-September. Such conditions favor the *Aphanizomenon* and *Anabaena*, since they meet part of their nitrogen requirements by fixing atmospheric N_2, a process the other algae cannot do.

EXPLANATION OF DATA TABLES

The following 12 tables present the physical/chemical information acquired on each date in 1993. The headings, abbreviations, and analytical units are explained here.

DATE OF SAMPLE: Date of the daytime visit, as month/day/year.

JULIAN DATE: Day of the year, from 1-365.

TIME: Approximate start or mid-time of sampling, 24-hr clock in decimal format (e.g. 1:30 PM is "13.50").

SECCHI M: Secchi depth in metres (m).

WEATHER: Brief comments on weather, especially cloudiness.

PERSONNEL: Initials of sampling crew (see names below).

TMETHOD: Temperature method #10 (see **METHODS AND RESULTS**).

LMETHOD: Light methods #12,13 (see **METHODS AND RESULTS**).

AMETHOD: Alkalinity method #11 (see **METHODS AND RESULTS**).

OMETHOD: Oxygen method #10 (see **METHODS AND RESULTS**).

PHMETHOD: pH method #11 (see **METHODS AND RESULTS**).

CAMETHOD: Chlorophyll-a method #12, 13 (see **METHODS AND RESULTS**).

COMMENTS: Notes on unusual procedures, also ice thickness.

DATE OF: Date of sample (month/day/year).

JULIAN: Julian date.

STRA: Stratum or layer: **S** (air above surface), **E** (epilimnion), **M**(metalimnion), **H** (hypolimnion).

REP: Replicate (1 or 2); Replicates were usually analyzed for pH, alkalinity, chlorophyll--other data are merely repeated on rep 2 line for convenience in graphing.

DEPTH: Depth of sample (metres); **-1** for air above surface.

TEMP C: Temperature in degrees Celsius (°C).

OXYGEN: Dissolved oxygen (mg per litre--not corrected for elevation).

OFLAG: Error flag for oxygen; "**4**" means reported value should be interpreted as a true "zero".

LIGHT PC: Light as percent of intensity at 0.1-m depth.

pH: pH.

ALKAL: Alkalinity as microequivalents per litre (μeq/L).

CHLAC: Chlorophyll-a, corrected for pheopigments (μg/L).

CHLASUM: Chlorophyll-a, including pheopigments (μg/L).

CHLAC P: Percentage of CHLAC passing 22-μm net.

Names of Sampling Personnel:

EMB, EMN	Gina Brockway
MB	Michaela Bodnarova
BH	Bruce Hargreaves
LG	Lauren Graves
BKS	Brian Sharer
PLS	Paul Stutzman
HS	Henry Su
TLV	Tim Vail

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 1/20/93 JULIAN DATE: 20 TIME: 15.58

SECCHI M: 3.9 WEATHER: sunny, windy

PERSONNEL: TLV EMN

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 12

COMMENTS: 20cm ice

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
1/20/93	20	S	1	-1.0	2.9								
1/20/93	20		1	0.0	2.7	14.68		100.0000					
1/20/93	20	E	1	1.0	3.3	13.08		10.6180	6.88	327	4.59	4.59	
1/20/93	20	E	2	1.0	3.3	13.08		10.6180	6.96	302	4.82	4.82	47.40
1/20/93	20		1	2.0	3.6	10.98		3.3474					
1/20/93	20		1	3.0	3.4	10.28		1.4342					
1/20/93	20	M	1	4.0	3.4	9.34		0.6915	6.96	373	4.39	4.39	
1/20/93	20	M	2	4.0	3.4	9.34		0.6915	6.96	369	3.53	3.53	67.40
1/20/93	20		1	5.0	3.6	8.08		0.3422					
1/20/93	20		1	6.0	3.7	7.45		0.1489					
1/20/93	20		1	7.0	3.8	7.08		0.0646					
1/20/93	20		1	8.0	4.0	6.22		0.0278					
1/20/93	20	H	1	9.0	4.0	5.80		0.0120	6.77	389	0.39	1.35	
1/20/93	20	H	2	9.0	4.0	5.80		0.0120	6.75	398	0.43	1.30	79.10
1/20/93	20		1	10.0	4.0	4.15		0.0050					
1/20/93	20		1	11.0	4.2	0.33		0.0017					
1/20/93	20		1	12.0	4.5	0.13							

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 2/18/93 JULIAN DATE: 49 TIME: 16.50

SECCHI M: 2.2 WEATHER: cloudy, windy

PERSONNEL: EMN BKS TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 12

COMMENTS: 26cm ice with 5cm snow

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
2/18/93	49	S	1	-1.0									
2/18/93	49		1	0.0	1.4	17.88		100.0000					
2/18/93	49	E	1	1.0	3.7	13.68		5.0378	6.85	334	94.34	94.34	
2/18/93	49	E	2	1.0	3.7	13.68		5.0378	6.92	348	80.84	82.48	5.62
2/18/93	49		1	2.0	3.9	13.34		1.0606					
2/18/93	49		1	3.0	3.9	13.28		0.2016					
2/18/93	49	M	1	4.0	3.9	13.22		0.0411	6.94	347	19.20	20.60	
2/18/93	49	M	2	4.0	3.9	13.22		0.0411	6.90	354	12.51	14.52	18.30
2/18/93	49		1	5.0	3.9	13.18							
2/18/93	49		1	6.0	3.9	13.18							
2/18/93	49		1	7.0	3.9	13.09							
2/18/93	49		1	8.0	4.0	12.53							
2/18/93	49	H	1	9.0	4.1	8.68			6.87	345	4.03	5.66	
2/18/93	49	H	2	9.0	4.1	8.68			6.82	363	3.45	5.14	38.60
2/18/93	49		1	10.0	4.2	4.63							
2/18/93	49		1	11.0	4.5	0.39							
2/18/93	49		1	12.0	4.7	0.22							

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 3/22/93 JULIAN DATE: 81 TIME: 16.25

SECCHI M: 3.5 WEATHER: clear

PERSONNEL: TLV BKS

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 12

COMMENTS: >50 cm of ice

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
3/22/93	81	S	1	-1.0	2.8								
3/22/93	81		1	0.0	1.2	10.27		100.0000					
3/22/93	81	E	1	1.0	2.4	9.24		7.6864	6.70	357	0.64	0.90	
3/22/93	81	E	2	1.0	2.4	9.24		7.6864	6.76	353	0.46	0.77	54.30
3/22/93	81		1	2.0	3.6	8.28		1.3311					
3/22/93	81		1	3.0	3.6	8.19		0.3941					
3/22/93	81		1	4.0	3.6	8.16		0.1612					
3/22/93	81	M	1	5.0	3.6	8.08		0.0495	6.78	353	0.73	0.98	
3/22/93	81	M	2	5.0	3.6	8.08		0.0495	6.78	334	0.67	0.93	56.70
3/22/93	81		1	6.0	3.7	8.02		0.0220					
3/22/93	81		1	7.0	3.7	8.00		0.0095					
3/22/93	81		1	8.0	3.8	7.08		0.0036					
3/22/93	81	H	1	9.0	3.8	6.80		0.0015	6.70	357	0.28	0.97	
3/22/93	81	H	2	9.0	3.8	6.80		0.0015	6.72	358	0.22	0.79	72.70
3/22/93	81		1	10.0	3.9	4.95							
3/22/93	81		1	11.0	3.9	3.93							
3/22/93	81		1	12.0	4.5	0.11							

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 4/19/93 JULIAN DATE: 109 TIME: 14.50

SECCHI M: 2.5 WEATHER: sunny and windy

PERSONNEL: EMN TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 12

COMMENTS:

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
4/19/93	109	S	1	-1.0	19.3								
4/19/93	109		1	0.0	7.0	12.03		100.0000					
4/19/93	109		1	1.0	6.8	11.57		25.4712					
4/19/93	109	E	1	2.0	6.5	11.20		7.7162	6.74	256	8.07	8.07	
4/19/93	109	E	2	2.0	6.5	11.20		7.7162	6.77	254	5.59	6.00	91.10
4/19/93	109		1	3.0	6.3	11.00		2.5466					
4/19/93	109		1	4.0	6.3	10.86		0.7534					
4/19/93	109		1	5.0	5.6	10.37		0.2631					
4/19/93	109	M	1	6.0	5.6	10.16		0.0943	6.77	249	2.32	2.69	
4/19/93	109	M	2	6.0	5.6	10.16		0.0943	6.77	254	4.03	4.79	91.30
4/19/93	109		1	7.0	5.6	9.95		0.0306					
4/19/93	109		1	8.0	5.6	9.78		0.0105					
4/19/93	109		1	9.0	5.5	9.53		0.0037					
4/19/93	109	H	1	10.0	5.4	9.37		0.0014	6.75	252	2.76	4.04	
4/19/93	109	H	2	10.0	5.4	9.37		0.0014	6.73	258	2.87	3.40	92.00
4/19/93	109		1	11.0	5.3	9.15		0.0004					
4/19/93	109		1	12.0	5.1	5.84							

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 5/12/93 JULIAN DATE: 132 TIME: 15.00

SECCHI M: 4.3 WEATHER: sunny and windy

PERSONNEL: EMB TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 12

COMMENTS: Secchi measured without viewing box

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
5/12/93	132	S	1	-1.0	24.5								
5/12/93	132		1	0.0	21.2	9.33		100.0000					
5/12/93	132	E	1	1.0	21.1	8.90		27.2702	7.22	246	1.18	1.29	
5/12/93	132	E	2	1.0	21.1	8.90		27.2702	7.28	238	1.04	1.21	69.20
5/12/93	132		1	2.0	19.4	9.31		10.8690					
5/12/93	132	M	1	3.0	12.2	11.96		3.9252	7.22	237	2.19	2.40	
5/12/93	132	M	2	3.0	12.2	11.96		3.9252	7.24	238	2.25	2.49	63.10
5/12/93	132		1	4.0	8.8	11.02		2.0433					
5/12/93	132		1	5.0	7.4	7.48		0.7951					
5/12/93	132		1	6.0	6.8	7.16		0.3154					
5/12/93	132	H	1	7.0	6.6	6.78		0.1126	6.52	255	0.95	1.42	
5/12/93	132	H	2	7.0	6.6	6.78		0.1126	6.52	256	0.68	1.33	65.20
5/12/93	132		1	8.0	6.5	6.80		0.0411					
5/12/93	132		1	9.0	6.4	6.33		0.0153					
5/12/93	132		1	10.0	6.3	5.81		0.0053					
5/12/93	132		1	11.0	6.1	3.73		0.0013					
5/12/93	132		1	12.0	6.1	2.82							

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 6/09/93 JULIAN DATE: 160 TIME: 14.75

SECCHI M: 4.9 WEATHER: overcast, rain

PERSONNEL: EMB TLV HS

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS: light from 6/11/93 at 14.66 hr (partly cloudy, windy)

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
6/09/93	160	S	1	-1.0	23.4								
6/09/93	160		1	0.0	19.5	9.22		100.0000					
6/09/93	160	E	1	1.0	18.4	9.25		40.4858	7.13	297	2.40	3.60	
6/09/93	160	E	2	1.0	18.4	9.25		40.4858	7.22	278			
6/09/93	160		1	2.0	17.8	9.15		16.1298					
6/09/93	160		1	3.0	16.5	8.84		6.8638					
6/09/93	160	M	1	4.0	14.9	8.36		2.8130	7.00	277	1.80	4.90	
6/09/93	160	M	2	4.0	14.9	8.36		2.8130	7.05	278			
6/09/93	160		1	5.0	10.2	6.41		1.0946					
6/09/93	160		1	6.0	7.7	4.67		0.4326					
6/09/93	160		1	7.0	7.1	2.90		0.1703					
6/09/93	160		1	8.0	6.6	2.64		0.0560					
6/09/93	160	H	1	9.0	6.4	2.00		0.0175	6.45	289	0.70	1.50	
6/09/93	160	H	2	9.0	6.4	2.00		0.0175	6.44	342			
6/09/93	160		1	10.0	6.3	0.96		0.0041					
6/09/93	160		1	11.0	6.2	0.57							
6/09/93	160		1	12.0	6.2	0.55							

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 6/22/93 JULIAN DATE: 173 TIME: 10.67

SECCHI M: 4.4 WEATHER: partly cloudy, wind W 5-10 knots

PERSONNEL: TLV LG

TMETHOD: 10 LMETHOD: 12 AMETHOD:
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS: light data doubtful near surface; no alkalinity this data

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
6/22/93	173	S	1	-1.0	21.1								
6/22/93	173		1	0.0	23.6	8.14		100.0000					
6/22/93	173		1	1.0	23.7	8.15		9.0253					
6/22/93	173	E	1	2.0	23.6	8.25		3.5772	7.34		4.60	3.30	
6/22/93	173	E	2	2.0	23.6	8.25		3.5772	7.42				
6/22/93	173		1	3.0	20.6	8.92		1.8411					
6/22/93	173		1	4.0	17.4	8.43		0.8920					
6/22/93	173	M	1	5.0	11.7	5.42		0.3352	6.63		6.60	8.60	
6/22/93	173	M	2	5.0	11.7	5.42		0.3352	6.67				
6/22/93	173		1	6.0	8.6	2.63		0.1285					
6/22/93	173		1	7.0	7.3	1.43		0.0488					
6/22/93	173		1	8.0	6.9	0.99		0.0161					
6/22/93	173		1	9.0	6.7	0.65	4	0.0047					
6/22/93	173	H	1	10.0	6.5	0.56	4	0.0012	6.54		1.90	3.70	
6/22/93	173	H	2	10.0	6.5	0.56	4	0.0012	6.53				
6/22/93	173		1	11.0	6.4	0.46	4	0.0002					
6/22/93	173		1	12.0	6.3	0.44	4						

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 7/06/93 JULIAN DATE: 187 TIME: 15.08

SECCHI M: 4.4 WEATHER: hazy, windy(S)

PERSONNEL: EMB TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS: Chlorophyll by methods 12 and 13 today

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
7/06/93	187	S	1	-1.0	28.5								
7/06/93	187		1	0.0	26.6	8.61		100.0000					
7/06/93	187		1	1.0	26.6	8.44		29.4985					
7/06/93	187	E	1	2.0	24.8	8.55		12.8478	7.62	254	2.02	2.03	
7/06/93	187	E	2	2.0	24.8	8.55		12.8478	7.63	255	2.40	3.10	
7/06/93	187		1	3.0	23.1	8.68		5.8800					
7/06/93	187		1	4.0	18.5	11.06		2.8080					
7/06/93	187	M	1	5.0	12.5	3.65		0.9144	7.14	278	50.15	50.15	
7/06/93	187	M	2	5.0	12.5	3.65		0.9144	7.27	256	26.40	28.50	
7/06/93	187		1	6.0	9.7	1.26		0.2945					
7/06/93	187		1	7.0	7.5	0.44	4	0.0986					
7/06/93	187		1	8.0	6.9	0.44	4	0.0315					
7/06/93	187	H	1	9.0	6.7	0.43	4	0.0074	6.52	391	7.95	9.07	
7/06/93	187	H	2	9.0	6.7	0.43	4	0.0074	6.55	364	6.30	12.10	
7/06/93	187		1	10.0	6.5	0.41	4	0.0018					
7/06/93	187		1	11.0	6.4	0.40	4	0.0005					
7/06/93	187		1	12.0	6.4	0.23	4						

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 7/20/93 JULIAN DATE: 201 TIME: 10.67

SECCHI M: 3.4 WEATHER: mostly cloudy (but sun/clouds during light profile)

PERSONNEL: EMB TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD:
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS:

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
7/20/93	201	S	1	-1.0	24.4								
7/20/93	201		1	0.0	23.8	7.60		100.0000					
7/20/93	201		1	1.0	23.8	7.60		26.1028					
7/20/93	201	E	1	2.0	23.6	7.50		9.4713	7.36		5.00	6.80	
7/20/93	201	E	2	2.0	23.6	7.50		9.4713	7.37				
7/20/93	201		1	3.0	23.6	7.61		4.3526					
7/20/93	201		1	4.0	21.1	9.57		0.6168					
7/20/93	201	M	1	5.0	14.7	10.52		0.1429	7.45		56.20	67.00	
7/20/93	201	M	2	5.0	14.7	10.52		0.1429	7.47				
7/20/93	201		1	6.0	9.8	0.47	4	0.0436					
7/20/93	201		1	7.0	8.0	0.37	4	0.0128					
7/20/93	201		1	8.0	7.3	0.35	4	0.0029					
7/20/93	201	H	1	9.0	6.9	0.32	4	0.0009	6.52		3.20	8.80	
7/20/93	201	H	2	9.0	6.9	0.32	4	0.0009	6.51				
7/20/93	201		1	10.0	6.8	0.33	4						
7/20/93	201		1	11.0	6.6	0.31	4						
7/20/93	201		1	12.0	6.5	0.28	4						

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 8/03/93 JULIAN DATE: 215 TIME: 16.67

SECCHI M: 3.3 WEATHER: sunny, windy

PERSONNEL: EMB TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS:

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
8/03/93	215	S	1	-1.0	29.9								
8/03/93	215		1	0.0	25.3	9.59		100.0000					
8/03/93	215		1	1.0	25.2	9.56		28.9436					
8/03/93	215	E	1	2.0	24.5	9.64		10.0849	8.59	286	8.80	10.70	
8/03/93	215	E	2	2.0	24.5	9.64		10.0849	8.74	293			
8/03/93	215		1	3.0	24.1	9.47		4.1985					
8/03/93	215		1	4.0	22.5	9.99		1.4573					
8/03/93	215	M	1	5.0	16.2	9.04		0.2611	7.88	299	41.40	44.20	
8/03/93	215	M	2	5.0	16.2	9.04		0.2611	7.58	312			
8/03/93	215		1	6.0	10.7	0.34	4	0.0629					
8/03/93	215		1	7.0	8.5	0.26	4	0.0219					
8/03/93	215		1	8.0	7.7	0.28	4	0.0087					
8/03/93	215	H	1	9.0	7.3	0.12	4	0.0035	6.63	504	11.50	19.70	
8/03/93	215	H	2	9.0	7.3	0.12	4	0.0035	6.60	501			
8/03/93	215		1	10.0	7.0	0.24	4	0.0023					
8/03/93	215		1	11.0	6.8	0.25	4						
8/03/93	215		1	12.0	6.6	0.25	4						

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 8/18/93 JULIAN DATE: 230 TIME: 10.00

SECCHI M: 2.2 WEATHER: overcast, breezy

PERSONNEL: EMB TLV

TMETHOD: 10 LMETHOD: 12 AMETHOD:
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS: No alkalinity this date

DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
8/18/93	230	S	1	-1.0	22.1								
8/18/93	230		1	0.0	22.9	9.02		100.0000					
8/18/93	230		1	1.0	22.9	8.87		16.2496					
8/18/93	230	E	1	2.0	22.8	8.79		4.4568	8.54		14.80	17.40	
8/18/93	230	E	2	2.0	22.8	8.79		4.4568	8.60				
8/18/93	230		1	3.0	22.6	8.60		1.2477					
8/18/93	230		1	4.0	21.0	7.06		0.2459					
8/18/93	230		1	5.0	16.6	1.70		0.0690					
8/18/93	230	M	1	6.0	11.1	0.44	4	0.0271	6.53		15.60	26.10	
8/18/93	230	M	2	6.0	11.1	0.44	4	0.0271	6.53				
8/18/93	230		1	7.0	9.0	0.45	4	0.0105					
8/18/93	230		1	8.0	8.0	0.44	4	0.0043					
8/18/93	230		1	9.0	7.1	0.39	4	0.0016					
8/18/93	230	H	1	10.0	6.7	0.38	4	0.0010	6.73		3.20	7.00	
8/18/93	230	H	2	10.0	6.7	0.38	4	0.0010	6.72				
8/18/93	230		1	11.0	6.6	0.36	4						
8/18/93	230		1	12.0	6.6	0.33	4						

LAKE WAYNEWOOD: SUMMARY OF PHYSICAL/CHEMICAL DATA

DATE OF SAMPLE: 11/16/93 JULIAN DATE: 320 TIME: 13.00

SECCHI M: 1.1 WEATHER: Sunny

PERSONNEL: EMB PLS BRH CEW

TMETHOD: 10 LMETHOD: 13 AMETHOD: 11
OMETHOD: 10 PHMETHOD: 12 CAMETHOD: 13

COMMENTS: Light collected with PUV by BRH and CEW

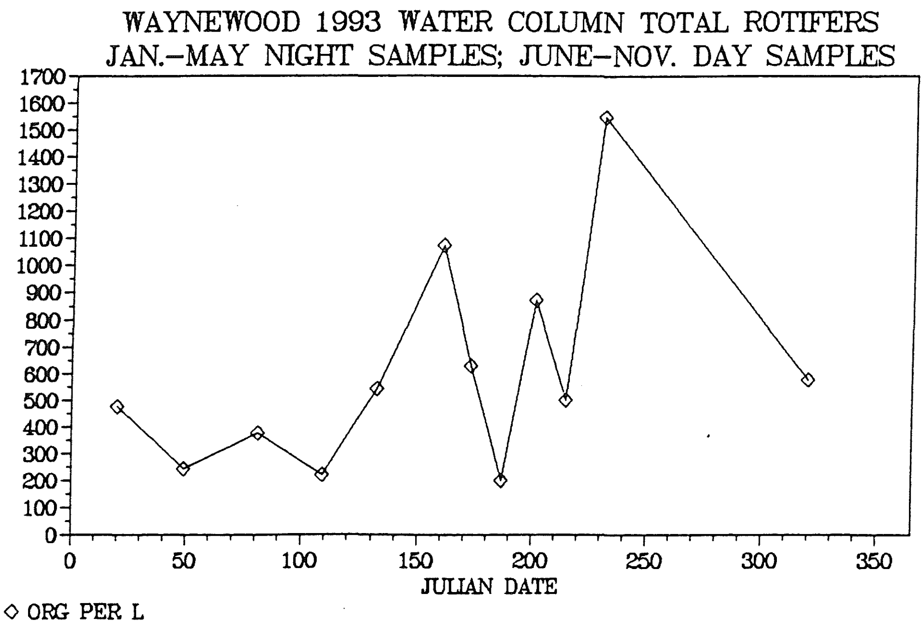
DATE OF	JULIAN	STRA	REP	DEPTH	TEMP C	OXYGEN	OFLAG	LIGHT PC	PH	ALKAL	CHLAC U	CHLASUM	CHLAC P
11/16/93	320	S	1	-1.0	13.5								
11/16/93	320		1	0.0	8.1	12.44		100.0000					
11/16/93	320		1	1.0	8.0	12.90		14.2700					
11/16/93	320	E	1	2.0	7.5	12.89		2.4700	7.44	333	39.20	45.70	
11/16/93	320	E	2	2.0	7.5	12.89		2.4700	7.45	333			
11/16/93	320		1	3.0	7.2	12.82		0.4910					
11/16/93	320		1	4.0	7.0	12.56		0.1067					
11/16/93	320		1	5.0	6.7	11.94		0.0230					
11/16/93	320	M	1	6.0	6.6	11.81		0.0052	7.17	334	25.80	29.80	
11/16/93	320	M	2	6.0	6.6	11.81		0.0052	7.19	333			
11/16/93	320		1	7.0	6.5	11.56							
11/16/93	320		1	8.0	6.4	11.38							
11/16/93	320		1	9.0	6.4	11.24							
11/16/93	320	H	1	10.0	6.4	11.16			7.09	330	41.40	44.10	
11/16/93	320	H	2	10.0	6.4	11.16			7.09	332			
11/16/93	320		1	11.0	6.4	10.98							
11/16/93	320		1	12.0	6.4	9.40							

ZOOPLANKTON GRAPHS

The following graphs present water-column mean concentrations of the common zooplankton at the main sampling station. Each data point was calculated by weighting concentrations in the three layers (EPI, META, HYPO) on each date by the relative thickness of the layer at the station, which was in the deepest part of the lake. Two replicate samples were taken in quick succession.

Data from January through May are from nighttime sampling (as in previous Annual Reports). Starting in June only daytime sampling was performed.

The electronic database contains the component concentrations within the three layers, separate counts for the two replicates, and similarly complete data from the comparable daytime sampling for the January--May dates.



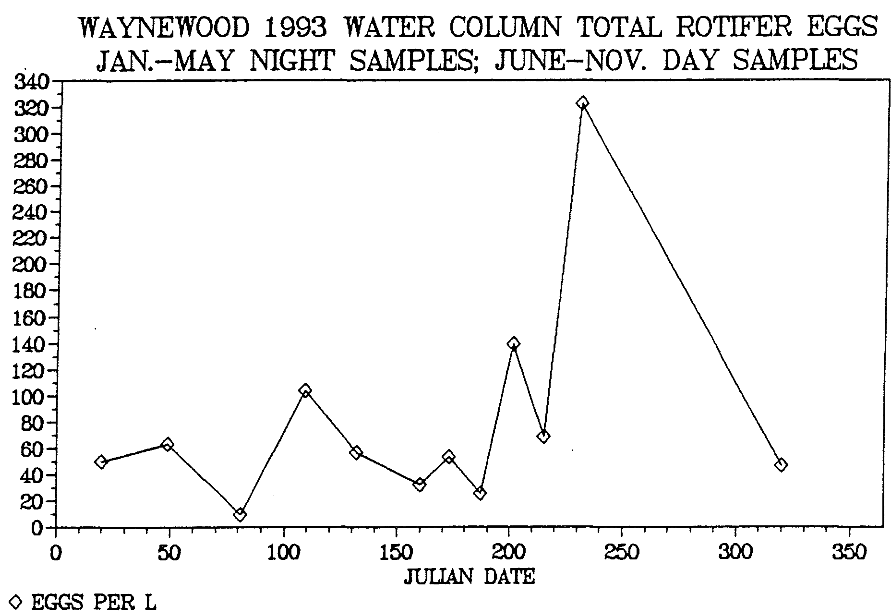


Figure 11. Rotifers in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** Rotifer eggs per liter.

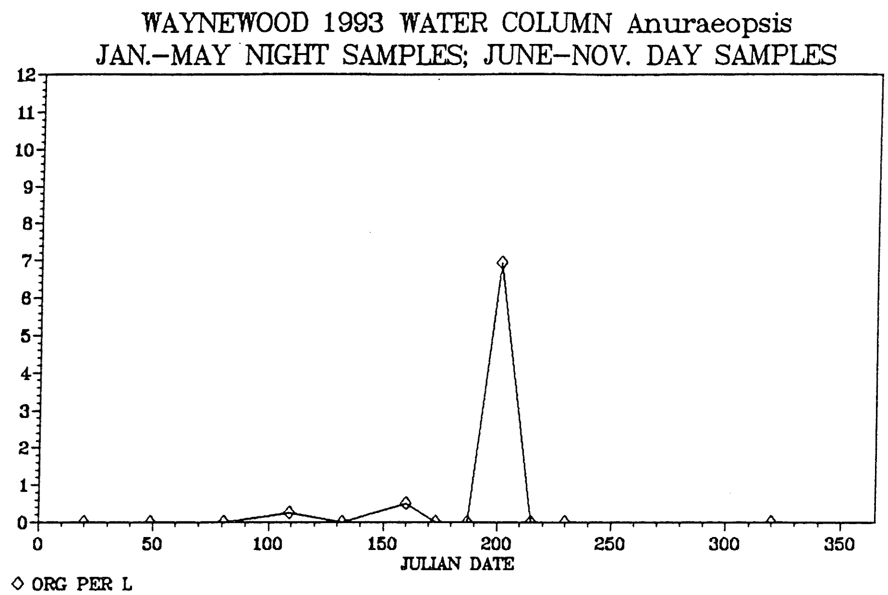
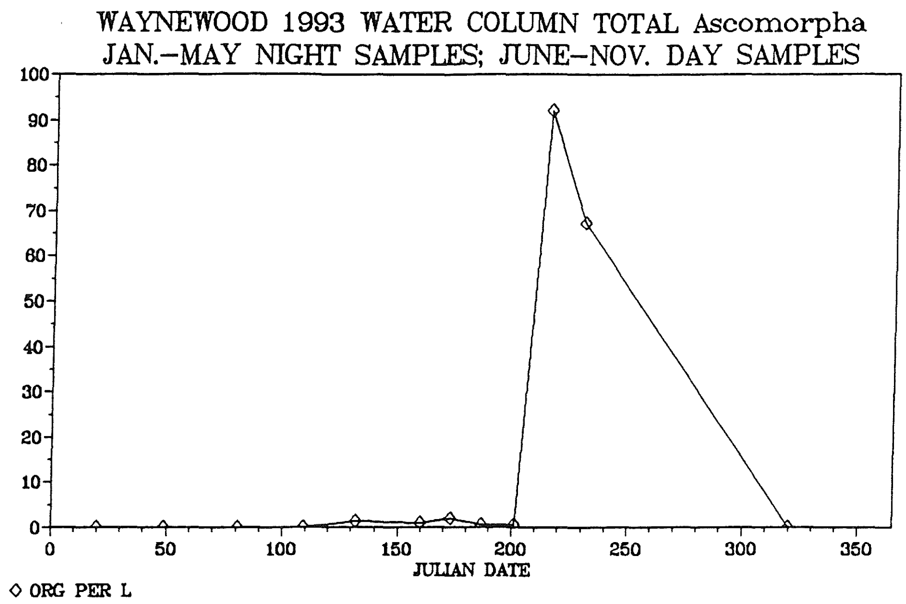


Figure 12. The rotifer *Anuraeopsis* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean.



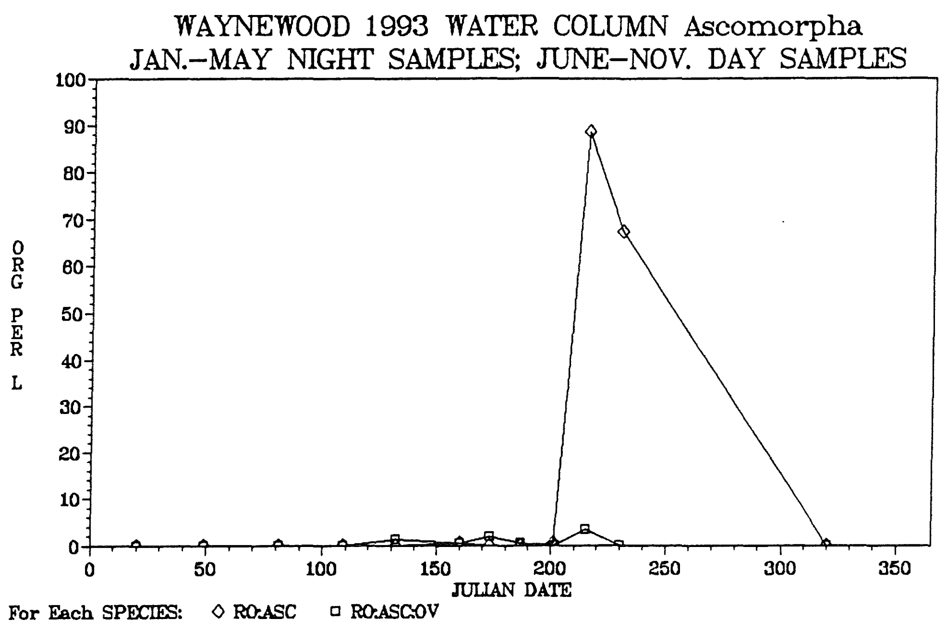


Figure 13. The rotifer *Ascomorpha* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals of all species per liter. **(Bottom)** *Ascomorpha* by species: **ASC** undifferentiated, **OV** *A. ovalis*.

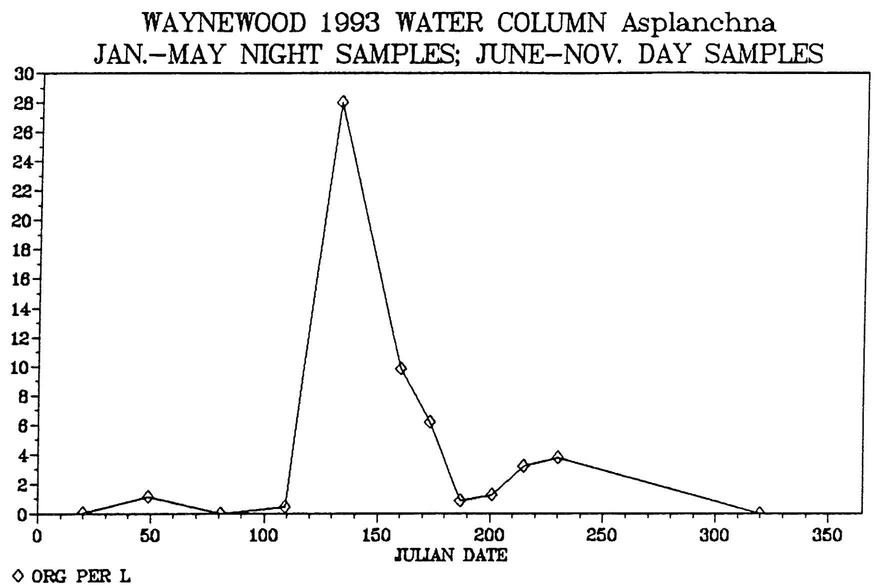


Figure 14. The rotifer *Asplanchna* in Lake Waynewood, 1993.

Net collections from three depths (48μm net) have been combined to give a water column mean.

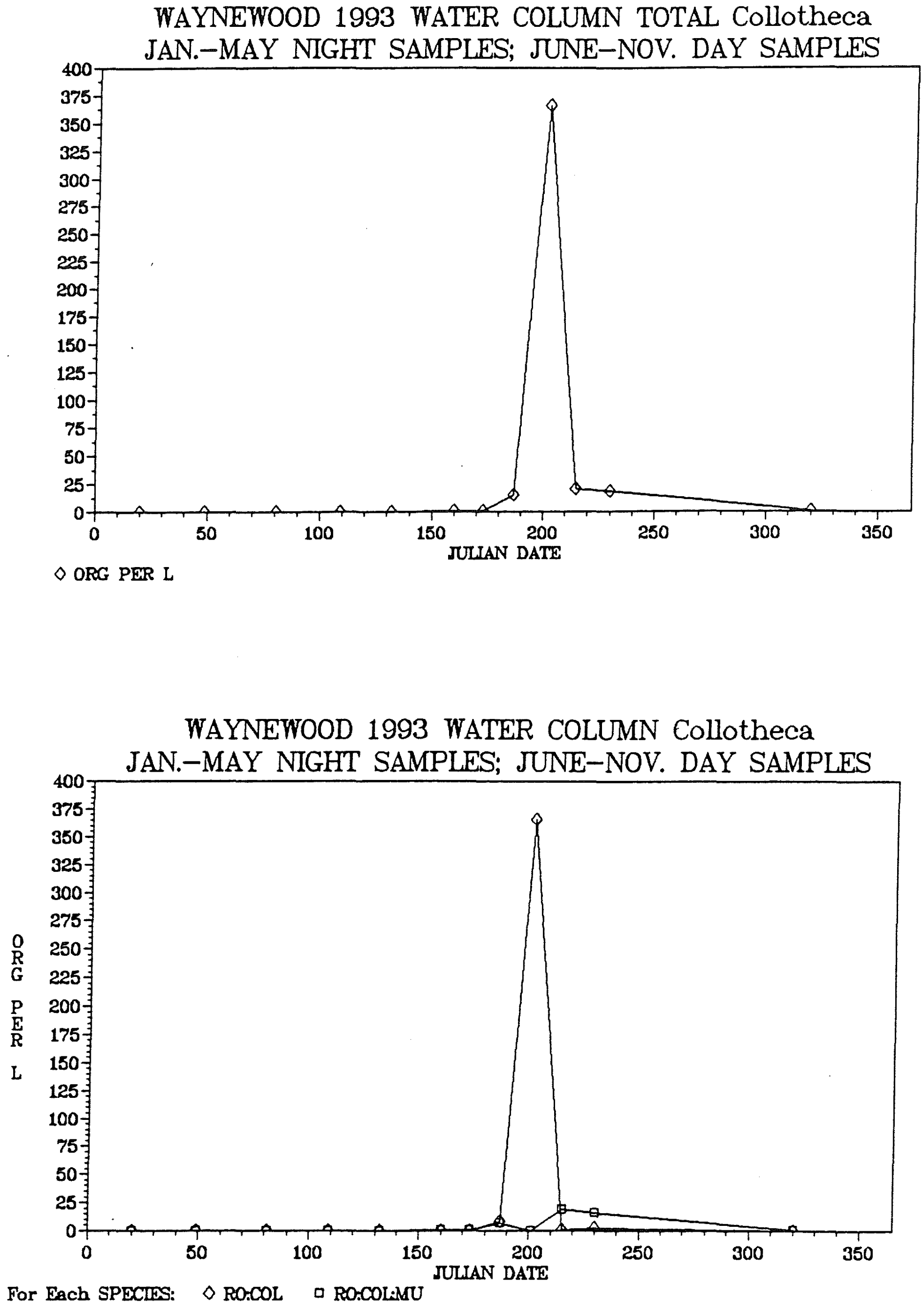
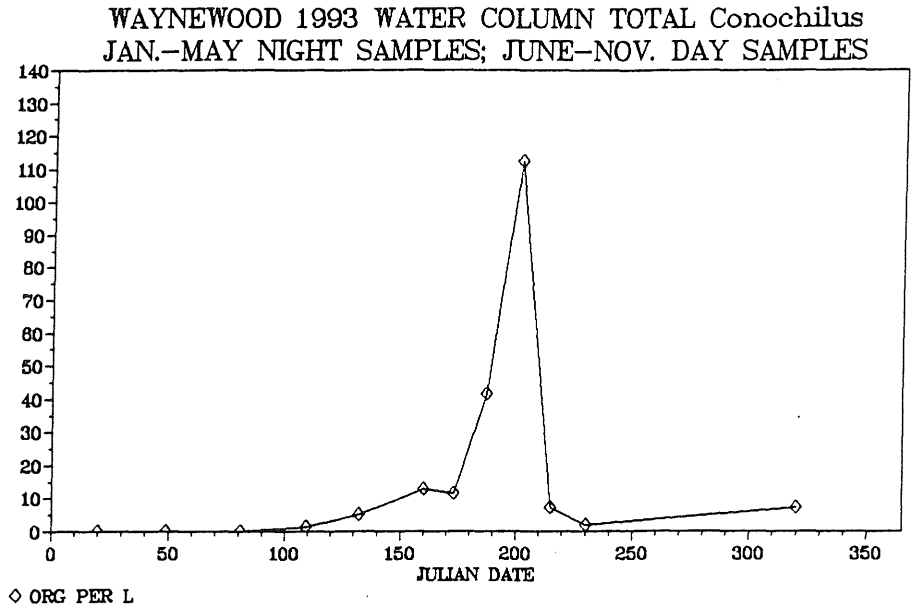


Figure 15. The rotifer *Collotheca* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals of all species per litre. **(Bottom)** *Collotheca* by species: **COL** undifferentiated species, **MU** *C. mutabilis*.



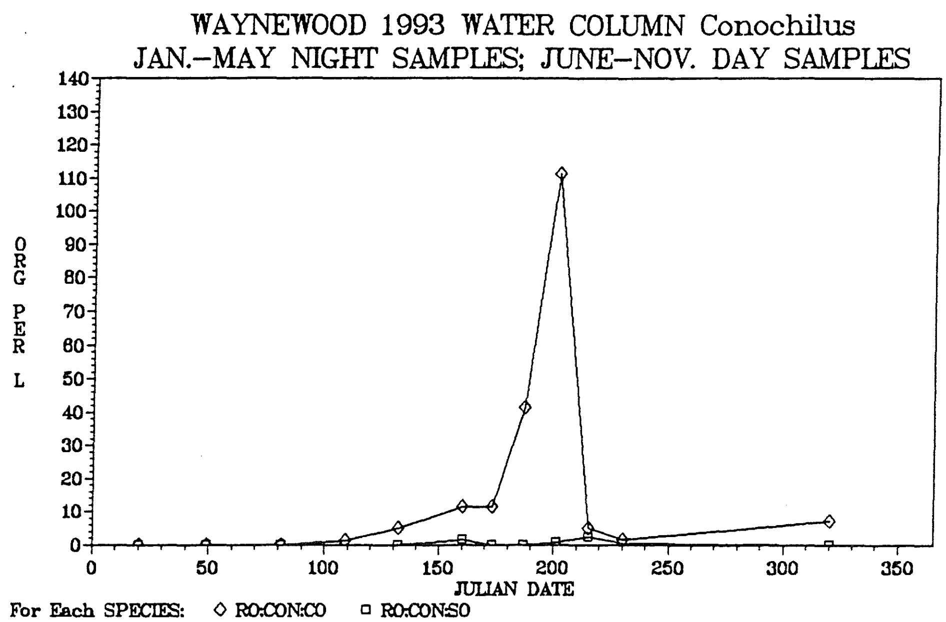
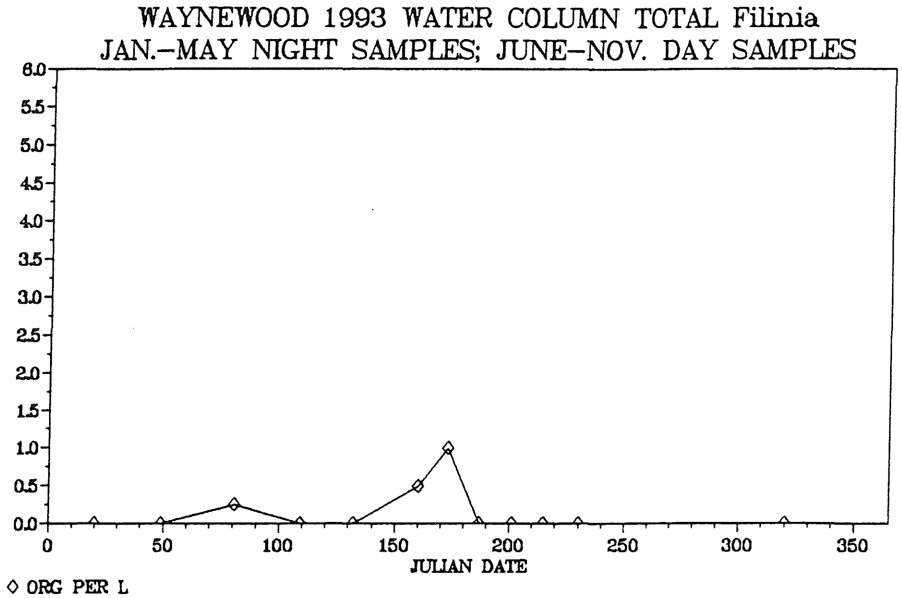


Figure 16. The rotifer *Conochilus* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals of all species per liter. **(Bottom)** *Conochilus* by group: **CO** colonial spp, **SO** solitary spp.



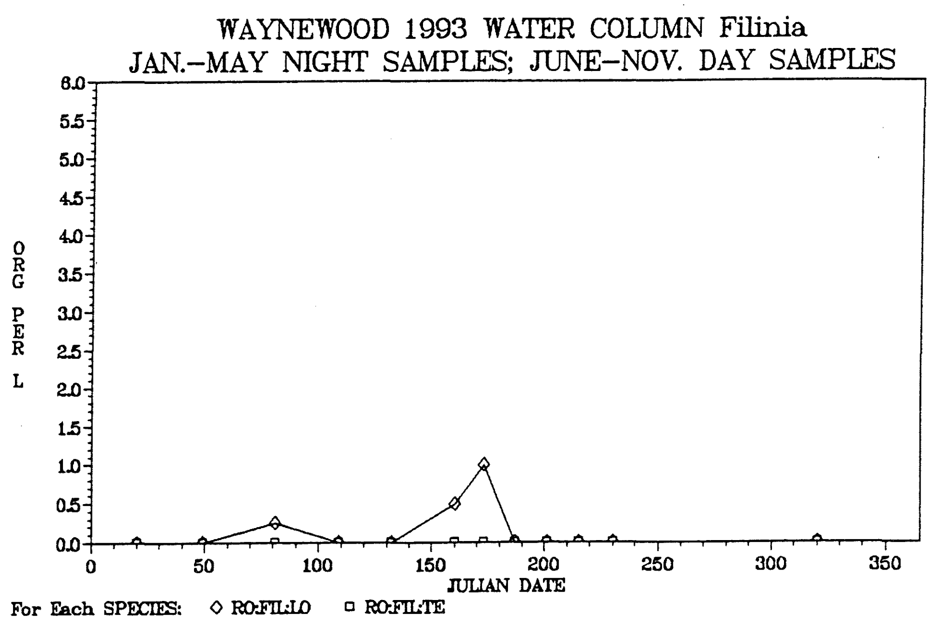
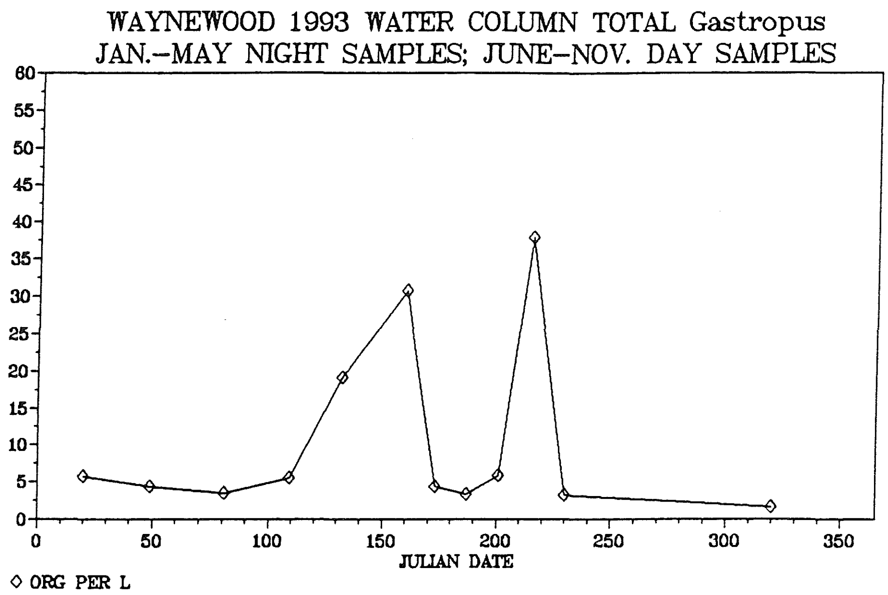


Figure 17. The rotifer *Filinia* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals of all species per liter. **(Bottom)** *Filinia* by species: **LO** *F. longiseta*, **TE** *F. terminalis*.



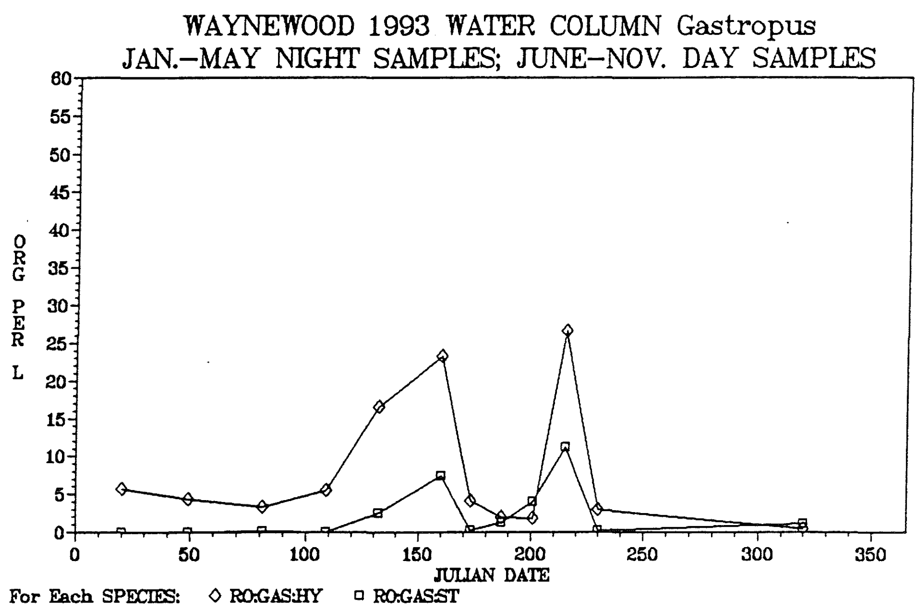
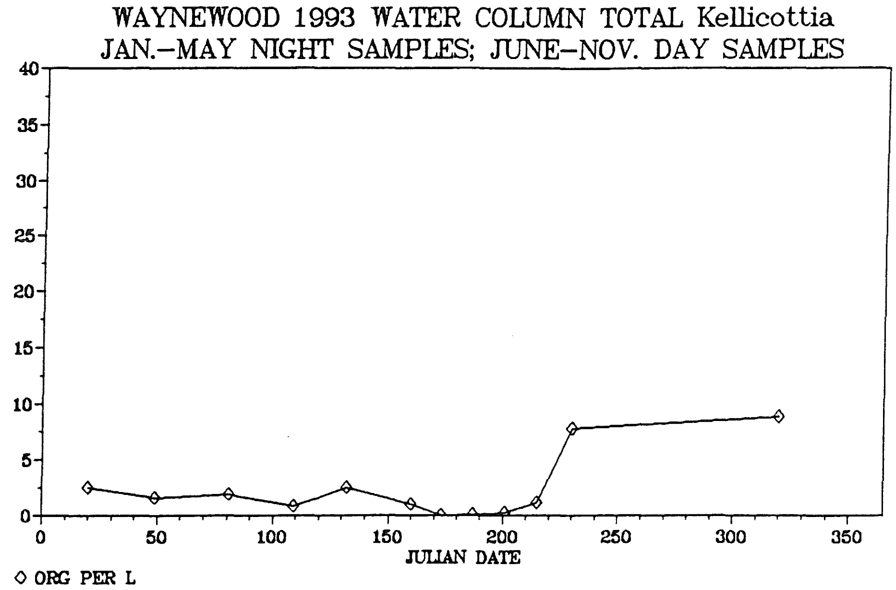


Figure 18. The rotifer *Gastropus* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals of all species per liter. **(Bottom)** *Gastropus* by species: **HY** *G. hyptopus*, **ST** *G. stylifer*.



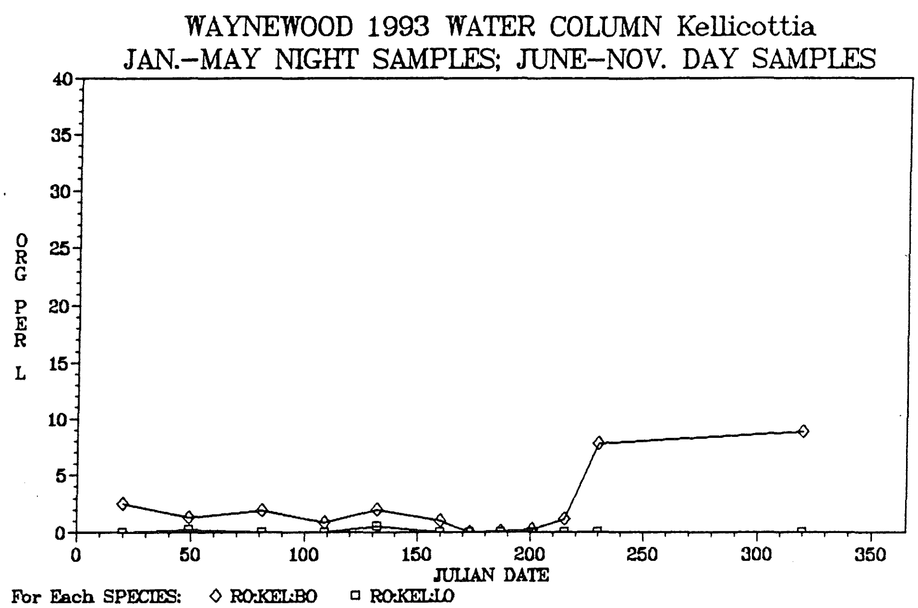


Figure 19. The rotifer *Kellicottia* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** **BO** *K. bostoniensis* and **LO** *K. longispina*.

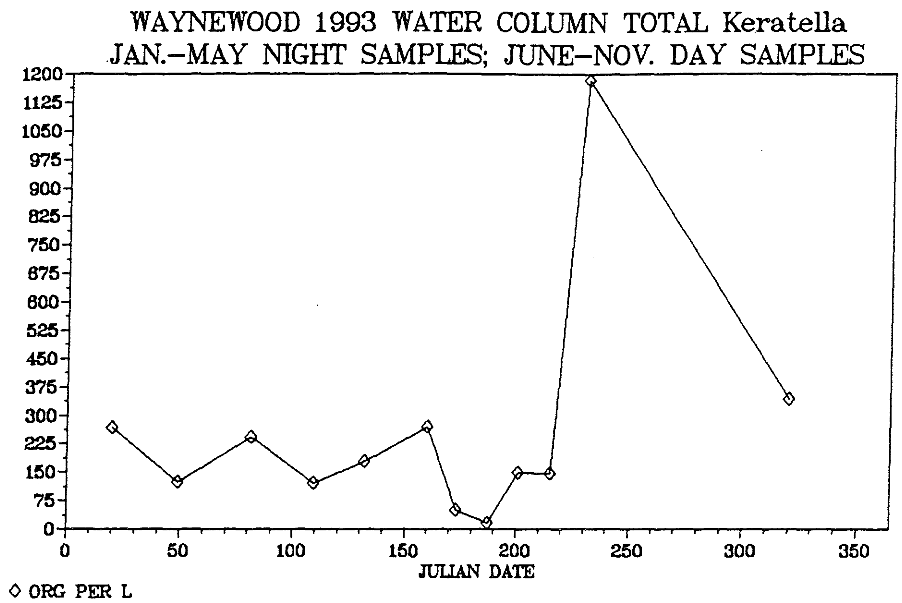


Figure 20. The rotifer *Keratella* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. Total individuals per liter.

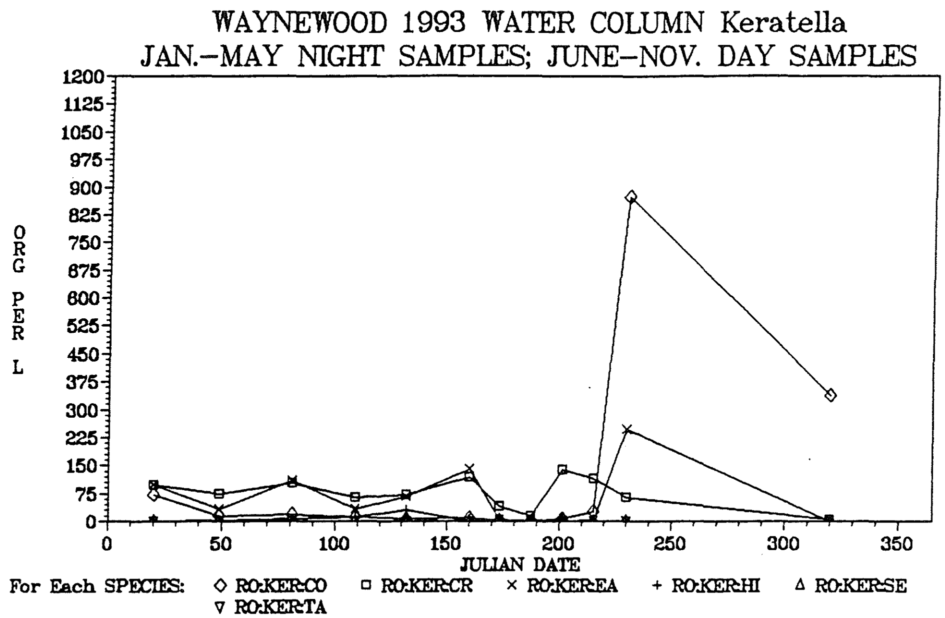


Figure 21. The rotifer *Keratella* (by species) in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **CO** *K. cochlearis*, **CR** *K. crassa*, and **EA** *K. earlinae*, **HI** *K. hiemalis*, **SE** *K. serrulata*, **TA** *K. taurocephala*.

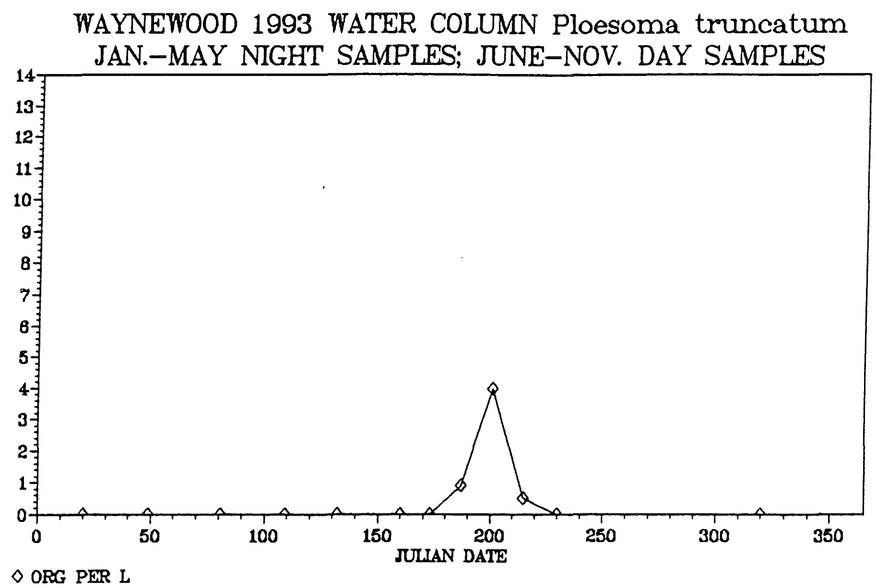


Figure 22. The rotifer *Ploesoma* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. Total individuals per liter.

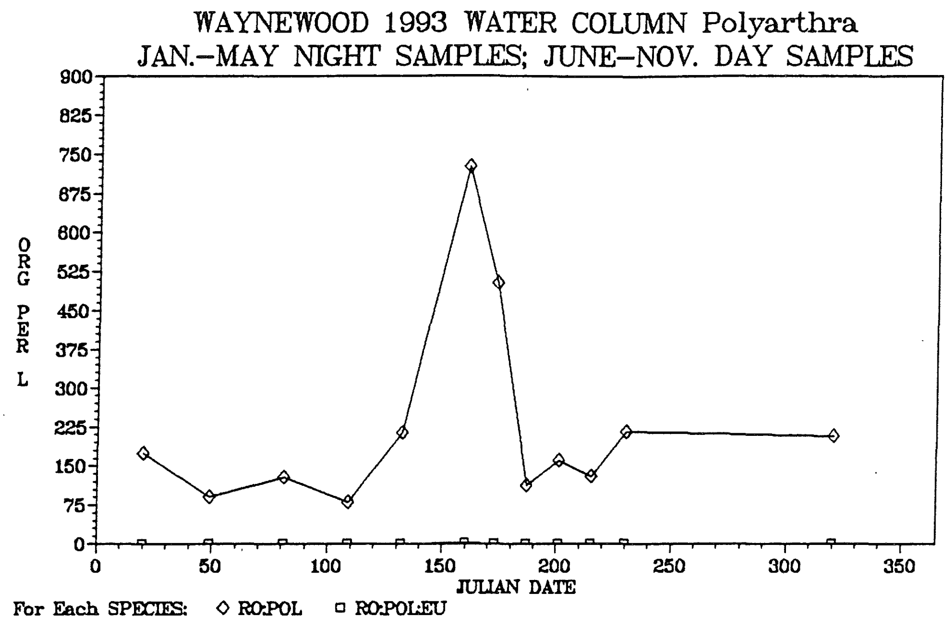


Figure 23. The rotifer *Polyarthra* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **POL** *Polyarthra* undifferentiated, **EU** *P. euryptera*.

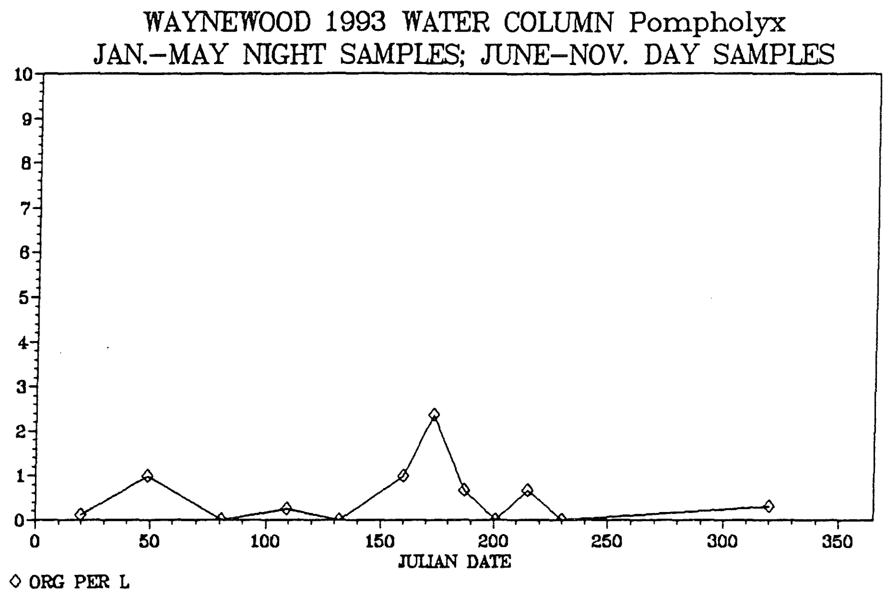


Figure 24. The rotifer *Pompholyx* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. Total individuals per liter.

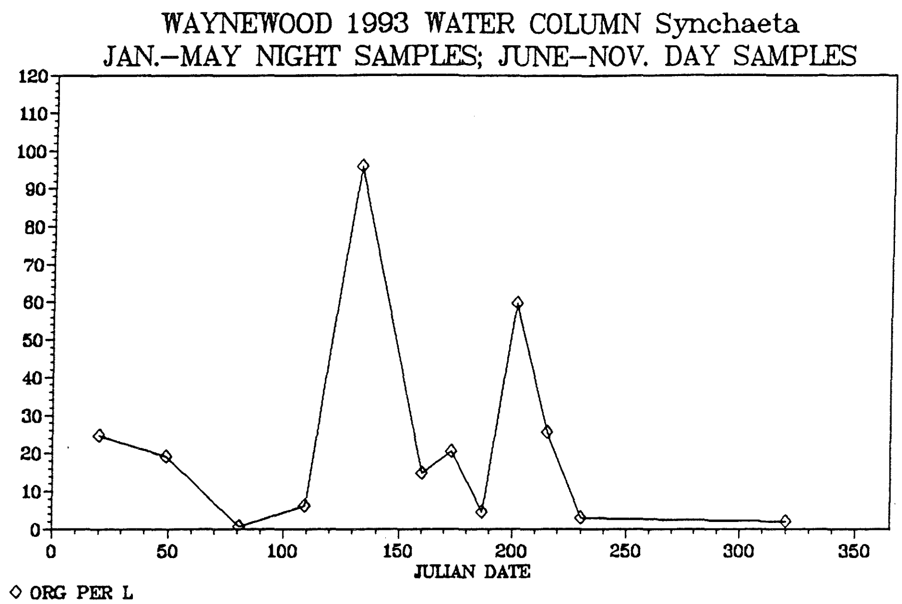
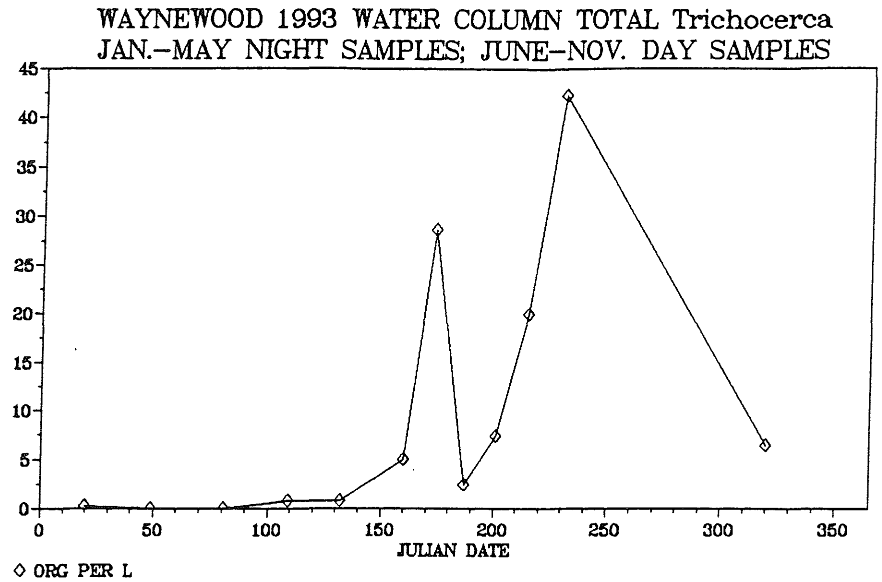


Figure 25. The rotifer *Synchaeta* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean.



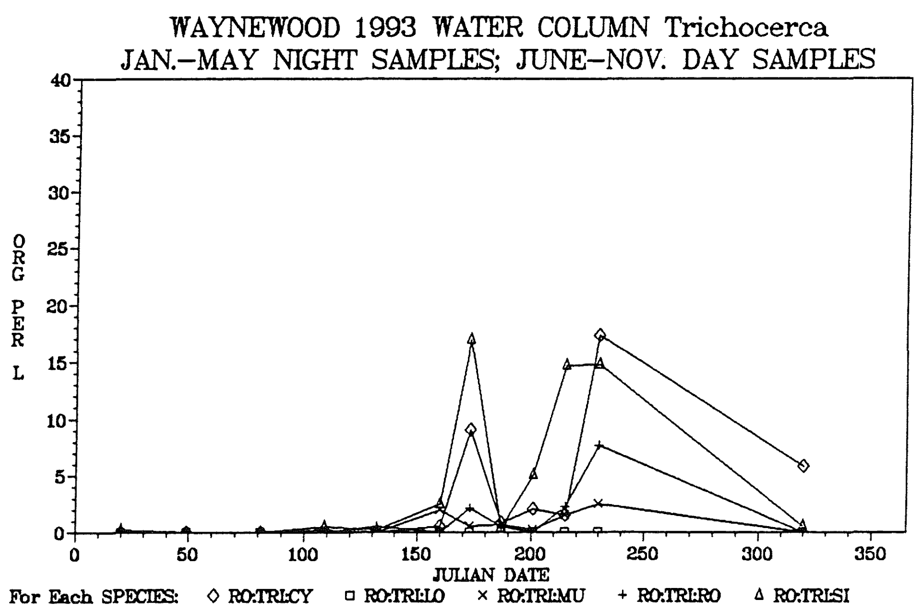


Figure 26. The rotifer *Trichocerca* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** *Trichocerca* by species:
CY *T. cylindrica*, **LO** *T. lophoessa*, **MU** *T. multicrinus*, **RO** *T. rousseleti* and **SI** *T. similis*.

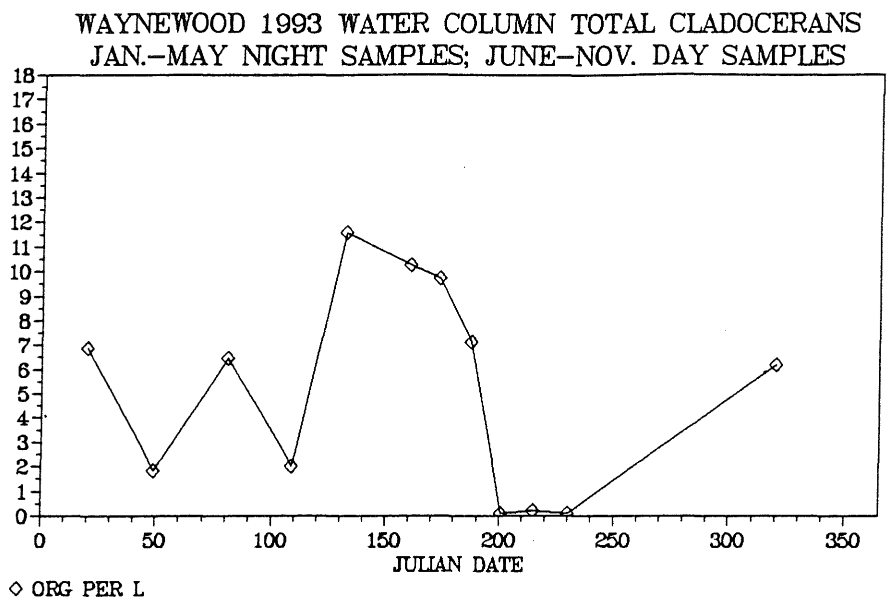
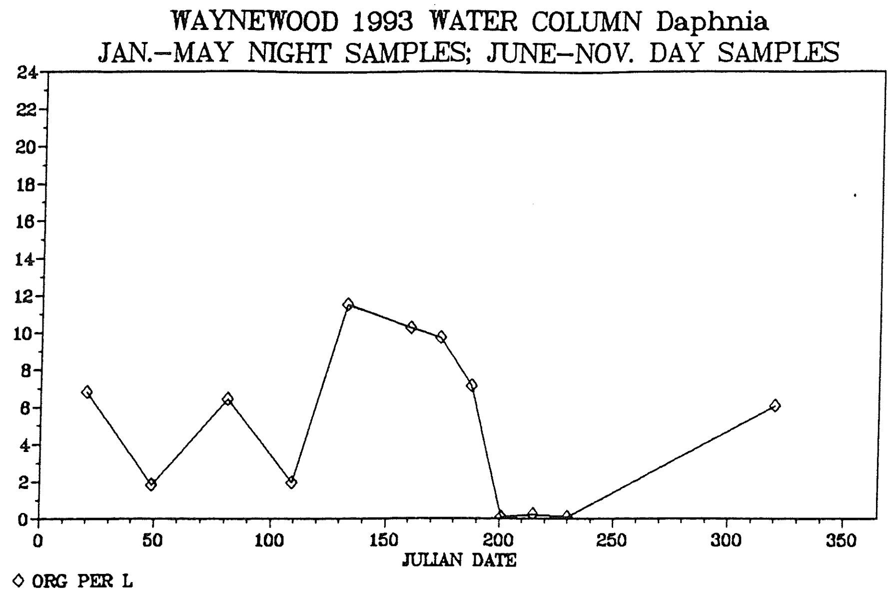


Figure 27. Cladocera in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean. Different organisms were counted from the 202μm net (mainly *Daphnia* spp.) and the 48μm net (mainly *Bosmina* spp.).



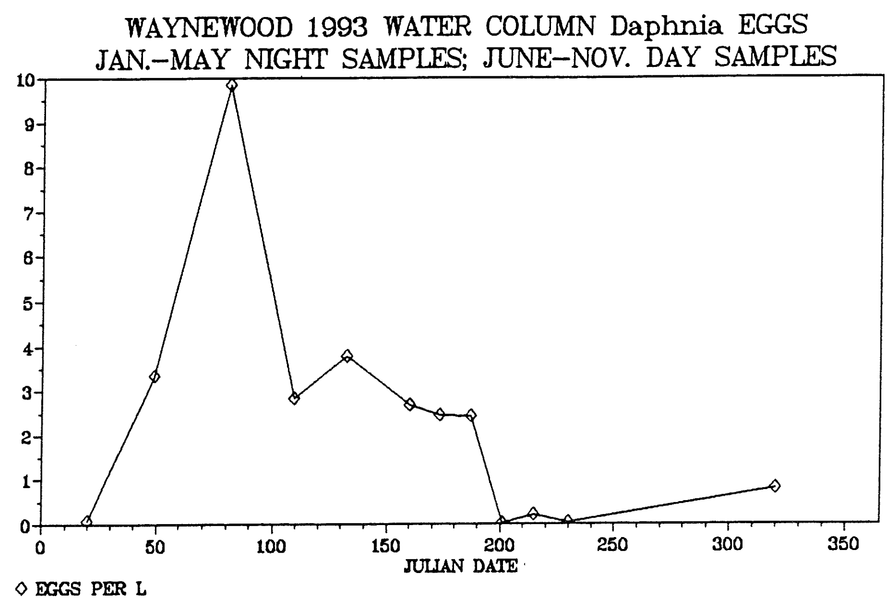


Figure 28. The cladoceran *Daphnia* in Lake Waynewood, 1993.

Net collections (202μm) from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** *Daphnia* eggs per liter.

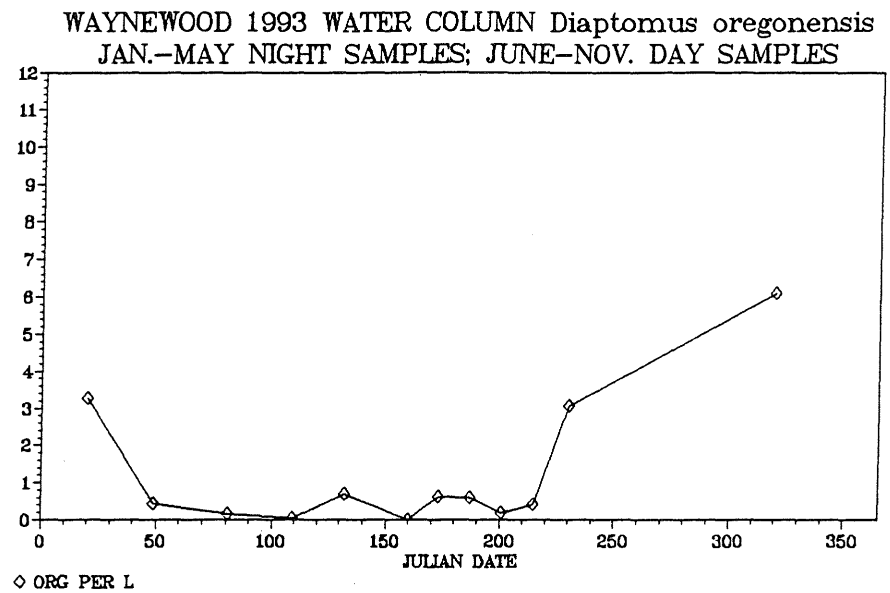
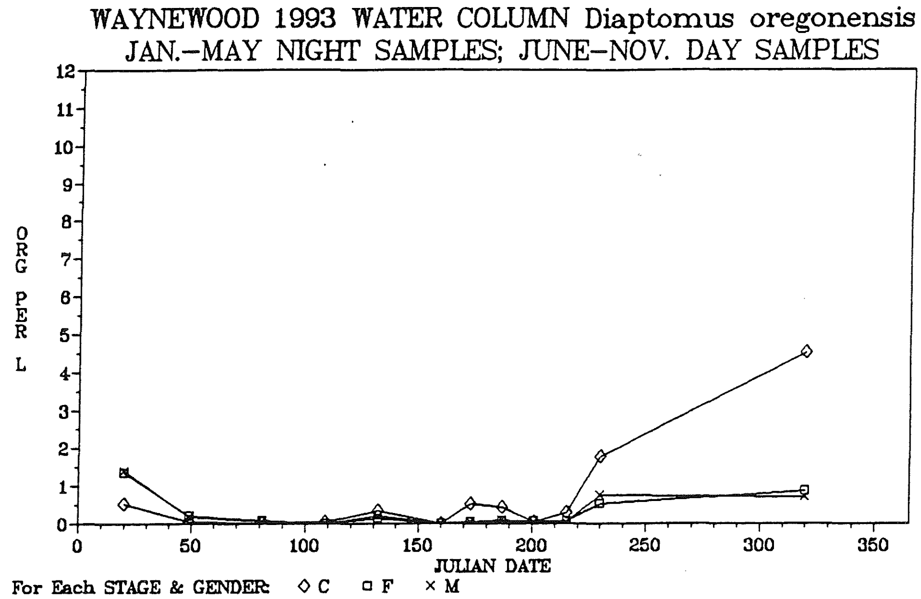


Figure 29. Calanoid copepods (*Diaptomus oregonensis*) in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean. Counts of adults and copepodids were all made from the 48μm-net samples.



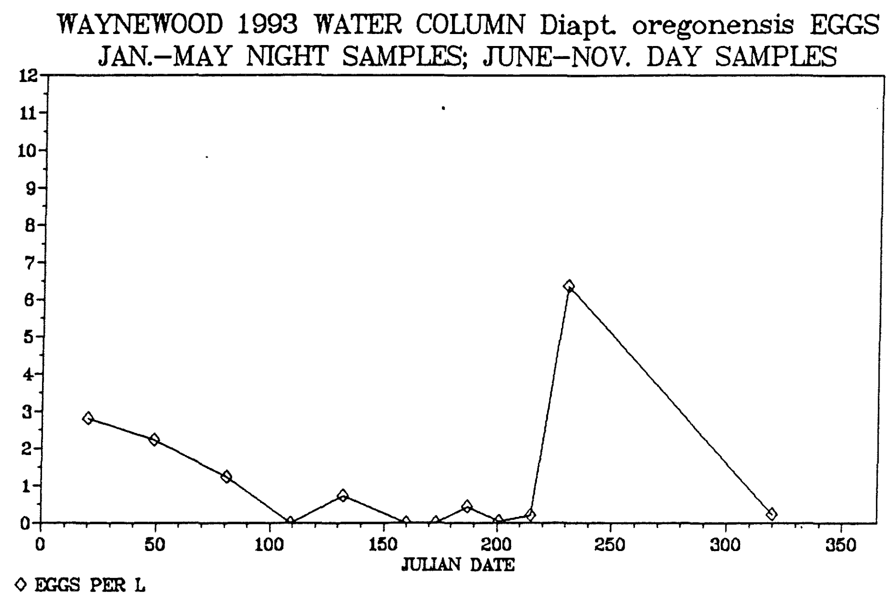
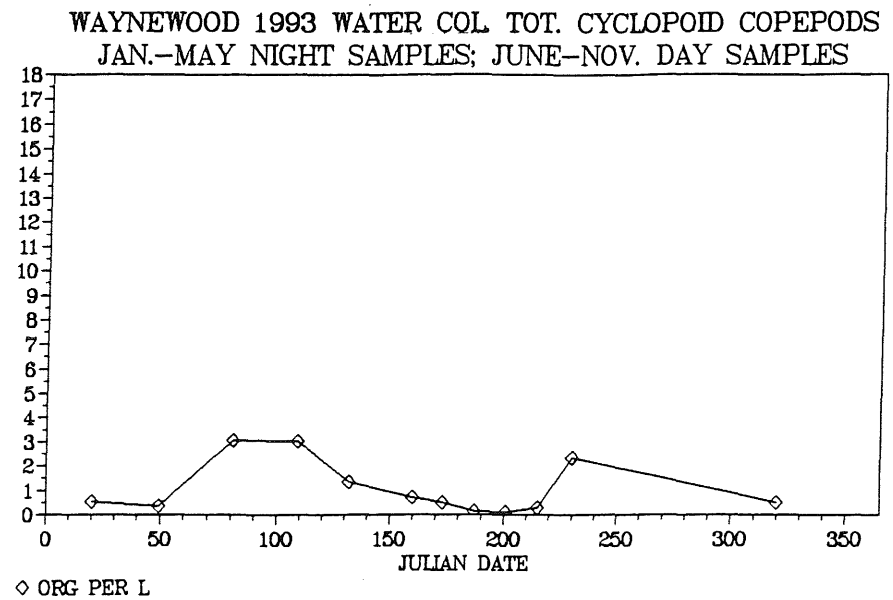


Figure 30. The calanoid copepod *Diaptomus oregonensis* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. **(Top)** Adults (males and females separately) and copepodids. **(Bottom)** *D. oregonensis* eggs per liter.



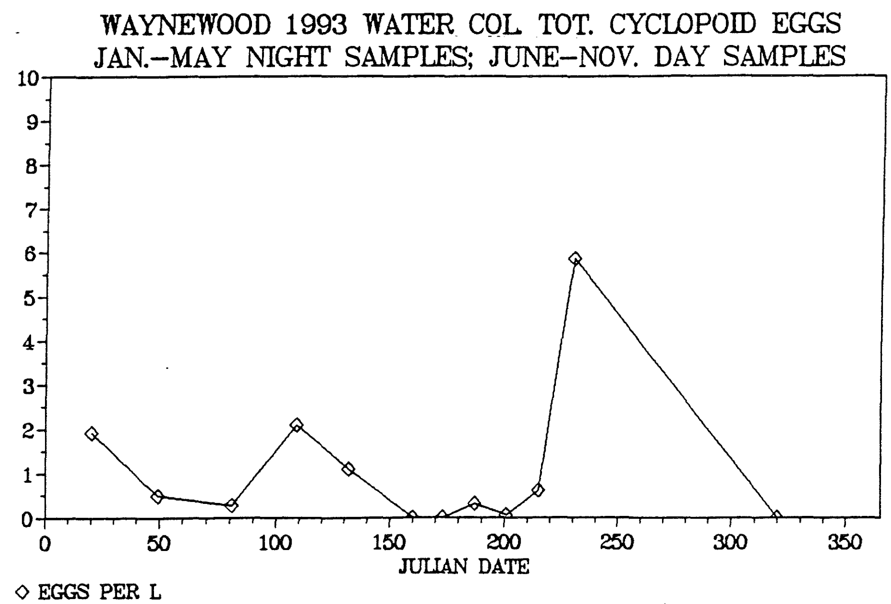
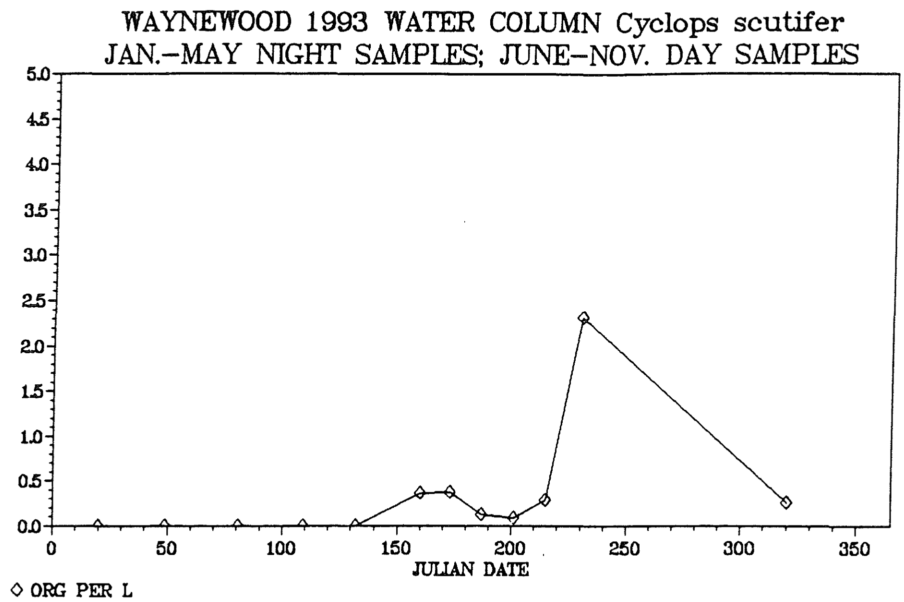


Figure 31. Cyclopoid copepods in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean. Several species, collected variously with the 48μm or 202μm net, are included. **(Top)** Total individuals, including copepodids. **(Bottom)** Total cyclopoid eggs.



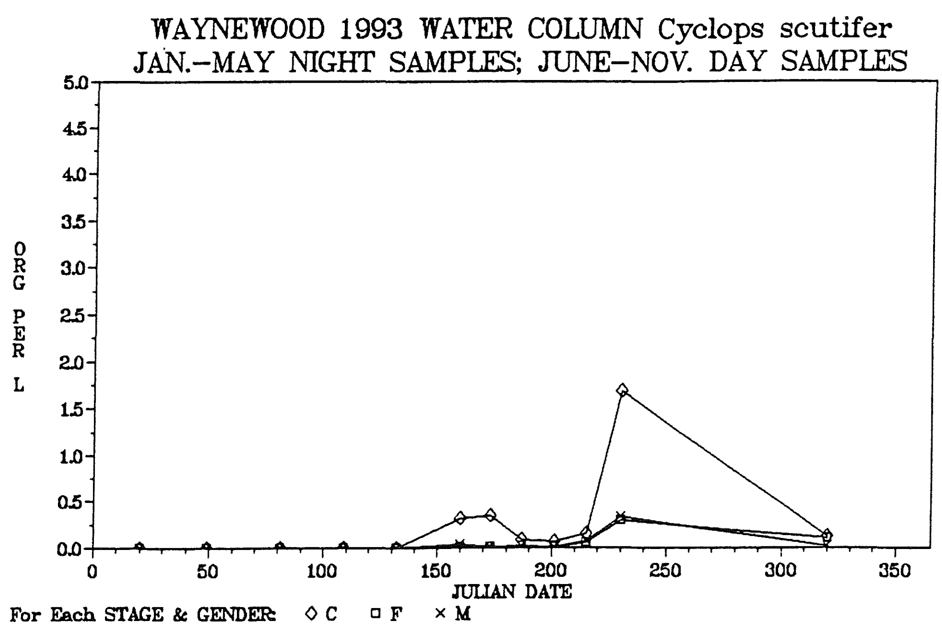
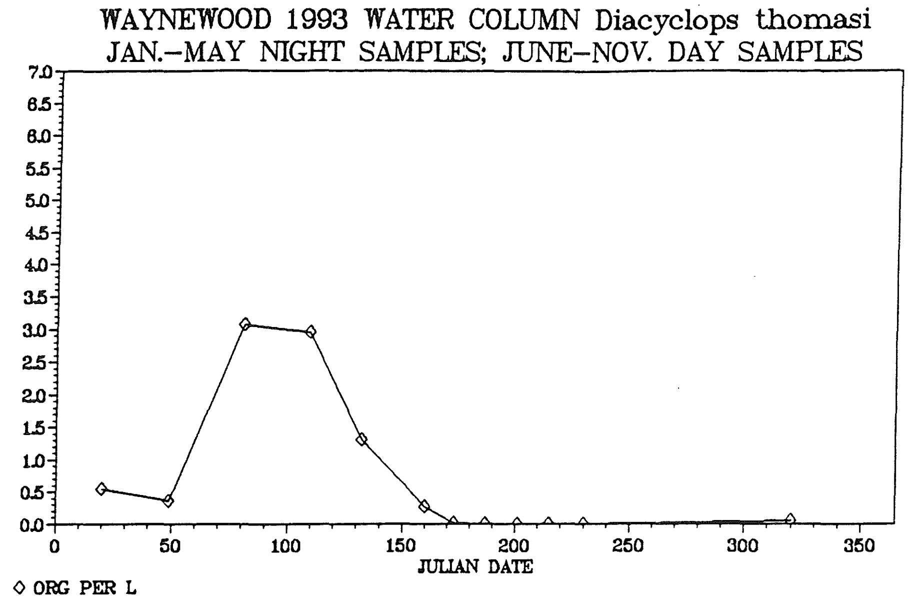


Figure 32. The cyclopoid copepod *Cyclops scutifer* in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** Separated into adults (males and females separately) and copepodids. Females were counted from the 202μm samples, males and copepodids from the 48μm samples.



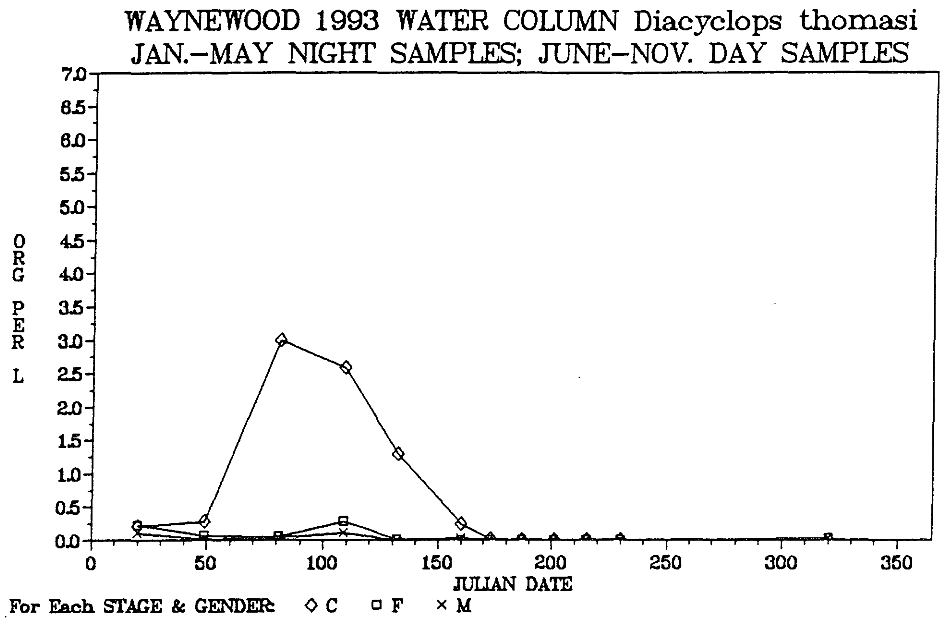
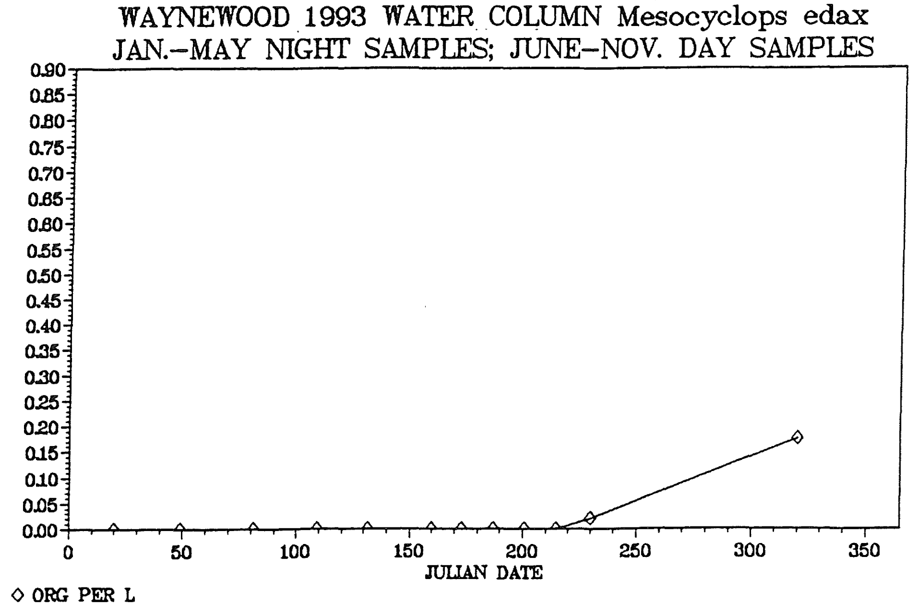


Figure 33. The cyclopoid copepod *Diayclops thomasi* in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** Separated into adults (males and females separately) and copepodids. Females were counted from the 202μm samples, males and copepodids from the 48μm samples. This species was referred to *Cyclops bicuspidatus* in the 1990 report.



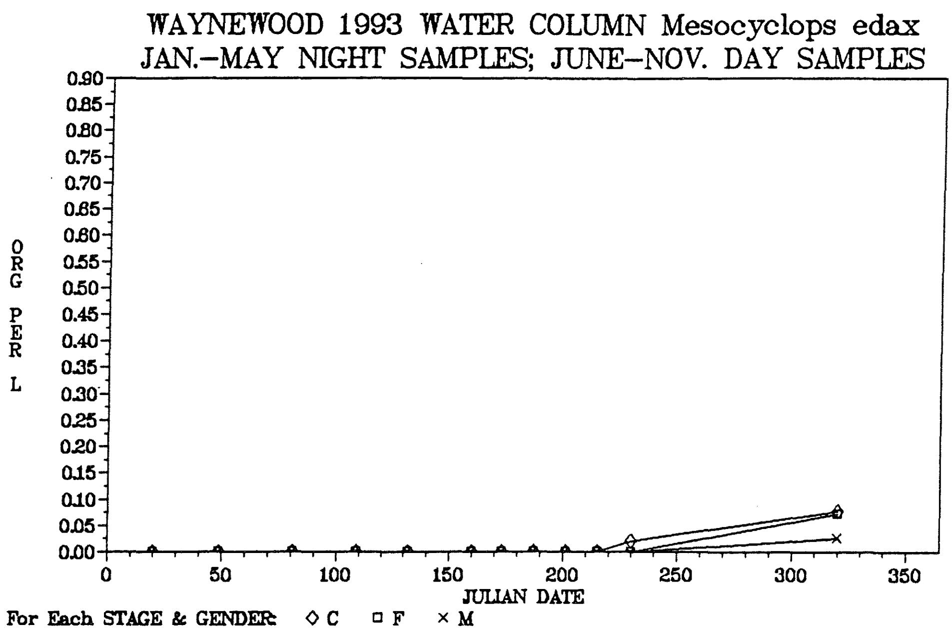
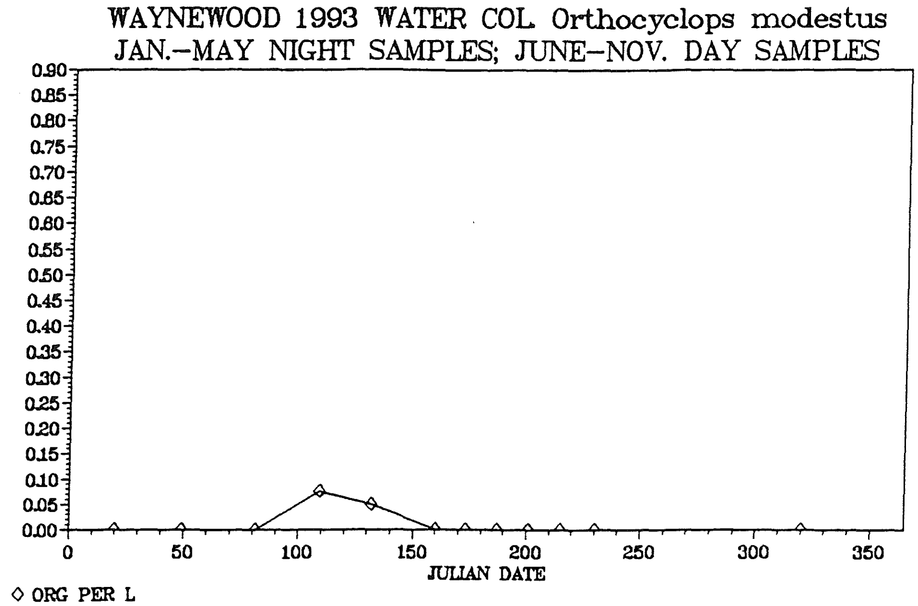


Figure 34. The cyclopoid copepod *Mesocyclops edax* in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean, differentiated into adults (males and females separately) and copepodids. Females were counted from the 202μm samples, males and copepodids from the 48μm samples.



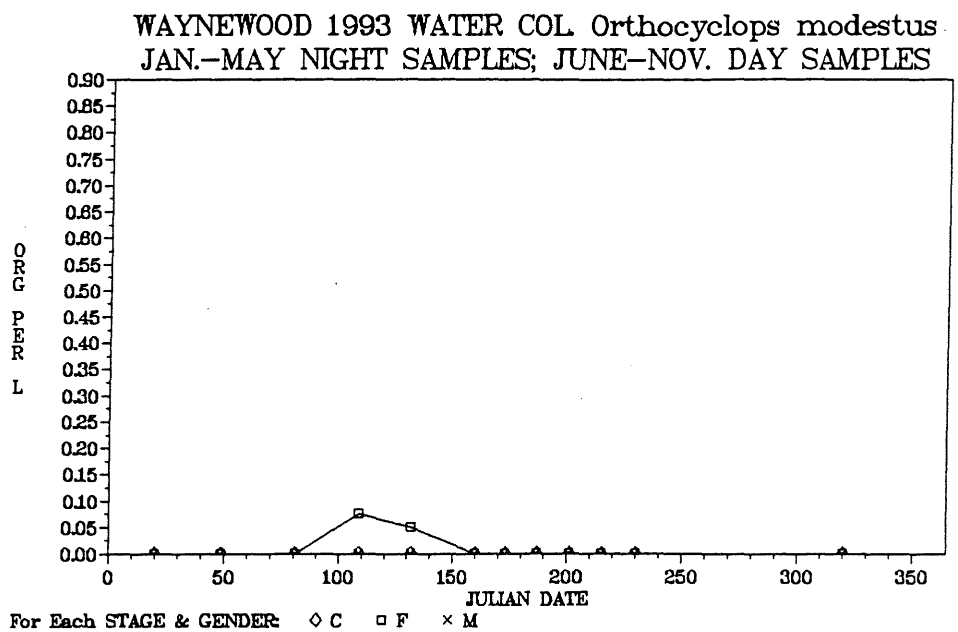


Figure 35. The cyclopoid copepod *Orthocyclops modestus* in Lake Waynewood, 1993.

Net collections from three depths have been combined to give a water column mean. **(Top)** Total individuals per liter. **(Bottom)** Separated into adults (males and females separately) and copepodids. Females were counted from the 202μm samples, males and copepodids from the 48μm samples.

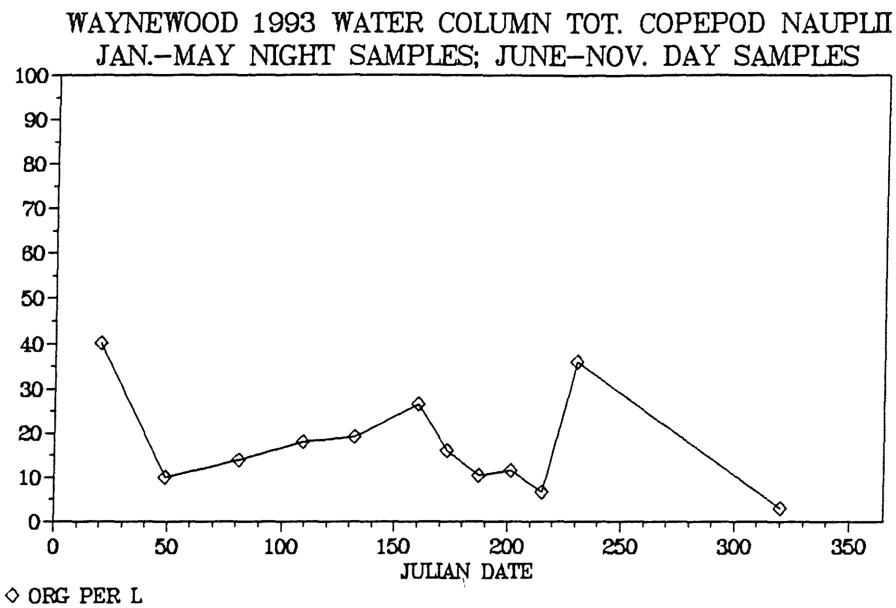


Figure 36. Copepod nauplii in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean. Nauplii of calanoid and cyclopoid species were not differentiated.

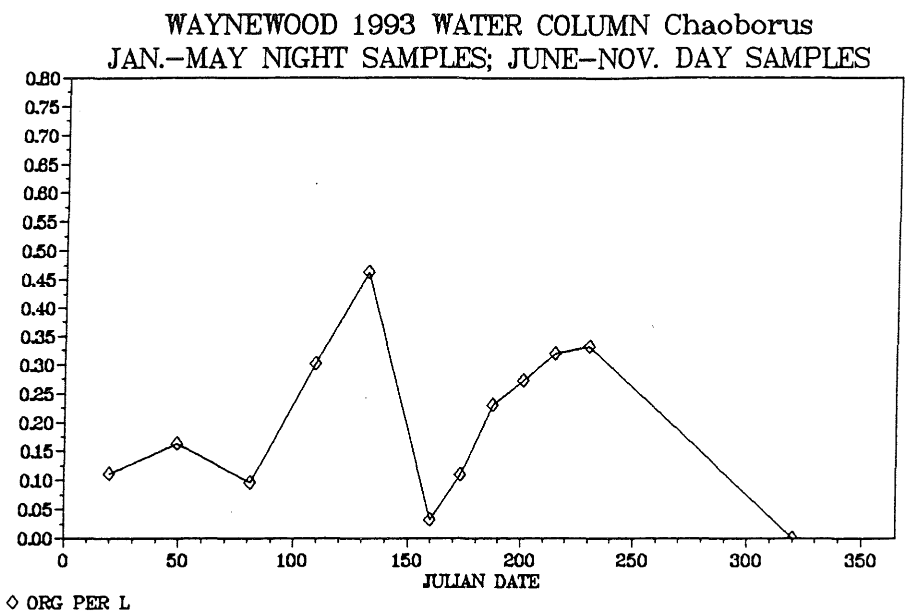


Figure 37. The dipteran *Chaoborus* in Lake Waynewood, 1993.

Net collections (48μm) from three depths have been combined to give a water column mean.

APPENDIX I: CHEMISTRY 1991-92

Chemical sampling in 1991-92 used field and analytical procedures similar to those employed in the 1989 sampling by Dr. Jonathan Cole and Dr. Nina Caraco of the Institute of Ecosystem Studies. A brief resume of the methods is presented here, highlighting differences between the two years. The 1989 results are summarized in the 1990 Annual Report (R.E. Moeller and C.E. Williamson, unpublished report, 1991). The 1991-92 results, from 6 dates, are presented in **Table W.AI**.

FIELD SAMPLING

Samples were collected during the day at the routine sampling station. Water was collected with a battery-operated peristaltic pump through 6-mm inside diameter clear tygon tubing. On the same day, profiles for temperature and dissolved oxygen were obtained *in situ* with a YSI meter (the usual PCLP methods #10 for temperature and dissolved oxygen). Six depths were sampled, including the regular "EPI", "META", and "HYPO" depths, plus 0.5 m and two other meta- or hypolimnetic depths.

Several discrete samples were collected at each depth: (1) a 250-ml polypropylene bottle of unfiltered sample for Ca, Mg, K, Na, Cl, and total phosphorus; (2) a second 250-ml polypropylene bottle of unfiltered sample for pH; (3) a 125-ml polypropylene bottle of filtered water for nutrients (47-mm Whatman GF/F glass fiber filter in a filter holder inserted into collection line just before pump); (4) a 60-ml glass BOD bottle of unfiltered water for total dissolved inorganic carbon; and (5) 35-ml of unfiltered sample into a 50-ml polypropylene centrifuge tube containing 5 ml of zinc acetate solution for sulfate (also sulfide in 1989). The zinc acetate solution was prepared as follows: add 5 volumes of solution I (26 g/L of zinc acetate) to 1 volume of solution II (sodium hydroxide 60 g/L), mix well and pipet suspension from a continuously mixed beaker. Finally, several liters of water were collected from 0.5 m or the "EPI" depth with Van Dorn bottle for particulate total organic carbon and nitrogen.

Soon after collection (in boat or back in laboratory), samples were acidified as follows:

DIC -- add 1.5 ml of 5N H_2SO_4 and place plastic cap over the stopper
Cation sample -- add 2 ml of 1N H_2SO_4
Nutrient sample -- add 1 ml of 1N H_2SO_4

ANALYTICAL METHODS

Analyses of pH were performed in the laboratory at room temperature within 4-8 hr of sampling (routine PCLP method #12, using Ross electrode and adding pHisa solution). Alkalinities are reported for the separate PCLP sampling (same day, different time using Van Dorn sampler, then Gran titration -- Method #11). Total dissolved inorganic carbon was determined by equilibrating 25 ml of acidified solution with 25 ml of N_2 in a 50-ml polypropylene syringe, then injecting 0.5 ml into a gas chromatograph (Shimadzu GC 8A, TCD detector, column of Poropak-Q, He carrier) calibrated with sodium carbonate solutions acidified in the BOD bottles (modified from M.P. Stainton. 1973. J. Fish. Res.

Res. Bd Canada 30:1441-1445). Blanks were subtracted from standards but not samples. DIC was analyzed within a few days of collection. Particulate C,N samples were prepared by filtering 1-1.5 liters (Lake Waynewood) onto precombusted 47 mm Whatman GF/F glass fiber filters, which were stored frozen.

Water samples for other chemical samples were stored at room temperature for many months before analysis at the Institute of Ecosystem Studies. Calcium (Ca) and magnesium (Mg) were determined by ICP emission, potassium (K) and sodium (Na) by atomic absorption spectrophotometry. Auto-analyzer methods were used for chloride (Cl), nitrate (NO_3, using cadmium reduction), soluble reactive phosphorus (SRP, using molybdenum blue reaction), and ammonium (NH_4, using the phenol-hypochlorite method of Solorzano). Sulfate (SO_4) was determined by ion chromatography -- these analyses are not yet reported for the 1991-92 series. Sulfide (S_2-, 1989 only) was determined spectrophotometrically (N. Gilboa-Garber. 1971. Anal. Biochem. 43:129-133). In the 1989 series, total and total dissolved iron (tFe and tdFe) were measured spectrophotometrically using the α,α-bipyridyl method. Total phosphorus (tP) was measured by molybdenum blue reaction after persulfate digestion. Particulate carbon and nitrogen were determined using a Perkin-Elmer elemental analyzer.

The earlier June-October 1989 sampling series differed from that described above for 1991-92 as follows. In 1989, temperature and oxygen profiles were obtained simultaneously with the pump sampling, as was *in situ* conductivity (not measured in 1991-92). pH was measured immediately in the boat with a battery-powered meter. Methane as well as CO_2 was determined gas chromatographically from the acidified sample in the 60-ml BOD bottle. Chloride was not determined in 1989. The persulfate digest of the unfiltered sample (for total phosphorus) also was analyzed for total iron (tFe). The total phosphorus and iron procedures were repeated on the filtered nutrient sample to give values for total dissolved phosphorus (tdP) and total dissolved iron (tdFe). This was not done in 1991-92.

SUMMARY OF PARTICULATE C,N DATA

Particulate organic carbon (C) and nitrogen (N) were determined on several dates in 1989 and 1991-92. Analyses are not available for other dates, because not enough sample was filtered to give reliable values.

Lake	Date	Depth m	C µM	N µM	C/N molar
Waynewood	06/20/89	0.5	49.0	8.30	5.9
Waynewood	08/03/89	0.5	145.8	19.0	7.7
Waynewood	09/14/89	0.5	90.2	11.7	7.7
Waynewood	"	4.	52.6	6.71	7.8
Waynewood	"	11.	89.9	12.5	7.2
Waynewood	11/23/91	2.	31.2	3.42	9.1
Waynewood	02/22/92	1.	26.8	3.18	8.4

analyses of N. Caraco and J. Cole

Table W.A.1. CHEMICAL CHARACTERIZATION OF LAKE WAYNEWOOD (1991-92).

Date	Depth m	Temp C	O2 mg/L	pH	Alkalinity uEq/L	DIC uM	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Cl uM	SO4 uM	NH4 uM	NO2 uM	P SRP uM	P tP uM
04/14/91	0.5	9.8	10.26	7.26	--	269	8.55	1.32	1.41	4.07	189	--	10.1	1.7	0.15	--
04/14/91	3	9.6	10.26	7.30	266	287	8.35	1.37	1.40	4.07	160	--	9.8	1.7	0.18	--
04/14/91	6	6.8	10.26	7.00	268	324	8.31	1.34	1.41	4.07	155	--	7.8	2.1	0.16	--
04/14/91	7	6.2	10.26	6.95	--	335	8.43	1.35	1.40	4.09	172	--	8.3	2.6	0.14	--
04/14/91	9	5.8	9.79	6.84	263	360	8.43	1.39	1.41	4.08	173	--	10.8	2.9	0.18	--
04/14/91	11	5.5	8.93	6.81	--	381	8.52	1.34	1.43	4.07	164	--	15.6	2.8	0.25	--
07/02/91	0.5	24.3	7.63	7.44	--	287	8.21	1.39	1.28	4.18	184	--	5.6	<0.5	0.12	0.74
07/02/91	2	24.4	7.67	7.46	284	283	8.36	1.35	1.28	4.13	182	--	5.1	<0.5	0.10	0.61
07/02/91	5	14.5	10.03	7.06	296	437	9.14	1.44	1.40	4.29	188	--	7.4	<0.5	0.61	0.58
07/02/91	6	10.2	0.12	6.86	--	690	9.86	1.46	1.59	4.16	195	--	12.4	<0.5	0.52	0.98
07/02/91	10	6.7	0.00	6.89	529	812	10.60	1.48	1.55	4.25	191	--	54.8	<0.5	6.77	1.54
07/02/91	11	6.5	0.00	7.05	--	918	10.80	1.53	1.30	4.23	199	--	78.8	<0.5	12.03	11.20
09/22/91	0.5	19.0	7.53	7.16	--	336	8.27	1.37	1.32	4.28	180	--	5.5	<0.5	0.10	--
09/22/91	3	18.5	7.40	7.09	--	347	8.57	1.35	1.29	4.32	171	--	4.7	<0.5	0.07	--
09/22/91	6	13.4	0.10	6.93	--	941	10.60	1.42	1.53	4.25	186	--	5.2	<0.5	0.27	--
09/22/91	7	10.2	0.00	7.06	--	1099	11.10	1.48	1.65	4.25	192	--	28.5	<0.5	3.93	--
09/22/91	10	7.1	0.00	7.03	--	1260	11.20	1.46	1.66	4.22	196	--	100.2	<0.5	13.00	--
09/22/91	11	6.9	0.00	7.08	--	1361	10.80	1.54	1.69	4.28	200	--	125.2	<0.5	17.10	--
11/23/91	0.5	9.1	9.83	7.00	--	407	8.70	1.39	1.44	4.10	171	--	18.2	3.8	0.85	0.91
11/23/91	2	7.6	8.95	6.97	372	418	8.78	1.44	1.50	4.19	171	--	18.1	4.3	0.80	0.63
11/23/91	6	6.3	8.27	7.00	370	476	9.06	1.39	1.42	4.21	177	--	19.9	3.2	0.95	0.91
11/23/91	8	6.1	7.91	6.96	--	483	8.77	1.36	1.42	4.20	177	--	21.9	2.9	0.99	1.84
11/23/91	10	6.1	7.83	6.96	373	479	9.02	1.40	1.42	4.20	175	--	22.0	2.8	1.00	0.98
11/23/91	11	6.1	7.39	6.88	--	490	8.93	1.39	1.42	4.23	156	--	24.8	2.7	1.04	1.38
02/22/92	1	3.3	10.71	6.81	307	424	9.47	1.56	1.52	4.32	174	--	9.2	11.2	0.47	0.95
02/22/92	2	3.3	10.61	6.81	--	434	9.90	1.60	1.52	4.25	177	--	10.2	11.0	0.46	0.44
02/22/92	4	3.3	10.50	6.80	322	436	9.84	1.55	1.52	4.26	176	--	10.4	11.2	0.48	0.71
02/22/92	7	3.3	10.50	6.81	--	427	8.80	1.65	1.55	4.33	178	--	10.9	11.2	0.49	0.63
02/22/92	9	3.2	10.19	6.81	319	440	10.30	1.63	1.56	4.35	183	--	11.4	11.4	0.51	0.99
02/22/92	11	3.1	7.35	6.69	--	633	10.70	1.75	1.66	4.53	185	--	39.3	9.5	1.64	3.69
04/10/92	0.5	5.4	11.29	7.12	--	301	9.09	1.43	1.42	4.30	200	--	5.0	13.2	0.24	0.75
04/10/92	2	4.7	11.10	7.08	270	303	9.11	1.48	1.42	4.30	205	--	4.6	12.9	0.26	0.92
04/10/92	6	4.4	10.72	7.05	271	313	9.09	1.50	1.37	4.43	194	--	5.1	13.1	0.26	0.92
04/10/92	8	4.3	10.63	7.02	--	309	9.04	1.44	1.42	4.31	202	--	5.1	12.8	0.26	0.89
04/10/92	10	4.1	10.16	7.04	269	324	9.02	1.46	1.44	4.30	203	--	5.1	12.9	0.26	0.88
04/10/92	11	4.1	10.14	7.05	--	330	9.25	1.45	1.44	4.30	187	--	6.3	12.8	0.24	0.56

APPENDIX II: PHYTOPLANKTON (1989-1992)

The following 6 pages present phytoplankton data in the form of species biovolumes. The first table summarizes the seasonal data over all three years. The subsequent four tables present the counts for the 12 composite samples. The samples were analyzed by Ann St Amand (PhycoTech).

Table W.AII.1. Phytoplankton from Lake Waynewood, 1989-1992. Major species with their abundance as biovolume. Values are means of three years, where a single sample was counted from each season of each year, representing a composite of all dates and sampling depths during the periods January--February (winter), March--May (spring), June--September (summer) and October--December (autumn).

Alga	Biovolume of species ($10^3 \mu m^3$/mL)			
	winter	spring	summer	autumn
Diatoms				
Asterionella formosa	17.	83.		1.0
Cyclotella spp.		1.2	3.2	0.2
Fragilaria capucina			7.4	162.
Melosira varians				320.
Melosira sp.	2.2		5.3	13.
Synedra sp.			35.	35.
Tabellaria fenestrata	18.	2.6	60.	96.
Chrysophytes				
Chrysococcus sp.	0.1			
Diceras sp.		0.2		
Dinobryon cylindricum		3.3		0.3
Dinobryon sertularia			0.6	0.6
Dinobryon cysts		1.0		
Epipyxis utriculus	0.1	12.		0.1
Mallomonas sp.	19.	1.2		0.3
Ochromonas sp.	1.0	4.9	1.7	
Synura uvella/sphagnicola	340.	1490.	5.9	2.9
Uroglena sp.		9.0		
Cryptophytes				
Cryptomonas sp.	1.2	0.6	1.1	
Cryptomonas erosa	3.1	28.	19.	24.
Cryptomonas ovata	120.	135.	31.	50.
Cryptomonas pyredinosa			0.6	
Rhodomonas minuta	2.5	9.5	2.7	2.0
Chlorophytes				
Ankistrodesmus falcatus	0.1	3.2	0.3	0.4
Chlamydomonas sp.		15.		
Closterium moniliferum			2.6	0.5
Eudorina sp.	95.	25.		8.4
Monomastix astigmata	0.9	1.5	0.2	0.7
Oocystis parva			23.	
Oocystis sp.			0.1	
Quadrigula lacustris	0.1			
Scenedesmus longus				2.2
Schroederia judayi	0.3		0.2	
Schroederia setigera	13.			
Sphaerocystis schroeteri	4.5	39.	1.6	
colonial Chlorophyte	1.5	14.		
misc. Chlorococcales	0.1	5.7	0.5	18.7

continued

Table W.AII.1. Phytoplankton from Lake Waynewood, 1989-1992. Major species with their abundance as biovolume. (continued)

Alga	Biovolume of species ($10^3 \mu m^3$/mL)			
	winter	spring	summer	autumn
Dinoflagellates				
Ceratium hirundinella			43.	
Gymnodinium spp.	2.1	5.8	2.0	1.3
dinoflagellate cyst		21.		1.3
Cyanobacteria				
Anabaena affinis			1.6	
Anabaena macrospora			130.	2.2
Aphanizomenon flos-aquae	37.	29.	860.	300.
Coelosphaerium naegelianum	0.2	0.2	5.6	4.7
Gloeothece rupestris			24.	
Merismopedia sp.		0.1	0.1	
Oscillatoria limnetica	0.3	0.5	38.	39.
Oscillatoria sp.			21.	
coccoid Cyanobacteria	0.9	0.1	0.1	3.1
Other				
Lepocinclis fusiformis			7.0	
Phacus sp.			20.	
microflagellates (misc.)	14.	5.7	7.4	9.5
unidentifiable cyst	0.1			
Total Biovolume ($10^3 \mu m^3$/mL):	695.	1942.	1363.	1094.

Table W.AII.2. Winter phytoplankton from Lake Waynewood--major species and their abundance as biovolume. A composite sample from each year of all dates and sampling depths during the period January through February was counted.

Alga	Type	Biovolume of species ($10^3 \mu m^3$/mL) 1990	1991	1992	mean
Diatoms					
Asterionella formosa	Dia		50.4	1.7	17.4
Melosira sp.	Dia		9.9		2.2
Tabellaria fenestrata	Dia		54.8		18.3
Chrysophytes					
Chrysococcus sp.	Chr	0.2			0.1
Epipyxis utriculus v. acuta	Chr			0.4	0.1
Mallomonas sp. 3	Chr	57.7			19.2
Ochromonas sp.	Chr		3.1		1.0
Synura uvella/sphagnicola	Chr	232.1	790.9		341.0
Cryptophytes					
Cryptomonas sp. 1	Cry	0.3		3.4	1.2
Cryptomonas erosa	Cry		7.5	1.7	3.1
Cryptomonas ovata	Cry		45.2	312.1	119.1
Rhodomonas minuta	Cry	5.3	0.4	1.8	2.5
Chlorophytes					
Ankistrodesmus falcatus	Chl		0.4		0.1
Eudorina sp.	Chl	266.5	18.8		95.1
Monomastix astigmata	Chl	2.0	0.6		0.9
Quadrigula lacustris	Chl			0.4	0.1
Schroederia judayi	Chl			1.0	0.3
Schroederia setigera	Chl			39.3	13.1
Sphaerocystis schroeteri	Chl			13.5	4.5
colonial Chlorophyte	Chl	2.7		1.8	1.5
misc. Chlorococcales	Chl	0.4			0.1
Dinoflagellates					
Gymnodinium sp.	Din	4.5		1.9	2.1
Cyanobacteria					
Aphanizomenon flos-aquae	Cya	16.5	81.6	12.4	36.8
Coelosphaerium naegelianum	Cya	0.2	0.3		0.2
Oscillatoria limnetica	Cya	1.0			0.3
coccoid Cyanophyta	Cya	2.0		0.8	0.9
Other					
microflagellates (misc.)	var	19.4	11.4	10.9	13.9
unidentifiable cyst	var			0.2	0.1
Total Counted Biovolume ($10^3 \mu m^3$/mL):		611.	1075.	403.	695.

Table W.AII.3. Spring phytoplankton from Lake Waynewood--major species and their abundance as biovolume. A composite sample from each year of all dates and sampling depths during the period March through May was counted.

Alga	Type	Biovolume of species ($10^3 \mu m^3$/mL)			
		1990	1991	1992	mean
Diatoms					
Asterionella formosa	Dia		223.7	26.4	83.4
Cyclotella spp.	Dia	3.5			1.2
Tabellaria fenestrata	Dia		7.7		2.6
Chrysophytes					
Diceras sp.	Chr			0.7	0.2
Dinobryon cylindricum	Chr	1.8		8.2	3.3
Dinobryon cyst	Chr		3.1		1.0
Epipyxis utriculus v. acuta	Chr		21.8	15.7	12.5
Mallomonas sp. 3	Chr	3.5			1.2
Ochromonas sp.	Chr		14.6		4.9
Synura uvella/sphagnicola	Chr	1625.9	2830.0		1485.3
Uroglena sp.	Chr			27.0	9.0
Cryptophytes					
Cryptomonas sp. 1	Cry	0.6		1.1	0.6
Cryptomonas erosa	Cry	12.6	10.8	60.5	28.0
Cryptomonas ovata	Cry	138.8	86.1	178.9	134.6
Rhodomonas minuta	Cry	6.2	9.0	13.2	9.5
Chlorophytes					
Ankistrodesmus falcatus	Chl	5.7	2.3	1.5	3.2
Chlamydomonas sp.	Chl			45.0	15.0
Eudorina sp.	Chl	25.1		49.0	24.7
Monomastix astigmata	Chl	0.1	1.1	3.3	1.5
Sphaerocystis schroeteri	Chl		9.4	106.5	38.6
colonial Chlorophyte	Chl			41.8	13.9
misc. Chlorococcales	Chl		1.5	15.7	5.7
Dinoflagellates					
Gymnodinium sp.	Din		17.3		5.8
dinoflagellate cyst	Din		62.7		20.9
Cyanobacteria					
Aphanizomenon flos-aquae	Cya		86.6		28.9
Coelosphaerium naegelianum	Cya	0.7			0.2
Merismopedia sp.	Cya	0.3			0.1
Oscillatoria limnetica	Cya			1.5	0.5
coccoid Cyanobacteria	Cya			0.1	0.1
Other					
microflagellates (misc.)	var	4.7	1.5	11.0	5.7
Total Counted Biovolume ($10^3 \mu m^3$/mL):		1830.	3431.	565.	1942.

Table W.AII.4. Summer phytoplankton from Lake Waynewood--major species and their abundance as biovolume. A composite sample from each year of all dates and sampling depths during the period June through September was counted.

Alga	Type	Biovolume of species ($10^3 \mu m^3$/mL) 1989	1990	1991	mean
Diatoms					
Cyclotella sp. 3	Dia	9.6			3.2
Fragilaria capucina	Dia			22.1	7.4
Melosira sp.	Dia		15.9		5.3
Synedra sp. 1	Dia	5.8	99.4		35.1
Tabellaria fenestrata	Dia	162.6	16.3		59.6
Chrysophytes					
Dinobryon sertularia	Chr	1.8			0.6
Ochromonas sp.	Chr			5.2	1.7
Synura uvella/sphagnicola	Chr			17.6	5.9
Cryptophytes					
Cryptomonas sp. 1	Cry	1.2	1.1	1.1	1.1
Cryptomonas erosa	Cry	1.7	17.3	39.1	19.4
Cryptomonas ovata	Cry	84.4		7.9	30.8
Cryptomonas pyredinosa	Cry			1.7	0.6
Rhodomonas minuta	Cry	0.8	4.9	2.4	2.7
Chlorophytes					
Ankistrodesmus falcatus	Chl			1.0	0.3
Closterium moniliferum	Chl		7.9		2.6
Monomastix astigmata	Chl		0.6		0.2
Oocystis parva	Chl	9.4		59.7	23.0
Oocystis sp. 2	Chl		0.4		0.1
Schroederia judayi	Chl	0.7			0.2
Sphaerocystis schroeteri	Chl			4.7	1.6
misc. Chlorococcales	Chl		1.5		0.5
Dinoflagellates					
Ceratium hirundinella	Din			129.8	43.3
Gymnodinium sp.	Din			6.0	2.0
Cyanobacteria					
Anabaena affinis	Cya			4.7	1.6
Anabaena macrospora	Cya	217.7	145.0	26.5	129.7
Aphanizomenon flos-aquae	Cya	661.5	1546.8	376.9	861.7
Coelosphaerium naegelianum	Cya	10.6	3.4	2.8	5.6
Gloeothece rupestris	Cya	70.9			23.6
Merismopedia sp.	Cya			0.3	0.1
Oscillatoria limnetica	Cya	16.2	45.8	53.3	38.4
Oscillatoria sp. 2	Cya			61.8	20.6
coccoid Cyanophyta	Cya			0.1	0.1
Other					
Lepocinclis fusiformis	Eug			21.1	7.0
Phacus sp.	Eug			58.8	19.6
microflagellates (misc.)	var		10.1	12.0	7.4
Total Counted Biovolume ($10^3 \mu m^3$/mL):		1255.	1916.	917.	1363.

Table W.AII.5. Autumn phytoplankton from Lake Waynewood--major species and their abundance as biovolume. A composite sample from each year of all dates and sampling depths during the period October through December was counted.

Alga		Biovolume of species ($10^3 \mu m^3$/mL)			
		1989	1990	1991	mean
Diatoms					
Asterionella formosa	Dia	3.1			1.0
Cyclotella spp.	Dia	0.7			0.2
Fragilaria capucina	Dia		485.		162.
Melosira varians	Dia		946.		315.
Melosira sp.	Dia			37.9	12.6
Synedra sp.	Dia		104.		34.8
Tabellaria fenestrata	Dia		255.	31.5	96.
Chrysophytes					
Dinobryon cylindricum	Chr			0.9	0.3
Dinobryon sertularia	Chr	1.8			0.6
Epipyxis utriculus	Chr			0.4	0.1
Mallomonas sp.	Chr		0.8		0.3
Synura uvella/sphagnicola	Chr			8.8	2.9
Cryptophytes					
Cryptomonas erosa	Cry		48.5	25.0	24.5
Cryptomonas ovata	Cry		109.	39.9	49.7
Rhodomonas minuta	Cry	0.4	3.9	1.6	2.0
Chlorophytes					
Ankistrodesmus falcatus	Chl			1.1	0.4
Closterium moniliferum	Chl			1.5	0.5
Eudorina sp.	Chl			25.1	8.4
Monomastix astigmata	Chl			2.1	0.7
Scenedesmus longus	Chl			6.6	2.2
misc. Chlorococcales	Chl	49.9	4.6	1.5	18.7
Dinoflagellates					
Gymnodinium spp.	Din		3.8		1.3
dinoflagellate cyst	Din			4.0	1.3
Cyanobacteria					
Anabaena macrospora	Cya			6.6	2.2
Aphanizomenon flos-aquae	Cya	720.	178.	4.1	301.
Coelosphaerium naegelianum	Cya	5.1		9.1	4.7
Oscillatoria limnetica	Cya	13.2		103.	38.8
coccoid Cyanobacteria	Cya	9.0		0.2	3.1
Other					
microflagellates (misc.)	var	0.1	21.0	7.4	9.5
Total Biovolume ($10^3 \mu m^3$/mL):		804.	2161.	318.	1094.

APPENDIX III: ZOOPLANKTON SAMPLING

Table. w.AIII. Zooplankton collection with nets compared to Schindler trap.

Values are concentrations (avg #/L ±SD) from N=5 vertical hauls or trap series (1 each at five stations in each lake). The ratios (R_{48}, R_{202}) are net values divided by trap values. The lakes were sampled the evening of 16 June 1993. Details of methods are discussed in the text (see **ZOOPLANKTON**).

	Schindler Trap		202-μm Net			48-μm Net		
	avg	±SD	avg	±SD	R_{202}	avg	±SD	R_{48}
Lake Giles								
Daphnia (total)	22.38	±2.17	15.81	±2.18	*0.706*	18.53	±1.19	*0.828*
Daphnia (large)	19.07	1.71	14.59	2.13	*0.765*	16.03	1.36	*0.841*
Daphnia (small)	3.31	0.70	1.21	0.18	*0.366*	2.49	0.21	*0.753*
Holopedium gibberum								
Diaptomus (total)	23.23	3.38	19.97	2.04	*0.860*	23.79	3.13	*1.024*
D. minutus	23.07	3.40	19.85	2.09	*0.860*	23.60	3.12	*1.023*
D. oregonensis								
D. spatulocrenatus	0.16	0.08	0.12	0.09	*0.775*	0.18	0.11	*1.138*
Cyclopoid copepods								
Asplanchna								
Lake Lacawac								
Daphnia (total)	6.16	±0.90	4.17	±0.75	*0.677*	5.03	±0.80	*0.817*
Daphnia (large)	4.08	0.79	2.46	0.36	*0.602*	3.22	0.73	*0.789*
Daphnia (small)	2.08	0.18	1.71	0.42	*0.823*	1.81	0.10	*0.871*
Holopedium gibberum	1.33	0.53	1.32	0.40	*0.995*	1.11	0.60	*0.839*
Diaptomus (total)								
D. minutus	5.36	0.66	4.04	0.52	*0.754*	6.31	0.92	*1.178*
D. oregonensis								
D. spatulocrenatus								
Cyclopoid copepods	1.84	0.53	1.26	0.25	*0.686*	1.92	0.31	*1.045*
Asplanchna	0.52	0.20	1.03	0.18	*1.981*	0.68	0.29	*1.308*
Lake Waynewood								
Daphnia (total)	21.55	±2.52	21.70	±4.93	*1.007*	25.83	±4.82	*1.199*
Daphnia (large)	14.55	1.51	12.96	2.76	*0.891*	16.86	3.26	*1.159*
Daphnia (small)	7.00	1.16	8.74	2.35	*1.248*	8.97	1.68	*1.282*
Holopedium gibberum								
Diaptomus (total)								
D. minutus								
D. oregonensis	0.10	0.04	0.14	0.04	*1.469*	0.12	0.04	*1.245*
D. spatulocrenatus								
Cyclopoid copepods	0.05	0.02	0.05	0.02	*1.174*	0.05	0.02	*1.043*
Asplanchna	1.88	0.45	2.46	0.64	*1.309*	2.44	0.74	*1.298*