CEW

SAMPLING PROTOCOLS (1988-1993)

OF THE

POCONO COMPARATIVE LAKES PROGRAM

Robert E. Moeller
Craig E. Williamson
John A. Aufderheide
Eugina M. Novak

POCONO COMPARATIVE LAKES PROGRAM

Lehigh University

Department of Earth and Environmental Sciences
31 Williams Drive
Bethlehem, Pennsylvania 18015

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It is Bound With the 1992 Annual Reports to Lake Owners.

OVERVIEW OF SAMPLING AND ANALYSIS

The sampling and analysis methods used for the routine monitoring of Lakes Giles, Lacawac, and Waynewood during 1988-93 are summarized here. This documentation is designed to allow evaluation and replication of procedures in the future. The methods are not necessarily the best available, and are not presented here as a manual of recommended techniques, although we have been generally satisfied with them. The descriptions assume familiarity with the equipment (i.e. with manufacturers' operating instructions for pH meter, oxygen-temperature meter, light meter, and fluorometer). We include notes on problems and on changes in procedure introduced during the course of the study.

According to the monitoring plan, each lake was sampled monthly, or twice-monthly during the summer. The lakes were usually visited in late morning, sometimes in early afternoon, or occasionally in late afternoon. A second visit was made after dark, usually between 10 pm and midnight, to resample the zooplankton. Samples were collected from a rowboat, which was moored to a buoy anchored near the deepest part of the basin (for locations see maps in 1992 Annual Reports to the lake owners). The same station was used at each lake throughout the study, including winter, when samples were taken through holes chopped or sawed through the ice. Because the buoy was sometimes dragged a little away from its designated site, changes in maximum depth are not to be interpreted as seasonal changes in water level.

Temperature, dissolved oxygen, and light (including Secchi depth) were measured first, *in situ* at 1-metre intervals, since thermal stratification dictated sampling depths for other parameters. The water column was divided into three layers, "EPI", "META", and "HYPO", corresponding in summer to epilimnion (low temperature gradient), metalimnion (steep temperature gradient), and hypolimnion (low temperature gradient). The metalimnion was delimited as the region where temperature changed more than 1°C per metre depth. In spring and fall, when thermal stratification was weak or absent, the water-column was divided into three equal layers (by depth). Under ice in winter the "EPI" layer was the top metre, and the remaining water column was divided equally to give the "META" and "HYPO" layers on each date.

Zooplankton samples were collected by vertical hauls of a closing net through each layer, while water samples (for pH, alkalinity, chlorophyll and algae) were collected at the mid-depth (to the nearest metre) of each layer. Duplicate collections of zooplankton and water samples were made in quick succession from each layer. Zooplankton were resampled at night to reveal diel changes in vertical distribution, and to get better estimates of abundance for taxa that swim to the bottom during the day (e.g. *Chaoborus*).

Water samples were collected with a transparent 4-L acrylic Van Dorn bottle (nominal sampling depth was to middle of the ca. 60-cm tall bottle). A 500-ml polypropylene bottle was filled for pH and alkalinity, and a 1-L polypropylene bottle for chlorophyll and algae. These were kept chilled in a cooler for transport to the field laboratory. Zooplankton were collected with tandem closing nets designed by C. E. Williamson (unpublished--see sketch **Appendix I**). A single frame supported a 48-μm mesh net (Wisconsin-style, mouth diameter 15 cm) and a 202-μm mesh net (diameter 30 cm). Zooplankton were preserved immediately in 10% sugar-formalin, then placed in a chilled cooler for transport to the field laboratory. A single composite of subsamples from the replicate 1 and replicate 2 chlorophyll-algae bottles from each layer was prepared for algae (ca. 100 ml sample preserved in capped glass bottles with 1% acid Lugol's solution).

Temperature was measured with a submersible thermister and oxygen was measured polarometrically with the Clark-style electrode of a Yellow Springs Instrument Co. meter. Light was measured as the ratio of photosynthetically active radiation (PAR, 300-700 nm, in quanta) between successive 1-metre depth intervals using Licor submersible sensors and a Licor 2-channel datalogger. From these ratios a depth-profile of light attenuation was calculated. Ross pH electrodes with an Orion pH meter were used to measure pH. Alkalinity was determined as microequivalents/L by Gran titration. Chlorophyll-a (total and corrected for pheopigment) was determined fluorimetrically (Sequoia-Turner fluorometer) following overnight extraction of frozen filters (Gelman AE glass-fibre filters) in a mixture of 90% acetone and methanol (5:1 by volume). Chlorophyll samples were filtered and pH and alkalinity were determined in the field laboratory, usually within 3-12 hr of collection.

After counting, zooplankton samples were returned to their capped plastic containers. These are in indefinite storage at Lehigh University. Algae samples have not been counted (though a set of seasonal composites from each lake for three years has been sent away for analysis). These are also retained at Lehigh. All zooplankton data, as well as the physical-chemical and chlorophyll measurements, have been entered into an electronic database (Borland "Reflex" v. 2 [1989]) running on IBM-type microcomputers. Inquiries to examine the database should be addressed to: Dr. Craig E. Williamson, Department of Earth & Environmental Sciences, 31 Williams Dr., Lehigh University, Bethlehem, PA 18015 (telephone 215-758-3675; FAX 215-758-3677).

The following sections of this report present detailed protocols for the procedures used:

1. Dissolved Oxygen
2. Temperature
3. Light and Secchi Depth
4. pH
5. Alkalinity
6. Algal Chlorophyll-a
7. Zooplankton

In addition, **Appendix I** includes several datasheets or graphs illustrating the analysis procedures. **Appendix II** is a detailed list of the zooplankton taxa recorded in Lakes Giles, Lacawac and Waynewood during the course of this study.

1. DISSOLVED OXYGEN

A. Overview

Oxygen is measured at 1-metre intervals in the water column on each sampling date. We use a Yellow Springs Instrument Company (YSI) oxygen meter (Model 58 or 57) with Clark-type polarographic oxygen electrodes. The electrodes (YSI catalog # 5739) are temperature and pressure compensating. They do not have a motorized stirrer, so are read while rapidly agitating the electrode cable (raising and lowering it within a 10-cm amplitude).

B. Protocol--DISSOLVED OXYGEN (Method 10)

1. **Verify electrode condition.** Replace membrane and solution with YSI replacement supplies if there are bubbles under the membrane or if the membrane has not been changed in a couple of months.

2. **Check battery.**

3. **Turn on meter** 15-30 min before starting sampling.

4. **Set salinity calibration** to zero if meter has a salinity-compensating knob.

5. **Calibrate meter in air**, with electrode inserted tightly in its saturated water-vapor housing, out of direct sunlight or wind. Set meter to 100% saturation when a constant reading is obtained (it may take 5 min or more for reading to stabilize).

6. **Read oxygen concentration** (to the nearest 0.05 mg/L) in surface water and other depths while agitating the cable. It may take several minutes to get stable readings, especially when moving into low-oxygen water.

7. **Recheck 100% calibration.** Read with probe back in its housing. Alternatively, verify surface water oxygen concentration. Note any major problems on the datasheet.

C. Comments--Dissolved Oxygen

1. The calibration to 100% saturation in air can be problematic. The meter often drifts, with calibration changing during the course of sampling. Consequently the ± 0.03 mg/L accuracy specified by the manufacturer is not realized. The realized accuracy is probably ± 0.5 mg/L in well oxygenated waters. The error is potentially larger in low-oxygen waters (see note 2).

2. The elevation of the PCLP lakes is not taken into account when calibrating the instrument to 100% saturation in air. In effect it is calibrated for sea level. Values should be multiplied by 0.95 to correct to the ca. 430 m elevation of the lakes ASL (Giles 428 m, Lacawac 439 m, Waynewood 421 m).

3. In anoxic waters (deep hypolimnial waters in late summer) the meter typically "bottoms out" at some positive oxygen level, usually 0.2-0.6 mg/L but sometimes more than 1 mg/L. Even long equilibration ($>$15 min) with agitation does not overcome this error. Poor electrode condition or operator impatience may aggravate the problem, but are not the main cause. Low oxygen readings must sometimes be interpreted as "zero". This can be guessed at by the context (e.g. constant but positive values through deep portion of hypolimnia of Waynewood and Lacawac in late summer), but in other cases (early summer, intermediate depths) low oxygen concentrations (0-2 mg/L) are difficult to interpret. Values that probably represent zero oxygen are assigned a code of "4" in the "Data Flag" field for oxygen error codes.

2. TEMPERATURE

A. Overview

Temperature is measured at 1-metre intervals throughout the water column using the thermister of a Yellow Springs Instrument Company (YSI) oxygen meter.

B. Protocol--TEMPERATURE (Method 10)

1. **Turn on oxygen meter** 5-15 minutes before starting to sample.
2. **Zero meter.**
3. **Record air temperature** (shade electrode from direct sun).
4. **Record temperature** to a tenth of a degree Celsius after equilibration at each sampling depth.

C. Comments--Temperature

a. The meter is not routinely standardized. Although it is capable of giving results reproducible to 0.2°C on any given day, the overall accuracy is much less. Moreover, we use several combinations of meters and temperature/oxygen probes. Two meters were calibrated in a water bath with two probes (4 combinations) on 16 December 1991 against a high-quality mercury thermometer (Fisher Scientific ASTM 90 C, #804-050). The accuracy was ±1°C over the range 0-30°C. The error was fairly consistent (±0.3°C) for a particular meter/probe combination (e.g. consistency of ±0.3°C within a single depth-profile). The ±1°C inaccuracy sometimes shows up in the database as date-to-date irregularities in the summer trend of slowly increasing hypolimnial temperature.

3. LIGHT

A. Overview

Light penetration is measured in two ways: as the Secchi disk transparency and as the downward attenuation of visible light. The Secchi disk is a black-and-white quartered disk 20-cm in diameter that is lowered until it disappears (Welch 1948 p. 159). The depth of disappearance is a measure of water clarity or transparency, and is less in waters high in suspended particles or dissolved organic matter. We measure Secchi depth by observing the descent of the disk through a transparent acrylic-bottomed viewing box (ca. 15 by 25 cm) to reduce surface reflections. Light attenuation throughout the water column is also measured metre-by-metre, using flat-plate, cosine-corrected quantum sensors (Li-Cor Instruments, Lincoln, Nebraska: LI-1925A underwater quantum sensors and LI-1000 data logger).

The quantum sensors are manufactured to give a quantum response to photosynthetically active radiation ("PAR"); that is, an equal response per photon (quantum) regardless of wavelength within the 400-700 nm spectral band. Since mid-1989 we have used a dual-sensor instrument, with the data logger automatically monitoring two sensors exactly 1 metre apart. The data logger provides a reading of irradiance at one depth (as μEinst/m^2-sec) and simultaneously measures the ratio of irradiance between that depth and the metre above it. By simultaneously monitoring two sensors, we obtain metre-by-metre estimates of the downwelling attenuation coefficients that are relatively uneffected by changing cloud conditions.

B. Protocol--SECCHI DISK TRANSPARENCY

1. **Lower Secchi disk** while observing it through the viewing box. Note the depth of disappearance (to the nearest 0.1 m). Then lower it another metre.

2. **Raise disk** slowly toward the surface. Note the level of reappearance.

3. **Record the average of these two depths.**

C. Protocol--LIGHT ATTENUATION (Method 12)

1. **Check batteries** of the Li-Cor data logger.

2. **Attach sensors** to input connectors and remove protective caps from the sensing cells.

3. **Configure datalogger.** Verify that proper coefficients for both sensors are in memory, or re-enter them.

4. **Read light intensity at 10 cm.** Record irradiance of lower cell when it is 10 cm below lake surface, on sunny side of boat. Hold cell away from boat to reduce shading.

5. **Continue with greater depths.** At each depth "z", record the irradiance of the lower sensor (data logger channel 2) and the ratio of irradiances between upper and lower sensors (Rz = [z-1]/z; Math channel of datalogger).

6. **Disassemble for storage.** After sampling, let cable and case dry thoroughly. It is best to store the case open, to prevent high humidity from penetrating the meter and condensing on the electronics.

7. **Calculate light penetration.** The percentage of 0.1-m PAR at depth z is calculated as: 100/(R1*R2...*Rz), where R1, R2...Rz are ratios of readings for the depth intervals up to and including z.

8. **Update database.** Enter both the ratios and the calculated attenuation profile (% of 0.1-m PAR) into the Reflex database.

D. Variants--Light

1. Single-sensor quantum method (Method 10: June-July 1989)

A Li-Cor meter with a single underwater quantum probe was used. The attenuation ratios were constructed from readings at successive depths. Percentage of 0.1-m PAR was calculated directly from irradiance values. Several profiles were averaged when cloudiness caused changing light conditions (alternatively, on some dates readings were standardized to those of a separate deck cell).

2. Photometer method (Method 9: 1988).

A photometer (Protomatic, Dexter, Michigan) equipped with a silicon photocell and hemispherical diffusing collector was used to measure light at metre depth-intervals. This commercial version of a prototype described by Rich and Wetzel (1969) measures illuminance in foot-candles. Replicate profiles were obtained (sometimes) when clouds caused unstable readings. Ratios and percentages of 0.1-m light were calculated from these readings.

E. Comments--Light

1. Accuracy of the two-sensor method depends on maintaining precise relative positioning (1.00 metre apart) and orientation (horizontal) of the sensors, and on identical response of the two meters to the same light conditions (e.g. to a clear or uniformly overcast sky). This must be checked occasionally. Deviations from uniform response can be offset by resetting the calibration value for one or the other sensor. The whole unit should be returned to the factory for recalibration every year or two.

2. A major problem with all the light readings is shading from the boat (or, in winter, from people and equipment standing around the hole through the ice). Careful technique can minimize the effect on clear days (sensors lowered on sunny side of boat), but shading is often unavoidable. The effect is exaggerated attenuation at near-surface meter intervals, succeeded by one or two intervals of decreased attenuation. In our database, irregular or changing attenuation ratios within the top 3 metres of the water column should be treated with caution.

3. The photometer method of 1988 gave results not fully comparable to those from the Li-Cor quantum sensors, because of differences in collector shape (hemispherical 2π vs. flat cosine-response) and wavelength sensitivity (500-600 nm peak sensitivity of silicon photocell vs balanced quantum response).

4. Use of the viewing box improves reproducibity of Secchi disk measurements, especially on bright days with a choppy water surface. Our standard limnological disk is small (20-cm)--a bigger oceanographic-style disk would probably give significantly greater transparency values in Lake Giles.

F. References--Light

Rich, P.H. and R.G. Wetzel. 1969. A simple, sensitive underwater photometer. Limnol. Oceanogr. 14:611-613.

Welch, P.S. 1948. Limnological Methods. McGraw-Hill, New York, New York.

4. pH

A. Overview

Values of pH are obtained on each sampling date from the EPI, META and HYPO samples with an Orion model SA-250 meter (manufactured ca. 1989) and Orion Ross combination electrode with epoxy body. The meter is calibrated at pH 7.00 and pH 4.00 using commercial high ionic strength buffer solutions. Samples and buffers are read at laboratory temperature. Samples are read with gentle magnetic stirring, with or without added salt solution to increase ionic strength.

B. Protocol--pH (Method 12)

1. Sample Collection

Fill 500-ml polypropylene bottles from Van Dorn collections (exclude all bubbles). Return to laboratory in cooler. Ideally, samples should be processed within a couple of hours, as soon as they have equilibrated to lab temperature (on counter or in water bath). Keep cool/dark if they must be held longer.

2. Calibrate meter (fill in pH calibration sheet)

a. **Soak electrode** in distilled water or dilute buffer for several hours or overnight. Lower sleeve from hole in electrode to assure free flow of electrolyte.

b. **Attach temperature-compensating probe and turn on meter.**

c. **Calibrate at pH 7.** Rinse electrode with distilled water, blot tip of electrode casing (not sensing glass!). Gently swirl a 50-ml beaker of standard pH 7 buffer around electrode, then stop. When reading has equilibrated, adjust pH and enter the value.

d. **Calibrate at pH 4.** Repeat above procedure with pH 4.00 buffer.

e. **Read pH 7 again.** Rinse electrode, then read the pH 7 buffer again. Repeat the calibration if it is off by >0.03 units.

f. **Read distilled water.** Rinse electrode thoroughly and blot. Then read a sample (50-100 ml) of distilled water, with swirling or gentle stirring. A reading of 5.2-5.6 should be obtained, though it may take a while. If meter does not come to this range, the electrode may be in poor condition. Note this fact.

g. **Add KCl to the distilled water.** Reread the same beaker of distilled water, with stirring, after adding salt solution (Orion pHix/pHisa at ca. 0.5ml/50 ml of sample). If reading fails to equilibrate within the range 5.2-5.6, make notation on main data sheet that pH readings are suspect. If new reading is more than 0.1 unit different from reading without salt, electrode may be suboptimal and this fact should be recorded on datasheets.

3. Read samples

a. **Rinse electrode.** First rinse electrode with distilled water (squirt bottle), then place into ca. 50 ml beaker of sample. Swirl, and allow to stand a minute or longer to equilibrate. Discard sample.

b. **Read sample.** Without rerinsing electrode, immerse it in a second 50 ml sample. Swirl sample, then stop and record pH value after it eqilibrates. This is the unstirred reading. Then resume swirling (or magnetic stirring) and record this pH also.

c. **Add salt and reread sample.** Add 0.5 ml pHix/pHisa solution (1-ml disposable syringe) and reread, with stirring.

4. Reread buffers

Read distilled water, pH 4 buffer, and pH 7 buffer. Record values on the pH calibration sheet to demonstrate stability of meter.

C. Variants--pH

1. pH measurement without salt addition (Method 11)

Measurements and meter calibration are as in Method 12 except that the salt solution is not added to samples.

2. pH measurement without electrode verification (Method 10)

Measurements and meter calibration are as in Method 11 (no salt added to samples) but in addition the electrode is not tested in distilled water after standardization in buffers, and the buffers are not always read after the samples to establish stability of meter performance.

D. Comments--pH

1. Addition of KCl solution--always pHiX (1990) then pHisa (1991-93) sold by Orion Research--assured consistent pH measurements. At first the protocol was to add KCl to Giles samples only, and other samples if electrode performance seemed suboptimal. Later it was added to all samples, even though electrode performance seemed adequate. Usually adding KCl had little effect (change of <0.1 pH unit), so later results should be consistent with earlier data. Adding KCl tends to eliminate differences between stirred and unstirred samples, giving a value similar to that of a stirred sample without KCl.

2. For Method 12, the values entered in the database are the pH readings with pHiX/pHisa added, or averages of pHiX/pHisa values and pH readings stirred without pHiX/pHisa. Averages often were entered when the readings seemed to differ only by analytical noise. For

methods 10 and 11, the stirred pH values were preferred, though these, too, were sometimes averaged with unstirred values when the variability was small.

3. The PCLP lakes have quite dilute waters. After standardizing in high ionic strength buffers it is necessary to thoroughly rinse and soak the electrode in distilled water or sample. By reading distilled water after the standards (to pH ca. 5.5), we try to assure that the electrode is performing properly and has been thoroughly rinsed of buffer. Nevertheless, it is especially important to allow an extra long, several-minute soak in the first of any sequence of samples. On two dates in early 1993 we tested the reliability of the usual standardization procedure--using high ionic strength buffers--by reading special low ionic strength buffers (Orion Research, pH 6.97 ± 0.03 and 4.10 ± 0.03) along with the lake samples. Readings were within the claimed accuracy of the standards. These tests were performed with an electrode that had been in use for eight months.

4. The electrode has been replaced at 1-2 year intervals when it becomes sluggish (ie., slow to read pH 5.2-5.6 in distilled water). The electrode is used only for lake samples, and is little used except for the routine PCLP monitoring. It is stored closed and capped when not in use.

5. Overall, replicate sample collections yield consistent pH's (usually within ± 0.05 units, especially when KCl is added). Given the precision of the standardization, which usually "drifts" no more than 0.05 pH unit during the course of measurements, the individual pH values are believed to be "accurate" to within ± 0.15 pH unit. The manufacturer's claimed potential accuracy of the meter itself is ± 0.01 pH unit.

6. Since the samples are measured after they have equilibrated to laboratory temperature, and often 6-12 hr after collection, they may not represent in situ conditions. Since pH is measured during stirring, it may have decreased as carbon dioxide is taken up (Waynewood summer epilimnial samples?) or increased as it is given off (most other samples).

5. ALKALINITY

A. Overview

Alkalinity is measured by potentiometric titration of 100-ml samples with dilute acid (0.1 or 0.01 N hydrochloric acid). The endpoint is located graphically or by regression of Gran-transformed data (Mackereth et al. 1978). The titration is monitored with the same pH meter/electrode combination used for pH measurements. Five to eight data points within the pH range 4.4 to 3.7 are required for Gran plots.

B. Protocol--ALKALINITY by Gran titration (Method 11)

1. Sample collection

Samples are taken from the same 500-ml polypropylene bottles used for pH. The alkalinity titrations should follow the pH readings, which are performed when the bottles are first opened. It is best to measure all pH's before starting alkalinities, in order to avoid contamination with titrant acid.

2. Prepare pH meter

The pH meter (Orion Research model SA-250 with Ross combination electrode) is set up and standardized as for pH measurements.

3. Prepare titrant

Make a 1/10 dilution of 0.1 N HCl stock solution (e.g. Fisher standard solution) by pipetting 5.00 ml into a 50-ml volumetric flask, then bringing to volume with distilled water. The 0.1 N titrant will be standardized and used for Lake Waynewood and occasionally Lake Lacawac samples. The 0.01 N titrant is assumed to be an accurate dilution of the 0.1 N stock; it will be used for Lake Giles and Lake Lacawac samples.

4. Sample determination

a. **Measure out sample.** Fill a 100-ml volumetric flask with sample. Decant into 120-ml plastic titration cup. Insert electrode and temperature-compensating probe.

b. **Fill microburet.** Draw titrant (0.01 N for Giles and Lacawac; 0.1 N for Waynewood) into 2-ml syringe-type microburet. Adjust to 0.000 mark and wipe tip. Insert tip below surface of sample.

c. **Titrate sample.** Start magnetic stirrer and titrate to pH 4.5, being careful not to overshoot. Then record titrant volume (to 0.01 ml) and resultant pH at this point and at 5-8 subsequent points between pH 4.4 and pH 3.7.

5. **Standardize the titrant (fill out the alkalinity calibration sheet).**

   a. **Weigh out standard.** Redry sodium carbonate (Na_2CO_3, FW = 106 mg/mmole) at 105°C. Cool under dessication, then weigh out several 106 ± 1-mg aliquots. Store these tightly capped in 2-ml plastic vials.

   b. **Prepare 5 mM solution (10 mEq/L).** Add contents of one vial (1.00 millimole), with rinsing, to 100 ml of water in 200-ml volumetric flask, then bring to volume.

   c. **Titrate the standard.** Pipette 3.00 ml of the 10 mEq/L standard into ca. 100 ml distilled water in the titration cup. Titrate this 30 microequivalent sample with the nominally 0.1 N HCl as for the lakewater samples. Repeat the titration to obtain three replicates.

   d. **Calculate the second Gran function:** F2 = [antilog(5-pH)]/(V_0 + v) for all points in the pH range 4.4-3.5. Here V_0 is the volume of sample (100 ml) and v is volume of titrant (ml) to the measured pH.

   e. **Calculate titrant strength ("N").** Plot F2 vs v to find x axis intercept, v'. Calculate N from v' for each replicate titration: N = 0.001*30/v', where 30 is the microequivalents of standard added and v' is titrant volume (ml) to the equivalence point. N should be within a few percent of 0.1 mEq/ml.

6. **Calculate alkalinities from Gran plots.**

   a. **Enter data** from titrations of samples and standard carbonate into a spreadsheet that can calculate linear regressions with y intercepts <use Quattro-Pro program XA3YYDDD.WQ1>.

   b. **Calculate the second Gran function:** F2 = [antilog(5-pH)]/(V_0 + v) for all points in the pH range 4.4-3.5. Here V_0 is the volume of sample (100 ml) and v is volume of titrant (ml) to the measured pH.

   c. **Calculate alkalinity.** Plot F2 vs v. The intercept v' gives the alkalinity (A) as microequivalents/litre: A = v'*N*1000/(0.001*V_0), where N is titrant normality (Eq/L or mEq/ml), v' is ml of titrant to equivalence point, V_0 is volume of sample in ml. Calculate v' as the y intercept of v regressed on F2 in Quattro-Pro program XA3YYDDD.WQ1. Note: v' is better calculated as the x axis intercept of the regression line of F2 on v. But with r^2's of >0.99 (as all reliable titrations should have) the difference is negligible.

C. Variants--ALKALINITY.

1. Titration to equivalence point (Method 10: 1989 some dates)

A titration similar to that for the Gran plot was carried out, except that it was not necessarily continued into the pH range 4.4-3.7 required for the Gran plot. The equivalence point was determined graphically as the inflection point of pH plotted against v. The commercial titrant solutions were not standardized when this method was in use.

2. **Titration to fixed pH endpoint (Method 9: 1989 some dates)**

The titration was to a fixed endpoint of pH 5.2. This approximation was used for some Lake Lacawac and Lake Giles samples for which the pH vs ml of titrant plot did not show a distinct inflection point. The endpoint was selected after examining many Gran titrations of Lake Lacawac epilimnial samples.

D. Comments--ALKALINITY.

1. The Gran titration (Method 11) should give more precise values for alkalinity than the methods used in 1989. For Lake Waynewood samples, method 10 (titration to the inflection point) is comparable in accuracy and precision to the Gran plot since inflection points are easy to locate. In Lake Lacawac samples and Lake Giles hypolimnetic samples, Method 10 is applicable but imprecise because the inflection point is hard to recognize. Only the Gran plot establishes the slight negative alkalinity characteristic of Lake Giles.

2. There is some evidence that the Gran titration and titration to the inflection point give different results. For Lake Lacawac samples from March 1990, the Gran titrations consistently gave alkalinities ca. 10% greater than Method 10. Lake Waynewood samples from this date were only 3% greater by Gran titration. These differences may reflect some buffering constituent other than bicarbonate.

E. Attachments--pH and ALKALINITY (see Appendix I)

1. **pH/Alkalinity calibration sheet**

2. **pH/Alkalinity datasheet with example data for Gran plots.**

3. **Gran plots of epilimnion samples from all three lakes on 1-3 July 1991 (Figure A.I.1).** In these plots, the X axis incorporates the calculation of alkalinity from "v", the volume of titrant. The x axis plots $v*N*1000/(0.001*V_0)$. Therefore the X axis intercept, v', is alkalinity in units of μEq/L.

F. Reference--ALKALINITY

Mackereth, F.J.H., J. Heron and J.F. Talling. 1978. Water Analysis: Some Revised Methods for Limnologists. Sci. Publ. 36. Freshwater Biol. Assoc., Ambleside, England. p. 52.

6. ALGAL CHLOROPHYLL-a

A. Overview

Chlorophyll-a is measured as an index of algal biomass in the water column. Water samples (0.5-1 L) are filtered onto glass-fiber filters (Gelman AE). These are frozen and stored, ideally not more than 1 month. The still-frozen filters are extracted overnight, without grinding, in a 5:1 (vol:vol) mixture of 90% alkaline acetone (4 drops of conc. ammonium hydroxide/L) and methanol. The extraction is carried out in a dark refrigerator (2-4°C).

The extract, or a suitable dilution, is read in a fluorometer before and after acidification to 0.03 N HCl, and chlorophyll-a (corrected for pheopigment) and pheophytin-a are calculated. The fluorometer is calibrated periodically (every 2-3 months) with dilutions of more concentrated extracts of a higher plant leaf that are read, undiluted, in a spectrophotometer for determination of chlorophyll-a.

The fluorometer is a Sequoia-Turner™ model 112 fluorometer (ca. 1989 manufacture) equipped with F4T5/B lamp, red-sensitive photomultiplier, Corning 5-60 excitation filter and 2-64 emission filter. This lamp/filter combination gives an acid ratio of 2.1 with purified chlorophyll-a (Sigma Chemical Co.), though we use a ratio of 2.0 for algal samples. The extracts of higher plant leaves, which contain chlorophyll-b and other pigments, but little or no pheopigment, give ratios of ca. 1.8.

B. Protocol--CHLOROPHYLL-a (Method 12: mid-June 1990--1992)

1. Sample Collection and Filtration.

a. **Collect duplicate water samples** (e.g. from "EPI", "META", and "HYPO" depths) with a transparent plastic Van Dorn or Kemmerer bottle. Fill 1-litre polypropylene bottles, and keep these in a darkened cooler during sampling. Filter samples within 8 hr. If they must be kept overnight (only a few dates in the 1989-1992 database), refrigerate.

b. **Filter whole water sample.** Measure out 500 ml of freshly shaken sample (composite of replicate bottles) into a graduated cylinder or other calibrated bottle (accuracy of ±3%). Filter at low vacuum (0.1-0.2 atmosphere) onto 47mm glass fiber filters (Gelman AE). These are the "whole" samples.

c. **Prepare and filter size-fractionated sample.** Measure out 500 ml of composite sample, and rinse gently through a 20-μm mesh nitex screen. Refilter this filtrate and, separately, the algae rinsed off the screen (vigorous jets of distilled water from a squirt bottle) onto glass-fiber filters as above. These are the "$< 20\ \mu$m" and "$> 20\ \mu$m" samples.

d. **Freeze all filters** in individual snap-cap petri dishes, labelled on top and bottom. Wrap in foil and store frozen. Samples should be analyzed within 1 month.

2. Extraction and Fluorometric Determination

a. **Extraction.** Place frozen filter in calibrated polypropylene centrifuge tube and add ca. 11 ml of the 90% acetone/methanol (5:1 vol:vol) solvent. Cap and place in refrigerator overnight.

b. **Adjust volume of extract.** Remove tubes from refrigerator and warm to room temperature (in darkness!). Working in subdued light, bring volume up to calibration (e.g. top of meniscus to "12" ml mark in Corning 15-ml polypropylene tubes--this gives a volume of 11.5 ±0.2 ml).

c. **Centrifugation.** Shake tubes, then centrifuge (10 min at 3/4-full speed on a clinical centrifuge). Hold tubes in darkness.

d. **Zero fluorometer** on the appropriate scale (usually the least sensitive "1" scale) with a cuvette of solvent. Rezero between each sample. Use 1-cm diameter cuvettes (supplied with instrument, or use any borosilicate test tubes that fit--but calibrate instrument with the same tubes!).

e. **Read sample.** Read sample or an appropriate dilution (e.g. 1/5), so that reading is at least 25 and not more than 100 (top of scale is 109). Make dilutions with adjustable pipettors (e.g. 1 ml sample plus 4 ml solvent). Serial dilutions of 1/400 may be necessary for some Waynewood and Lacawac hypolimnial samples. Pipettors should be calibrated by weighing out aliquots of distilled water (1.000 g/ml).

f. **Reread after acidification.** Acidify sample in tube with 3 N HCl (1 drop/5 ml sample). Mix, then reread after 1-2 min.

3. Calibration of the Fluorometer.

a. **Prepare standard extract.** Macerate a healthy leaf from lettuce or other higher plant at hand. Place in capped tube with solvent to extract (1-several hr in darkness). Use 90% alkaline acetone. If the acetone/methanol mixed solvent is used, the extinction coefficient for chlorophyll-a needs to be adjusted downward slightly (see Pechar 1987).

b. **Centrifuge extract** and decant supernatant into new tube.

c. **Prepare a dilution** to be read on least sensitive scale of fluorometer. For example, 0.5 ml to 200 ml of acetone/methanol solvent--dilution factor df equals 0.0025--may be appropriate for a parent extract that reads ca. 0.5 at 665 nm in 1-cm cell of spectrophotometer.

d. **Read dilution in fluorometer.** Read 3-4 replicate samples (aliquots of dilution) before and after acidification. Calculate mean values for the fluorescence before acidification ("Reading") and the acidification ratio "R" (before/after).

e. **Read undiluted extract in spectrophotometer.** Read 3-4 undiluted aliquots of original extract in 1-cm cell of spectrophotometer (Perkin-Elmer lambda 3, with bandwidth ≤ 1 nm), with a capped cell of solvent in the reference beam. Read at 750, 665, 663, 645, and 630 nm; reread 1-2 min after acidification (1 drop 3 N HCl/5 ml of sample--mix thoroughly). Run same cell with solvent only to obtain cell blank. [Note that cells containing solvent should be in place in both cell holders when instrument is first turned on--then a baseline correction is automatically recorded that will bring cells close to matching.]

f. **Verify wavelength calibration.** Run one aliquot of original extract at many wavelengths in range 550-750 nm to locate chlorophyll-a absorbance peak. A peak at 663 ± 1 nm verifies instrument monochrometer setting.

g. **Calculate chlorophyll-a for standard.** Compute mean blank-corrected absorbances for each wavelength. Enter these values in a program to calculate corrected chlorophyll-a by the trichromatic equation of Strickland and Parsons (1972). [Use Quattro-Pro spreadsheet "FLUORCAL.WQ1".]

h. **Establish calibration.** Calculate the calibration factor "F" that gives chlorophyll-a concentration in the parent extract (CHLA as $\mu g/cm^3$) per unit of fluorescence on scale 1: F= Reading/(CHLA*df). Usually, F is ca. 3000.

i. **Calculate chlorophyll-a for samples.** Enter calibration factor, acid ratio (=2.0, see comments), fluorescence of diluted sample before and after acidification, dilution factor, volume filtered (litres), and volume of extract (usually 11.5 ml) into Reflex database to calculate chlorophyll-a corrected for pheopigment (CHLAC), pheophytin-a (CHLAP) and total chlorophyll-a (CHLASUM--includes pheopigment).

C. Variants--CHLOROPHYLL-a.

1. Spectronic-20 method (CHLOROPHYLL-a Method 10: 1988)

In 1988 a simple spectrophotometric method modified from Lind (1974) was used. Whole water samples of 1-litre volume were filtered onto Gelman AE filters and frozen. The frozen filters were extracted in the refrigerator overnight, usually without prior grinding, in 7 ml of 90% acetone made basic with a slurry of magnesium carbonate. The centrifuged extract was read in a broad-bandwidth (20 nm) spectrophotometer (Spectronic 20) at 663 nm. Chlorophyll-a was calculated using an extinction coefficient of 11.9 (vs 13.4 suggested by Lind (1974) for 1-cm cuvette). By this technique, no correction is possible for phaeophytin, which, along with any chlorophyll-b, contributes to the apparent chlorophyll-a.

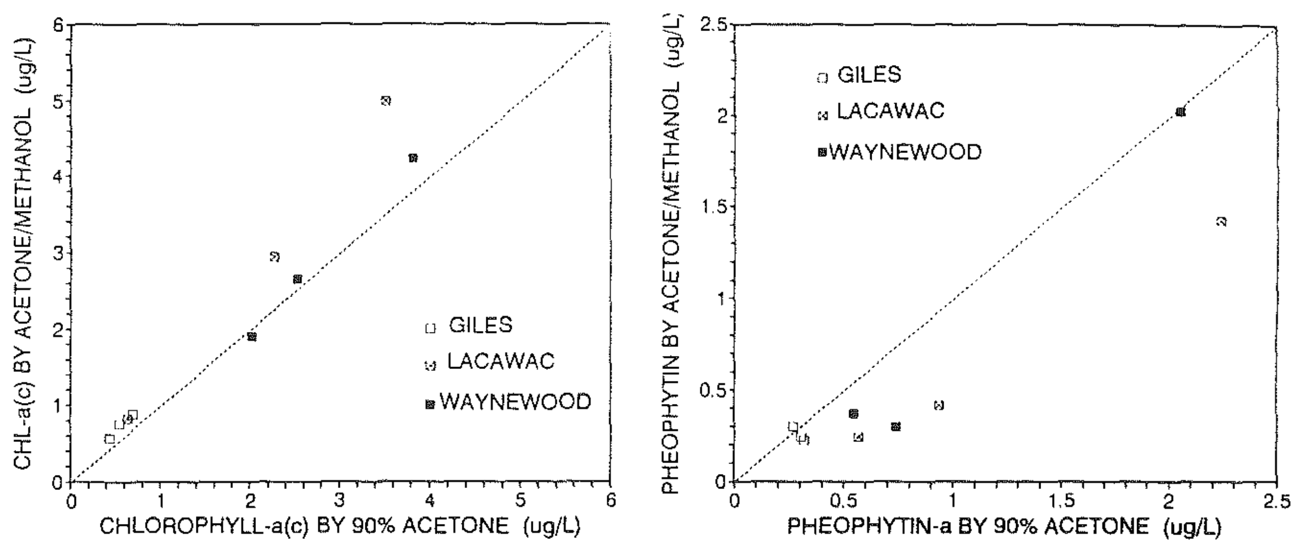
2. Extraction with grinding in 90% acetone (CHLOROPHYLL-a METHOD 11: 1989-mid June 1990)

Whole water samples of 1-litre were filtered onto Gelman AE filters and frozen. After 1-9 months these were ground in 90% basic acetone with a motorized teflon pestle in a glass mortar (Strickland and Parsons 1972, Wetzel and Likens 1991). The extracts were held overnight in the refrigerator, then read in the fluorometer. Chlorophyll-a and pheopigment were calculated as in Method 12.

D. Comments--CHLOROPHYLL-a

1. **The Acetone/Methanol Extraction (Method 12).** The acetone-methanol extraction modified from Pechar (1987) provides chlorophyll-a concentrations similar to, but slightly greater than, those of the traditional 90% acetone extraction with grinding (Method 11). We applied both methods to the 20 June 1990 EPI, META, and HYPO whole-water samples from the three lakes, after cutting frozen filters in two. As the graphs below show, the acetone/methanol combination extracted equal or greater amounts of chlorophyll-a (on average ca. 15% more). There was more pheophytin-a in some of the 90% acetone extractions, suggesting that part of the difference can be attributed to greater degradation of chlorophyll-a to pheopigment in the 90% acetone extraction. In any case, the extractions are close enough for direct comparability within our database. The acetone/methanol extraction seems to be both quicker (no grinding step) and analytically superior.

CHLOROPHYLL EXTRACTION TEST
PCLP SAMPLES OF 20 JUNE 1990

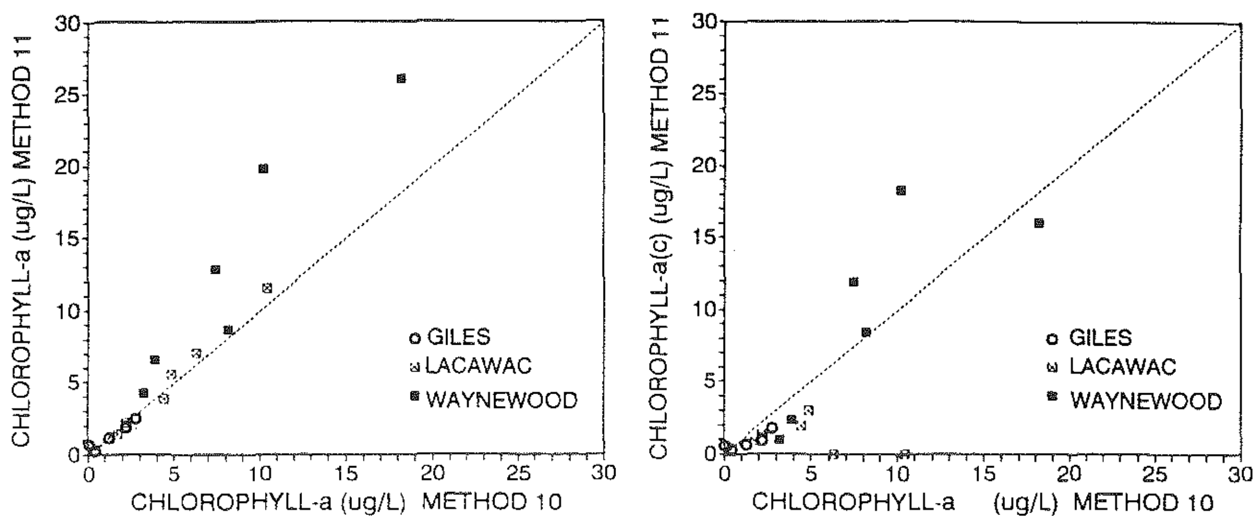


We verified that chlorophyll-a gives the same fluorescence yield and same acidification ratio in the two solvents (within ±3 percent, the precision of our test). For greatest accuracy of calibration, the standard chlorophyll solution is prepared for spectrophotometric assay in 90% acetone, but the dilution for calibration of the fluorometer (usually 0.5/200 ml), is made up with the 90% acetone/methanol (5:1) mixed solvent.

Our overnight extraction in cold acetone/methanol (under refrigeration) substitutes for Pechar's extraction in boiling solvent. The techniques seem to be equivalent; no additional pigment was extracted by boiling our samples following the overnight extraction.

2. **The 1988 Spectronic-20 Technique (Method 10).** The 1988 chlorophyll values are not fully comparable analytically with the fluorometric, pheopigment-corrected measurements of subsequent years. This method was compared with Method 11, using samples from EPI, META, and HYPO of the three lakes from ca. 15 June and ca. 28 June 1989. Half of each filter was analyzed one way, half the other. The comparison between total chlorophyll-a (corrected chlorophyll-a plus pheophytin-a) by the fluorometric method and "chlorophyll-a" by the simple spectrophotometric method is plotted below:

CHLOROPHYLL ANALYSIS TEST
PCLP SAMPLES OF JUNE 1989



Some high Waynewood samples (metalimnetic bluegreen populations) were underestimated by ca. 30%, but others were within ca. 10% of the fluorometric analyses. Epilimnetic samples from Giles were too low ($<0.5\ \mu g/L$) to be accurately determined by the spectrophotometric method. Comparing the spectrophotometric values with values just of chlorophyll-a, corrected for pheopigment, gives a less satisfying picture: the high Waynewood samples remain underestimated by 30% (they lack pheopigment), but the other samples are consistently overestimated (by 20-100%). Values from 1988 should be compared to total chlorophyll-a data from subsequent years, not to corrected chlorophyll-a.

3. **Fluorometer Calibration.** Calibration factors obtained from extracts of plant leaf, which contain chlorophyll-b, are different from those obtained using purified chlorophyll-a (e.g. Sigma Chemical Co.). The factor is ca. 10% lower with pure chlorophyll-a, leading to higher apparent sample concentrations. The PCLP data almost always were calculated from leaf extracts. Analyses will be more accurate with samples that contain appreciable chlorophyll-b (e.g. lots of green algae). The acidification ratio for pure chlorophyll-a in the fluorometer is 2.1, but is 1.8-2.0 for leaf extracts free of pheopigment. We use a factor of 2.0 for all PCLP analyses.

4. **Storage of Frozen Filters.** Filters are stored in the freezer compartments of standard refrigerators. Long storage probably causes loss of pigment, or conversion of chlorophyll-a to pheopigment. Ideally analyses are carried out within 1 month. In 1989 and 1990, however, storage for 3-6 months, even 9 months, was the rule. Such long storage is noted in the error code field of the database.

5. **Screening Samples with 20-μm Nitex.** This procedure aims to separate large algae that may resist grazing from other, smaller types. A major problem is that the sum of the $<$20-μm fraction and the $>$20-μm fraction is usually less than the chlorophyll-a of the unfractionated duplicate. Sometimes the difference is quite large (20-50%). To avoid biasing the chlorophyll data, the sum of the fractionated sample is treated as a duplicate analysis only when it is $\geq$85% of the whole-water sample. Size-fractionation was not done in 1988 or 1989. During summer 1990 it was done on alternate sampling dates, then every sampling date thereafter.

6. **Interference in Lacawac hypolimnetic samples.** During late summer and early fall, when the hypolimnion is anoxic, an interference prevents accurate measurement of chlorophyll-a and pheophytin-a by method 12. Upon acidification, fluorescence increases rapidly. All fluorescence is assigned to pheophytin-a; chlorophyll-a (corrected) is set to zero. But in fact some other pigment must be present, in high concentrations.

E. Attachments--CHLOROPHYLL-a (see Appendix I)

1. **Chlorophyll Data Entry Sheet** (example)

2. **Fluorometer Calibration Sheet** (example)

F. References--CHLOROPHYLL-a

Lind, O.T. 1974. Handbook of Common Methods in Limnology. C.V. Mosby Co., Saint Louis. 154 pp.

Pechar, L. 1987. Use of an acetone:methanol mixture for the extraction and spectrophotometric determination of chlorophyll-a in phytoplankton. Arch. Hydrobiol. Suppl. 78:99-117.

Strickland, J.D.H. and T.R. Parsons. 1972. A Practical Handbook of Seawater Analysis. 2nd. Ed. Fisheries Research Board of Canada, Ottawa. 310 pp.

Wetzel, R.G. and G.E. Likens. 1991. Limnological Analyses. Springer-Verlag, New York. 391 pp.

7. ZOOPLANKTON

A. Overview

Zooplankton are collected by vertical hauls of plankton nets at the main sampling station. Two nets with different mesh are used: **(1) 48-μm (15-cm diameter mouth)**, which collects rotifers along with larger zooplankton, and **(2) 202-μm (30-cm diameter mouth)**, which collects larger zooplankton only. The nets are mounted side-by-side and deployed simultaneously. The design of these custom-built nets is illustrated in **Appendix I.**. These are "closing" nets (the 48-μm net is traditional Wisconsin-style) which can be supported alternatively from attachment rings at the net mouth (during deployment and sample collection through a portion of the water column), or from a lower ring below the solid Dacron collar (for withdrawal to the surface through a non-sampled layer). When the nets have been pulled to the top of the intended sampling layer, the attachment is switched from the upper to the lower collar by dropping a weighted messenger; this releases the upper ring, causing the collar to collapse and close off the net, which is then pulled to the surface. The tails of the nets, which are weighted down with lead sinkers, are sewn to small funnels equipped with tubing drains and screw clamps.

Zooplankton samples are collected both during the day, when other sampling is done, and at night (at least 2 hr after dark, usually between 10 pm and midnight). The water column is sampled in three intervals (epilimnion, metalimnion, hypolimnion during thermal stratification), so it is possible to examine day-night differences in vertical positioning of species within the water column. The nighttime samples tend to have higher concentrations of some species (especially *Chaoborus*), and are preferred for following long-term trends of species abundance (e.g., figures in the **Annual Reports** for water-column mean concentrations).

Zooplankton samples are killed and preserved by adding ca. 10 ml of chilled formalin (35-40% formaldehyde) containing sucrose (40 g/L) per 90 ml of concentrated sample. The 202-μm net samples are briefly narcotized with carbon dioxide (rinsed in the net with soda water) before killing. Samples are stored at room temperature in tightly capped plastic cups before and following counting.

Appendix II is a list of taxa identified from the Pocono lakes, indicating also when each taxon was added to the suite of species consistently recognized and tallied by the counters. Not all taxa have been counted at the species level. Special effort has gone into species-level resolution of copepods and rotifers. *Daphnia*, in contrast, is counted only at the genus level. This list was prepared by John Aufderheide in April 1991, and was updated slightly by Robert Moeller in April 1993 with information provided by Gina Novak.

Calculations of concentration in the water column, or sampled portion of the water column, assume that the nets are 100% efficient at the nominal mouth area (0.0177 or 0.0707-m^2) for the organism in question (which may be counted from the 48-μm or the 202-μm sample, depending on its size). There have been several changes in counting strategy that may affect apparent trends. In general these changes (e.g. whether the 48-μm or 202-μm sample was used) were introduced to give more reliable and complete sampling.

Analysis strategy (since 1991):

a. **From 202-μm mesh net collection:** large Cladocera (all except *Bosmina*, *Chydorus*) and adult female cyclopoid copepods (except *Tropocyclops*). At least 100 organisms are counted in each of 1-2 subsamples.

b. **From 48-μm mesh net collections:** all remaining macrozooplankton (*Bosmina*, *Chydorus*, *Chaoborus*, *Asplanchna*, adult male cyclopoid copepods, adult male and female *Tropocyclops*, adult male and female calanoid copepods, cyclopoid copepodids, calanoid copepodids, copepod nauplii), rotifers, the ciliate cf. *Rhabdostyla*, miscellaneous other ciliates (an incomplete collection). At least 100 organisms (not including colonial cilates) are counted in each of 2 subsamples. Since 1991 copepodids have been counted at the species level.

During counting, an attempt is made to tally eggs, both loose and attached to adults.

B. Field Sampling Protocol--ZOOPLANKTON

1. **Prepare and rinse nets.** Attach calibrated line, with messenger, to lower support frame and open clamps on discharge tubes. Lower and raise nets in surface water 2-3 times to rinse. Then close clamps and attach release mechanism to upper support frame.

2. **Lower nets slowly** enough that they sink backwards (mouth open and directed upwards) to the base of the sampling zone (1 metre above the bottom in the case of the deepest sample).

3. **Collect sample.** Quickly pull up nets to top of sampling zone, then drop messenger to close them (or pull through the lake surface for samples that extend to the surface).

4. **Rinse sample into bottom funnel.** Lower and raise mesh portion of nets 2-3 times to rinse organisms into bottom of net, then use squirt bottle of surface water to complete process.

5. **Narcotize animals (202-μm sample).** Pour soda water through mesh into sample within funnel, swirl and wait ca. 1 minute. Then drain away soda water through side of net.

6. **Decant sample into plastic container.** Rinse funnel contents into sample container (Sarstedt polypropylene urine specimen containers with screw caps), keeping volume below 100 ml.

7. **Preserve samples.** Add chilled sugar formalin (40 g sucrose per litre of formalin) to give a final concentration of ca. 10% formalin (ca. 2-3% formaldehyde). Cap containers tightly, verify labels, and place in cooler on ice for return to laboratory. Then store at room temperature in ventilated storage area.

8. **Rerinse nets for next sample.** If the next sample is a replicate haul from the same depth, the nets are not rinsed.

9. **Clean nets following sampling.** Back at the field station, thoroughly wash out nets with spray from hose, to reduce chance of cross introductions of species among lakes, and spurious records of contaminants in database. Allow nets to drip dry; then wrap up inside a plastic bag for storage.

C. Analysis Protocol--MICROZOOPLANKTON

1. **Concentrate preserved sample.** Partially immerse a small plastic cup with 20-μm mesh nitex across the bottom into the preserved sample, and withdraw organism-free solution until desired volume of organism-rich concentrate is reached (sometimes as little as 10 ml). Instead of a small cup, we use a cut-off turkey baster (a tube 2-cm in diameter) with 20-μm nitex mesh across the mouth. Carefully rinse organisms adhering to the underside of mesh back into sample. Record volume of concentrate (CV, in ml) using a graduated cylinder.

2. **Prepare first subsample.** Add 1.0 ml of well mixed concentrate to a Sedgewick-Rafter cell (5.0cm x 2.0cm x 0.1cm). Allow organisms to settle for 1-2 minutes before counting.

3. **Count first subsample.** Count one or more transects using a compound microscope at 100x. Organisms extending more than half way into the field are included. Count at least 100 organisms. Record "TV", the transect volume counted (TV is the product of number of transects, length of each transect, depth of cell, and width of field, all in cm). Rinse subsample into holding container.

4. **Prepare and count second subsample.** Then return both subsamples to original container. Add extra sugar formalin to compensate for rinse water diluted into sample. Cap tightly and return to storage.

D. Analysis Protocol--MACROZOOPLANKTON

The counting protocol is similar to that used for microzooplankton except for the following points:

1. **The counting cell is a Bogorov chamber**, with a total volume of 10.0 ml. It is counted under a dissecting microscope.

2. **Samples are concentrated as for microzooplankton.** The volume of concentrate (CV) is recorded. When organisms are relatively abundant the concentration is stopped with more than 20 ml remaining, so that two separate subsamples can be prepared and counted. When organisms are sparse, only a single 10-ml sample is prepared. The "transect volume" (TV) entered on the datasheet is the volume of sample added to the Bogorov chamber, which is always completely counted. If organisms are very abundant to begin with, or after concentration, a suitable volume "TV" (e.g. 2 or 5 ml) is pipeted into the chamber, with the difference (to 10 ml) added as tap water.

E. Attachments--ZOOPLANKTON (see Appendix I and II)

1. **Microzooplankton Count Sheet** (example)

2. **Macrozooplankton Count Sheet** (example)

3. **Sketch of Closing Nets (Figure A.I.2)**

4. **Appendix II: List of Zooplankton Taxa Counted**

APPENDIX I

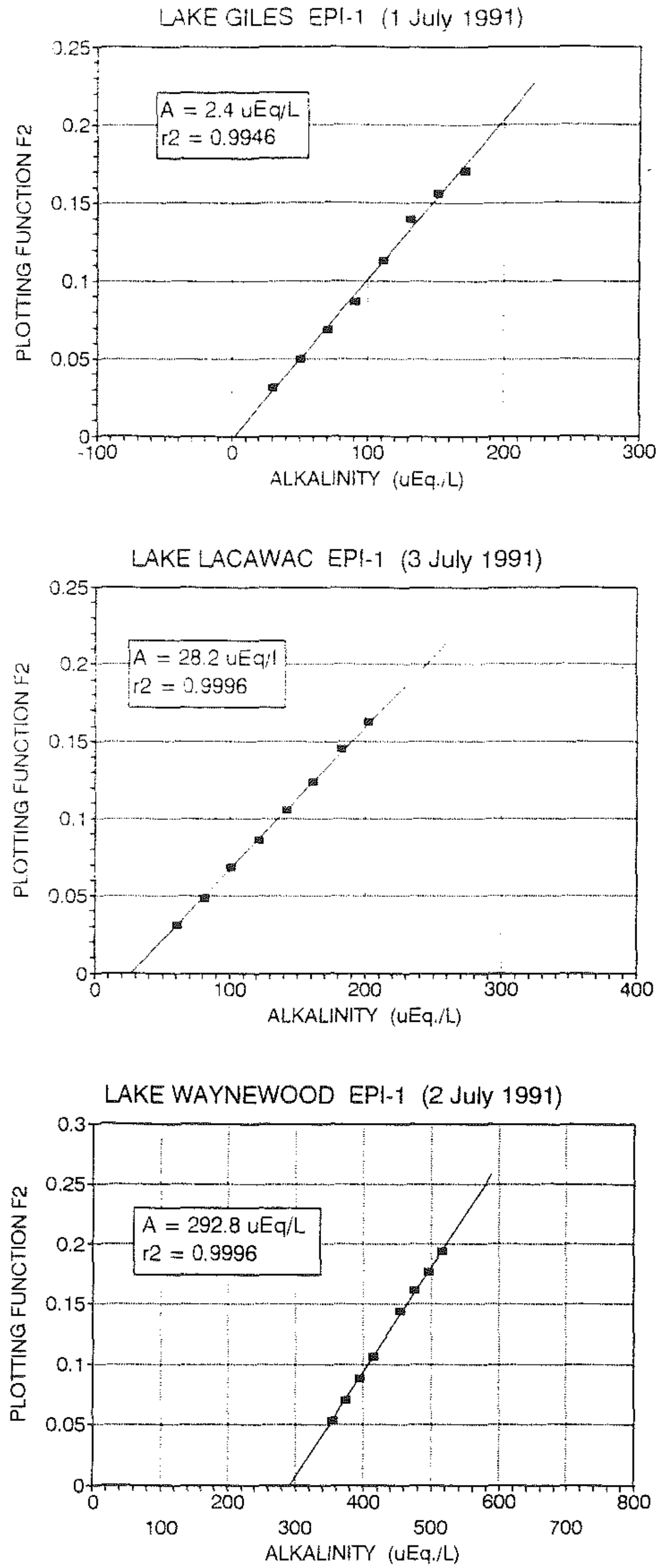


Figure A.I.1. Gran plots of alkalinity.
The x axis intercept gives the sample alkalinity in microequivalents per litre.

PCLP Project: ALKALINITY DATASHEET

composite Data: copied by R.Moeller 10/28/92 – Data for Gran plots.

Lake:	Giles, Lacawac, Waynewood	Date:	VII-1-91 VII-3-91 VII-2-91	Initials:	JAA, TLV
Sample Volume:	pH - 50 ml Alkalinity - 100 ml	Acid Normality:	≃ 0.1 (W); 0.01 (G, L)		

	Giles - EPI		Lacawac EPI		Waynewood - EPI	
Layer:	~~EPI~~ 1	2	~~META~~ 1	2	~~HYPO~~ 1	2
pH in bottle:	—	—	—	—	—	—
pH Unstirred:	5.36	5.47	6.20	6.36	7.14	7.44
pH Stirred:	5.32	5.40	6.35	6.33	7.39	7.50
pH with pHIX:	5.34	5.41	6.33	6.34	7.36	7.47
Titrant N (mEq/ml)	<0.01 N>		<0.01 N>		<0.1 N>	

(pH Stirred and pH with pHIX: Average these values for database)

Titrations:

ml	pH	ml	pH	ml	pH	ml	pH	ml	pH	ml	pH
0.30	4.50	0.30	4.51	0.60	4.50	0.60	4.50	0.35	4.27	0.31	4.45
0.50	4.30	0.50	4.30	0.80	4.31	0.80	4.30	0.37	4.15	0.33	4.29
0.70	4.16	0.70	4.18	1.00	4.16	1.00	4.17	0.39	4.05	0.35	4.15
0.90	4.06	0.90	4.07	1.20	4.06	1.20	4.06	0.41	3.97	0.37	4.05
1.10	3.	1.10	3.99	1.40	3.97	1.40	3.97	0.45	3.84	0.41	3.90
1.30	3.85	1.30	3.92	1.60	3.90	1.60	3.90	0.47	3.79	0.43	3.84
1.50	3.80	1.50	3.86	1.80	3.83	1.80	3.84	0.49	3.75	0.45	3.79
1.70	3.76	1.70	3.80	2.00	3.78	2.00	3.78	0.51	3.71	0.47	3.74
		1.90	3.76								
Alkalinity (μEq/L)	2.4		-5.2		28.2		27.6		292.8		275.7

NOTES: For Gran plots, 5-8 data points are needed in the range of pH 4.5 to 3.7.

Record cumulative volume of titrant added to each pH.

Check here if a pH/ALKALINITY CALIBRATION SHEET has been completed for this sampling. ☒

PCLP Project: pH/ALKALINITY CALIBRATION SHEET

Date: VII-1-91 Initials: JAA, TLV

Recopied by REM 10/28/92

I. pH CALIBRATION AND VERIFICATION (mix gently)

1. Standardize meter at 2 pH's (e.g. 7,4)
2. Reread buffers and record values; if necessary adjust and rerecord values:

pH 7 = 6.98 pH 4 = 4.00 pH ____ = ____

3. Record pH in fresh distilled water (ca. 50 ml) after thoroughly rinsing the electrode: 5.61

(Read after equilibration; should be ca. 5.4-5.6)

Add 0.5 ml pHIX/50ml sample and reread: 5.50

4. Reread distilled water and buffers after samples:

DW = 5.65 pH 4 = 4.02 pH 7 = 7.00

II. ALKALINITY CALIBRATION

This date 0.1 N = 0.1011

1. Dilute 0.1 N HCL stock to give a 0.01 N solution.

0.1 N aliquot volume (5) 5 ml ; final volume (50) 50 ml .

2. Make up 0.01 N Na_2CO_3 (106 mg into 200 ml)

Vial # 11 ; final volume (200) 200 ml .

3. Titrate replicate diluted standards (add to ca. 100 ml DW).

0.01 N Na_2CO_3 aliquot volume (3) 3.00 ml .

A ml	pH
0.35	4.32
0.37	4.19
0.39	4.08
0.41	4.00
0.45	3.87
0.47	3.82
0.49	3.77
0.51	3.73

B ml	pH
0.35	4.33
0.37	4.20
0.39	4.09
0.43	3.94
0.45	3.88
0.49	3.78
0.51	3.75
0.53	3.70

C ml	pH
0.35	4.33
0.37	4.28
0.39	4.19
0.43	4.01
0.45	3.94
0.49	3.82
0.51	3.78
0.53	3.74

Calculated Normality: 0.1018 N 0.1021 N 0.0993 N

FLUOROMETRIC CHLOROPHYLL DETERMINATION

Analysis Date: 1/22/91	Calibration:	Sample Date:
Analyst: VSJ	3427 (R=2.00)	3 September 1990

#	Lake	Date	EMH	Time	Dep (m)	Filt Vol.	Filt 1--½	Ext Vol	Dil	F1	F2 acid
1	GIL	9/3/90	EW			0.52	1	11.5	1/6	43.1	22.2
2	↓	↓	E<20			↓	↓	↓	3/8	27.2	15.6
3			E>20						– lost	——	——
4			MW						1/6*1/6	30.6	14.8
5			M<20						1/6	50.6	26.7
6			M>20						1/6*1/6	22.6	10.7
7			HW						1/6*3/8	37.2	19.8
8			H<20						1/6	30.2	17.2
9			H>20						1/6	35.9	18.9
10	LAC	9/3/90	EW			0.52	1	11.5	1/6	70.7	38.0
11	↓	↓	E<20			↓	↓	↓	1/6	37.0	19.9
12			E>20						3/8	34.1	18.5
13			MW						1/6*3/8	49.5	30.1
14			M<20						1/6	77.6	52.9
15			M>20						1/6	52.9	27.1
16			HW						1/6*1/6	45.0	57.4
17			H<20						1/6*1/6	40.0	52.3
18			H>20						1/1	37.6	27.3

Solvent: 90% Acetone/Methanol (5:1)
"Filt vol." is volume filtered in liters.
"Ext vol" is extract volume in ml.
"Dil" is 1/df where df is dilution factor

FLUOROMETER CALIBRATION DATA SHEET

DATE: 28 May 1990	INITIALS: REM
Chlorophyll Source Type: X H (plant leaf) ____ C (purified)	

(Read 2/3 dilution of Extract) Spectrophotometer Readings (at least 3 subsamples)

		Spectrophotometer Absorbances of Samples (without & with .4N HCl)									
λ nm	BLANK	S1	S1 a	S2	S2 a	S3	S3 a	S4	S4 a	Avg. w/o	Avg. w/ a
750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	NA	NA	0.000	0.000
665	-0.005	0.742	0.442	0.740	0.427	0.745	0.447	NA	NA	0.742	0.444
663	-0.005	0.773	—	0.771	—	0.775	—	NA	—	0.773	—
645	-0.006	0.284	—	0.285	—	NA	—	NA	—	0.285	—
630	-0.010	0.139	—	0.142	—	NA	—	NA	—	0.141	—

After reading the absorbances of 3-4 aliquots, run an additional aliquot through the spectrum range to pinpoint the chlorophyll peak:

λ (nm)	Absorbance	λ (nm)	Absorbance
750	0.000	665	0.745
690	0.015	664	0.765
685		663	0.775 ← MAX
680	0.106	662	0.774
675		661	
670	0.517	660	0.740
668	0.624	655	0.555
666	0.712	~~650~~ 652	0.445

Fluorometer sample readings (at least 3 samples)

Sample Dilution: 0.5ml/200ml = 1/400
(make sure the sample fluoresces above 35-40, adjust dilution accordingly)

	F1	F2 (acid)
S1	87.2	50.0
S2	87.8	50.2
S3	NA	NA
Average	87.5	50.1

Reduce to 2/3 for comparability : 58.4 33.4

FROM FLUORCAL: in 2/3 dilution, by Strickland & Parsons trichromatic equation: chlorophyll-a 0.826 μg/cm³; chlorophyll-b 0.211 "; (chlorophyll-c 0.010 ")

CALCULATED CALIBRATION FACTOR (from fluorcal.wq1): 2827

(Extraction and Dilution is with 90% basic Acetone)

MICROZOOPLANKTON COUNTS

LAKE: Lacawac
DEPTH (z): 5-0 m
STATION: A
LAKE VOL. SAMPLED: 88.56 L
$LV=\pi r^2 z/10$
COUNTING METHOD: Sedgwick-Rafter Cell

DATE: IX-07-91
LAYER: Epi
TIME: Day
INVESTIGATOR: EMN

NET MESH: 48µm
CONC. SAMPLE VOL.: 20 ml
TRANSECT VOLUME: 0.104 ml
DILUTION FACTOR: $\frac{CV(ml)}{LV(l) * TV(ml)}$
DATE COUNTED: 12/3/91

	JAR 1						JAR 2					
SUBSAMPLE	1			2			1			2		
TRANSECTS	1	2	3	1	2	3	1	2	3	1	2	3
Ascomorpha ovalis/species	4/5			2/3			5/5			4/7		
Asplanchna	0			0			0			0		
Collotheca mutabilis/species	0/0			0/0			2/0			1/0		
Conochilus solitary/colon.	0/0			0/2			1/2			0/1		
Gastropus stylifer/hyptopus	1/0			1/0			1/0			0/0		
Kellicottia bostoniensis/ longispina	0/0			0/0			0/0			0/0		
Keratella cochlearis/crassa	5/0			6/0			12/0			10/0		
Keratella gracilis/hiemalis	0/0			0/0			0/0			/0		
Keratella taurocephalus	2			5			2			2		
Lecane flexilis/mira	0/0			0/0			0/0			0/0		
Lecane luna/signifera	0/0			0/0			0/0			0/0		
Lophocharis species	0			0			0			0		
Monommata species	0			0			0			0		
Monostyla lunaris/ closterocerca	0/0			0/0			0/0			0/0		
Monostyla copeis	0			0			0			0		
Notholca squamula	0			0			0			0		
Ploesoma truncatum	0			0			0			0		
Polyarthra large/small	47/32			47/35			61/32			71/36		
Synchaeta	0			0			0			0		
Testudinella parva/reflexa	0/0			0/0			1/0			0/0		
Trichocerca cylindrica/mult.	3/1			2/0			2/0			0/1		
Trichocerca similis/ rousseleti	0/0			3/0			4/0			6/0		

Trichocerca porcellus	0			0			0			0		
Rotifer eggs	29			16			28			23		
Rhabdostyla	0			0			0			0		
Unknown Ciliates	76			119			130			153		
Tropocyclops prasinus ♀/eggs	0/0	/	/	0/0	/	/	0/0	/	/	0/0	/	/
Tropocyclops prasinus ♂	0			0			0			0		
Tropocyclops prasinus copep.	0			0			0			0		
Nauplii	13			11			20			27		

LAKE: Lacawac DATE: IX-07-91 LAYER: Epi TIME: DAY

MACROZOOPLANKTON COUNTS

LAKE: Lacawac
DEPTH (z): 5-0
STATION: A
LAKE VOL. SAMPLED: 202 // 48 353.43 // 88.36
LV=πr²z/10
COUNTING METHOD: Bogorov Chamber

DATE: IX-07-91
LAYER: Epi
TIME: DAY
INVESTIGATOR: TLV

202μm / 48μm
CONC. SAMPLE VOL.: 50 / 50
TRANSECT VOLUME: 5 / 5
DILUTION FACTOR: CV(ml) / LV(l) * TV(ml)
DATE COUNTED: II-25-92

		JAR 1			JAR 2		
		SUBSAMPLES			SUBSAMPLES		
ORGANISMS	NET MESH	1	2	3	1	2	3
Daphnia	202	99	100		106	116	
Daphnia (W)/eggs	202	21 / 34	21 / 35		22 / 34	10 / 19	
Diaphanosoma	202	0	0		0	0	
Diaphanosoma (W)/eggs	202	0 / 0	0 / 0		0 / 0	0 / 0	
Holopedium gibberum	202	16	15		21	15	
Holopeduim gibberum (W)/eggs	202	13 / 51	18 / 48		27 / 77	20 / 76	
Leptodora kindtii	202	0	1		0	0	
Leptodora kindtii (W)/eggs	202	0 / 0	0 / 0		0 / 0	0 / 0	
Chydorus	48	0	0		0	0	
Chydorus (W)/eggs	48	0 / 0	0 / 0		0 / 0	0 / 0	
Bosmina	48	0	0		0	0	
Bosmina (W)/eggs	48	0 / 0	0 / 0		0 / 0	0 / 0	
Diaptomus minutus ♀/eggs	48	2 / 0	5 / 22		46 / 145	10 / 32	
Diaptomus minutus ♂	48	8	2		32	18	
Diaptomus minutus copepodids	48	19	18		75	32	
Mesocyclops edax ♀/eggs	202	1 / 0	2 / 0		2 / 0	2 / 0	
Mesocyclops edax ♂	48	0	0		0	1	
Mesocyclops edax copepodids	48	0	0		1	0	
Cyclops scutifer ♀/eggs	202	0 / 0	0 / 0		0 / 0	0 / 0	
Cyclops scutifer ♂	48	0	0		0	0	
Cyclops scutifer copepodids	48	0	0		1	0	
Ortho. modestus ♀/eggs	202	0 / 0	0 / 0		4 / 0	6 / 0	
Orthocyclops modestus ♂	48	1	1		3	1	
Ortho. modestus copepodids	48	4	2		13	4	
Chaoborus	48	0	0		0	0	
Asplanchna	48	0	0		0	0	

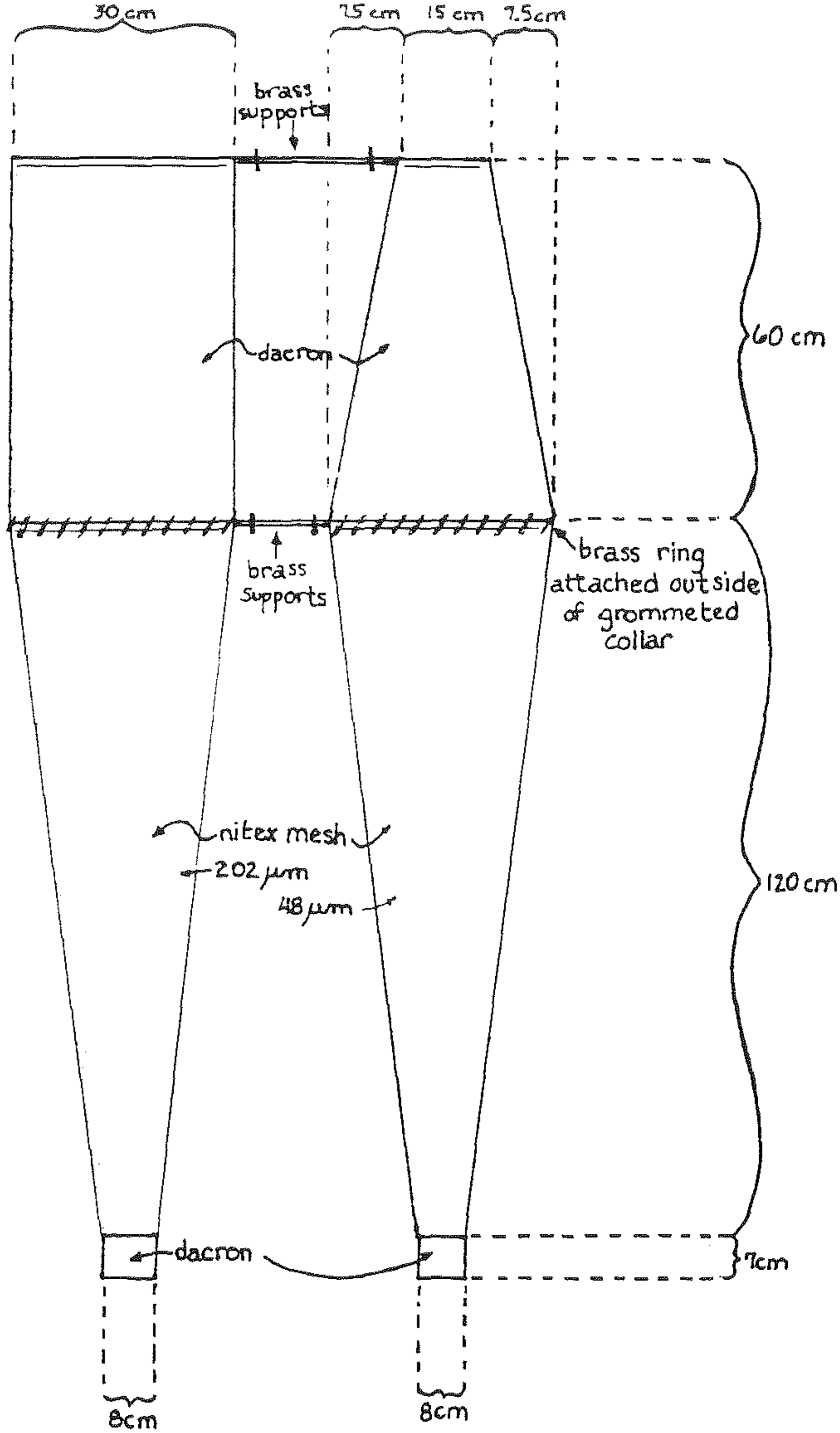


Figure A.I.2. Sketch of the closing nets used in 1989-1993.

The lower cones are of Nitex mesh, whereas the upper collars are solid dacron. Funnels with tubing for drains are sewn onto the small ends of the nets.

APPENDIX II: ZOOPLANKTON TAXA COUNTED

This listing of taxa was prepared by John Aufderheide in April 1991, and was edited slightly by Robert Moeller in April 1993. It documents several changes in the identification and counting of zooplankton that were introduced as the counters became more familiar with the material. Some simple changes have been transferred to the electronic database--at least to the annual summary datafiles--but others would require re-examination or recounting of earlier samples.

In 1991 we introduced additional changes in the counting strategy. Several macrozooplankton that had been counted from the 202-μm mesh samples were subsequently counted in the 48-μm samples. These changes were made to improve collection of smaller individuals, possibly at some lower collection efficiency for the larger individuals. In the following species list, therefore, several species are listed in the Macrozooplankton--202μm net category that more recently have been enumerated from the 48-μm net samples (see **ZOOPLANKTON** section).

Names and initials of investigators who identified species: John Aufderheide (JAA), Craig Williamson (CEW), Eugina Novak (EMN), Gabriella Grad (GG), Paul Stutzman (PLS), Natasha Vinogradova (NV).

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME / COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Anuraeopsis sp.	Stemberger 1979	JAA	W	W9/3/90 ...	RO:ANU
This species was recognized on 9/3/90. Earlier it may have been included with Pompholyx. However, I believe that this is unlikely since Pompholyx has not reached the same densities as Anuraeopsis. Due to its small size it may have been unnoticed in the mats of Aphanizomenon that persisted in the 1989 fall samples.					
Ascomorpha ovalis	Stemberger 1979	JAA	G,L,W	W8/28/89...	RO:ASC:OV
This species is distinguishable from other species in the genus due to the presence of a thickened lorica consisting of a dorsal and ventral plate.					
Ascomorpha sp.	Stemberger 1979	CEW	G,L,W	GLW6/7/88...	RO:ASC
The primary taxonomic feature that distinguishes this genus from others is the presence of dark circular bodies (typically four) visible within the visceral mass. The general body shape differentiates the Ascomorpha sp. from Gastropus sp.(see Gastropus sp.)					
Asplanchna sp.	Stemberger 1979	CEW	L,W	LW6/7/88...	RO:ASP
Asplanchna spp. are large soft bodied rotifers (sandwich bags) which are typically 500 to 1500 um. in length. They are distinguished from Synchaeta by the absence of a prominent eyespot. (see Synchaeta)					
Bosmina sp.	Edmondson 1959	CEW	L,W	LW7/19/88...	CL:BOS
The body of this small cladoceran is often oval or rounded. The carapace valves cover the body. The antennules of this species are large (compared to body size) and fixed to the carapace. They are nearly parallel to each other and curve towards the body. The body is typically smaller than 500 um. Due to their small size, they are counted in the 48 um. samples. An attempt was made to distinguish between adults and juveniles by counting the ones with eggs as Bosmina (E). This differentiation of these and other small cladocera (Chydorus) was first started 8/28/89. CEW identified B. longirostris from 1988 samples (CL:BOS:LO).					
Bosmina (E) /eggs	Edmondson 1959	JAA	L,W		CL:BOS
This classification is an attempt to estimate the number of adults. We felt that in order to calculate an egg ratio value we would need to eliminate the juveniles from this calculation. Since we are only counting adults with eggs we would expect our egg ratio to be an overestimate. A similar category has been used for other small cladocerans (see Chydorus).					

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Chydorus sp. This is another small cladoceran that is counted in the 48 um samples. The fornices of the carapace come together to form a beak-like rostrum which partially covers the anntenules. This genus is similar to Bosmina in shape, but tends to be more ovoid. It is uncommon for us to find representatives of this genus in our open-water samples.	Edmondson 1959	AY,JAA	G,L,W	G7/17/89... LW6/7/88...	CL:CHY
Collotheca mutabilis This is the only species fully described for the genus Collotheca. The key taxonomic feature is the presence of long setae that emerge from the anterior (oral) end. This species was initially mislabelled as C.mirabilis.	Stemberger 1979	JAA	L,W	L5/18/90... W7/18/90...	RO:COL:MU
Collotheca sp. This species was first described as Unknown Rotifer #1 in Lake Waynewood. It is a rotifer that secretes a gelatinous matrix. This matrix is pronounced in Waynewood due to its accumulation of detritus. The only species that is fully described is C. mutabilis. It is necessary to do the taxonomic characterization while the organisms are alive. The corona contracts after death and distorts the key features.	Stemberger 1979	JAA	G,L,W	G10/9/89... L6/6/89... W7/26/88...	RO:COL
Colurella sp. This is a small (50-70 um) loricated genus of rotifer. The lorica of this species is split at the ventromedian line, unlike most loricated species in which the lorica plates are dorsal or ventral. There are three foot segments and two toes, unlike Lepadella species which display four foot segments. The shape of the lorica is very similar to Lepadella triptera except for the medial split. Due to these similarities this species may have been misidentified as a Lepadella since the lateral view is encountered most frequently. Identification to species is difficult.	Stemberger 1979	EMN,JAA	W	W10/11/91...	RO:CLR
Conochilus sp. (colonial) This is a genus of typically colonial forms. The colonies of Conochilus are surrounded with a gelatinous matrix. They are typically smaller than 120 um in length (contracted). This group is most likely a mix of Conochilus unicornis and C. hippocrepis.	Stemberger 1979	JAA	G,L,W	GLW6/7/88...	RO:CON:CO
Conochilus sp. (solitary) These are large (>150 um. contracted) solitary species that secrete a gelatinous matrix. I have placed them in the genus Conochilus based on discussions with CEW. Stemberger puts them in the genus Conochiloides. However, we are following the taxonomy of Ruttner-Kolisko.	Ruttner-Kolisko 1974	JAA	G,L,W	G6/7/88 LW/8/28/89...	RO:CON:SO

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Cyclopoid copepodids The cyclopoid copepodids were counted with the 48 um mesh since it is believed that they may pass through the 202 um mesh. The data show evidence that the 48 um mesh is is more efficient at capturing these organisms.	Edmondson 1959	CEW	G,L,W	GLW7/3/89...	CY:CYC
Diaptomus minutus Due to the small size of these calanoids they are now counted with the 48 um sample. Comparisons of 48 um and 202 um mesh net collections from 1989 suggested that many copepodids and some adults passed through the 202 um mesh.	Edmondson 1959	CEW	G,L	GL7/3/89...	CA:DIA:MI
Diaptomus sp. copepodids These are copepodids of Diaptomus oregonesis. They are counted in the 48 um. mesh since there is the possibility of them passing through the 202 um mesh	Edmondson 1959	CEW	W	W7/3/89...	CA:DIA
Euclanis parva This species is distinguished from others in the genus by the presence of a rectangular notch in the anterodorsal margin. This species is not as large as E. pellucida which is also in Giles. The lorica of this rotifer is not keeled and is ovoid in shape (150 um).	Stemberger 1979	JAA	G	G10/19/90...	RO:EUC:PA
Euclanis pellucida The dorsal plates of this species are distinctly keeled. The toes are long (>100 um) and slender. The lorica is almost spherical in shape with a slight enlargement of the posterior end and pointed anteriorly. This is a large bodied rotifer (>290 um) and is the largest found in the PCLP lakes. In 1990 a species of Euclanis was seen in a littoral tow in Lacawac, but none have been seen in the PCLP sample. It may have been E. pellucida based on its large size.	Stemberger 1979	JAA	G	G7/19/90...	RO:EUC:PE
Filinia longiseta The lateral: caudal bristle length ratio was used to identify this species. It was > 1.8. This species is the dominant found in Waynewood and is most likely to have made up the majority of the organisms classified as Filinia sp.	Stemberger 1979	JAA	W	W7/18/90...	RO:FIL:LO
Filinia sp. This genus was described only in Waynewood. The two lateral bristles and the single caudal bristle were the key taxonomic features used for identification.	Stemberger 1979	JAA	W	W7/26/88...7/18/90	RO:FIL

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Filinia terminalis Only one specimen of this species was found. It was distiguished from F. longiseta by the ratio of the lateral bristles: caudal bristles of <1.6. The LBL:CBL was 1.19.	Stemberger 1979	JAA	W	W3/25/90...	RO:FIL:TE
Gastropus hyptopus I have had a problem identifying this species. It has the overall body shape of a Gastropus but has a prominent eye spot like a Synchaeta (see Synchaeta). The body is not as compressed as with G. stylifer. I went with G. hyptopus from Stemberger's key. This species was originally called Unk. rotifer (Synchaeta) and may have been placed with Synchaeta.	Stemberger 1979	JAA	G,L,W	G9/24/89 LW11/12/89...	RO:GAS:HY
Gastropus sp. This is a genus of soft-bodied rotifers. They can be laterally compressed (G.stylifer). However, G.hyptopus is not very compressed and is similar to a Synchaeta.	Stemberger 1979	CEW	G,L,W	GLW6/7/88...6/19/89	RO:GAS
Gastropus stylifer This species is laterally compressed. In its contracted state it appears to be lemon shaped. This species tends to be colored, usually a shade of pink.	Stemberger 1979	JAA	G,L,W	GLW6/19/89...	RO:GAS:ST
Hexarthra mira So far recorded only on 5/13/92.	Stemberger 1979	EMN,NV	L	L5/13/92...	RO:HEX:MI
Kellicottia bostoniensis This species is distinguished from K.longispina based on the presence of only four anterior spines of unequal length. One spine is typically longer than the other three.	Stemberger 1979	CEW	L,W	L7/12/88... W6/7/88...	RO:KEL:BO
Kellicottia longispina This species displays six anterior spines of unequal length. Typically three are longer than the other three. This species is typically found in the cold hypolimnetic waters.	Stemberger 1979	CEW	G,L,W	GW6/7/88... L6/28/88...	RO:KEL:LO
Kellicottia sp. This is a smooth loricated rotifer with a single posterior spine exceeding body length and four or six anterior spines of unequal lengths (see K.bostoniensis and K.longispina).	Stemberger 1979	CEW	G,L	GL6/7/88...6/28/88	RO:KEL

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Keratella cochlearis This species typifies the Keratella genus. It has six anterior spines and a single posterior spine. There are 1 or 2 pairs of polygonal facets on the mediodorsal surface. The anteromedian ridges (beneath the anteromedial spines) come to a point posteriorly. The lorica is typically translucent and not heavily pustulated. Earlier counted as Keratella sp.	Stemberger 1979	JAA	L,W	LW6/20/89...	RO:KER:CO
Keratella crassa This is a large (150-200 um. body length) robust species. The lorica is thick and opaque. There are two pairs of distinct polygonal facets. This species only has a single posterior spine. It was originally counted as Keratella sp. and not differentiated from K.cochlearis.	Stemberger 1979	JAA	L,W	LW6/20/89...	RO:KER:CR
Keratella earlinae This species is very similar to K.cochlearis in both size and shape. The medial line of the dorsal surface is developed posterior to two irregular medial facets. The ridges of the anteromedian surface are straight-lined, giving the appearance of an open rectangle. The lorica of this species is heavily pustulated and appears much darker than K.cochlearis. This species has been separated from K.cochlearis since 6/18/89	Stemberger 1979	JAA	W	W6/19/89...	RO:KER:EA
Keratella gracilenta This species is similar to K.cochlearis in its general body shape. However, there is a pair of hexagonal facets on the mediodorsal surface. The lorica of this species is heavily pustulated. I went with Ahlstrom's classification. This species is also known as Keratella americana (classified by Carlin 1943). Included in K. cochlearis until August 13, 1990. It was present but not very abundant in 1989, and presumably was counted with K.cochlearis.	Ahlstrom 1943	JAA	L	L8/13/90...	RO:KER:GR
Keratella hiemalis This organism has been called K.hiemalis due to the presence of two posterior spines. These spines are less than a third of the body length and are straight. However, there have not been many specimens that are merely empty loricas from which we can make out the distinct facet patterns. I am fairly certain that this organism is K.hiemalis for a number of other reasons. I have never seen a single posterior spined form which would indicate K.testudo. Also the spines are always <1/2 the body length, arguing against K. quadrata. Until I can confirm the facet patterns I am not 100% certain.	Stemberger 1979	CEW	G,L,W	LW6/7/88... G1/27/90...	RO:KER:HI

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Keratella serrulata f.curvicornis This is a large-bodied species. It has long anteriomedial spines (60-70 um). There are two hexagonal facets on the mediodorsal surface. This form does not display posterior spines. The lorica is opaque and thickened (see K.crassa).	Ahlstrom 1943	JAA	L,W	L4/30/90... W1/26/90...	RO:KER:SE
Keratella sp. This is a genus of rotifers with thickened and sculpted loricas. Each species has six anterior spines and 0, 1, or 2 posterior spines (see K. species).	Stemberger 1979	CEW	G,L,W	GLW6/7/88...6/20/89	RO:KER
Keratella taurocephala This species is very similar to K.cochlearis, although slightly larger. The key difference is that the antero-lateral spines are enlongated and bowed. Thus they resemble bull horns.	Stemberger 1979	CEW	G,L,W	GLW6/7/88...	RO:KER:TA
Lecane crepida So far this species has only been recorded on 9/21/91.	Stemberger 1979	EMN,JAA	W	W9/21/91...	RO:LEC:CR
Lecane flexilis This is a small Lecane species. The anterior margin of the dorsal plate is slightly convex. There are a pair of small cusps (not developed spines) on the anterolateral margin. The dorsal plate angles inward from these cusps (see Stemberger). The toes are shorter than 30um and each has a single claw (4-7um).	Stemberger 1979	JAA	L	L9/23/89...	RO:LEC:FL
Lecane ligona This species displays a prominent flaring of the posterior margin of the ventral plate. The ventral plate extends below the foot of the organism. It has short toes (<30 um) and each has a small claw.	Stemberger 1979	JAA	G	G11/13/89...	RO:LEC:LI
Lecane luna This is a large Lecane species (BL >140 um). The anterior margin of the dorsal plate is concave. The toes of this species are elongated (50-60 um) and end in a sharp claw. Both the dorsal and ventral plates are somewhat circular, more so than seen in other species.	Stemberger 1979	JAA	G,W	G8/11/90... W8/28/89...	RO:LEC:LU

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Lecane mira This species is similar in size and shape to L.luna. The anterolateral margin ends with a pronounced cusp. The key taxonomic feature is that the foot segment extends below the posterior margin of the ventral plate.	Stemberger 1979	JAA	G	G7/19/90...	RO:LEC:MI
Lecane signifera This is a large Lecane species (VPL > 130 um). The anterior margin of the dorsal plate is straight (compared to L.mira) with a pair of pronounced cusps. The lorica is elliptical in shape. It also is pustulated along a pattern of ridges. The toes are elongated (> 55 um) and without claws.	Stemberger 1979	JAA	L	L8/13/89...	RO:LEC:SI
Lecane sp. Species of this genus have well developed loricas and display a pair of elongated toes. They are considered to be closely related to the Monostyla spp. The members of this genus have not been abundant in our routine samples, but there have been a number of species recorded from the three lakes. This genus has been found in Waynewood, but infrequently and is never as common as in the other two lakes.	Stemberger 1979	JAA	G,L,W	G10/9/89... L7/6/88... W8/28/89...	RO:LEC
Lecane tenuiseta This is a small species (BL>100 um) similar to L.flexilis. The anterolateral margin does not have cusps. The lorica of this species appears to be well developed. The two toes are closely appressed to one another. It may be confused with a Monostyla species.	Stemberger 1979	JAA	G,L	G8/11/90... L11/19/90...	RO:LEC:TE
Lepadella sp. This species was only seen in Lake Lacawac. It did not fall within the counted transect and thus did not show up on the datasheets.	Stemberger 1979	JAA	L		RO:LEP
Lepadella patella The lorica is ovoid and the dorsal plate is strongly convex; the anteroventral notch is deep and V-shaped. The anterodorsal notch is shallow. The foot groove is parallel-sided and the edges extend beyond the edge of the ventral plate. The last foot segment is longer than the rest.	Chengalath 1976	JAA	W	W4/14/91...	RO:LEP:PA

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME	COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Lepadella triptera	The lorica of this small Lepadella species (70 um) is almost spherical in shape. The ventral sinus is shallow and U-shaped. The dorsal plate is keeled, thus the cross-sectional view is triradiate.	Chengalath 1976	JAA	W	W4/14/91...	RO:LEP:TR
Lophocharis sp.	Only one specimen of this species has been recorded. There is a possibility of a mistaken identity with a Lepadella or Ploesoma. Since no drawings were done it is difficult to be confident this species is truly present within Lake Lacawac. I would like to go and try to isolate this species from the L8/14/89 sample to confirm this identification.	Stemberger 1979	JAA	L	L8/14/89...	RO:LOP
Monommata sp.	This is a soft bodied species that is believed to exist primarily in the littoral zone. The key taxonomic feature is their pair of elongated (> 170 um) and uneven toes. The presence of this species in our samples, particularly in Giles 9/24/89, may be due to strong horizontal mixing of littoral waters into the pelagic zone..	Edmondson 1959	JAA	G,L	G9/24/89... L6/6/89...	RO:MNO
Monostyla closterocerca	This is a small bodied Monostyla species (VPL > 80 um). The anterior margin is slightly concave and narrower than 3/4 of the ventral plate width. The foot segment does not extend below the posterior of the body. The toe (35 um) does not have a claw.	Stemberger 1979	JAA	L	L8/2/90...	RO:MON:CL
Monostyla copeis	This is another small bodied Monostyla (VPL > 100 um). The anterior margin is straight and wider than 3/4 of the ventral plate width. The foot segment does not extend below the posterior of the body. The toe (40 um) is larger in the middle and has a claw.	Stemberger 1979	JAA	G,L	G10/9/89... L12/13/90...	RO:MON:CO
Monostyla lunaris	This is a large bodied Monostyla (VPL > 110 um). The body width is about 2/3 the body length. The anterior margin is concave (see Lecane luna), but without pronounced cusps. The toe has a claw (TL 60 um). This species has not been certainly recorded from Lake Giles, this species along with M.copeis likely account for the Monostyla sp. in Giles.	Stemberger 1979	JAA	G?,L	G?8/15/89... L10/19/90...	RO:MON:LU

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Monostyla sp.	Stemberger 1979	JAA	G,L,W	GL6/13/88... W6/7/88...	RO:MON
This genus has been combined with Lecane by many authors. However, I am following Stemberger's classification which separates these genera. Monostyla species are loricated and similar to Lecane (see Lecane sp.) in size and general body shape. Monostyla species all display a single toe, unlike Lecane species.					
Notholca acuminata	Stemberger 1979	JAA	W	W3/25/90...	RO:NOT:AC
This species is much longer than wide (BL >200 um, BW <100 um). Its lorica is heavily ridged. There is a short (<50 um) truncated posterior extension of the lorica.					
Notholca sp.	Stemberger 1979	JAA	L,W	L12/27/89...3/25/90 W1/27/90...3/25/90	RO:NOT
This genus is composed of loricated species. There are six or more anterior spines. Their loricas are thin and are not faceted (see Keratella sp.). The loricas in some species are ridged and pustulate. A few species display a posterior extension of the lorica (see N.acuminata). Stemberger suggests that this genus is composed of spring species. Our data agree.					
Notholca squamula	Stemberger 1979	JAA	L	L3/25/90...	RO:NOT:SQ
The lorica of this species is rounded and has varying degrees of ridging patterns. The BL is <140 um and BW is <100 um. The anterolateral and anteromedian spines are of similar length and the anterointermediate spines are much shorter. There is no posterior extension of the lorica.					
Ploesoma sp.	Stemberger 1979	JAA	G,L,W	G11/13/89... L6/28/88... W8/2/88...	RO:PLO
This is a heavy loricated species. The body is > 100 um in length (BL) and > 70 um in width (BW). The foot segments extend from the center of the ventral surface and are >50 um in length. There are two toes present.					
Ploesoma truncatum	Stemberger 1979	JAA	L,W	L6/7/90... W8/28/89...	RO:PLO:TR
This species displays a thickened opaque lorica. The lorica displays a well defined pattern. The anterior margin of the lorica is straight and without a spinelike projection. The BL is >110 um and the BW > 70 um.					

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Polyarthra dolichoptera	Stemberger 1979	JAA	W	W6/6/90	RO:POL:DO
This Polyarthra species has a large squarish body (BL>120 um, BW >90 um). The swimming fins extend well beyond the posterior of the body (FL >140 um). This species also has a small pair of ventral fins, which distinguishes it from other large Polyarthra species (see P.euryptera). The vitellarium gland contains only eight nucleii. This species was only recorded on W6/6/90. They are probably included within the P. large category.					
Polyarthra euryptera	Stemberger 1979	JAA	W	W8/1/89...	RO:POL:EU
This species is very large (BL >180 um) and is easily distinguished from other Polyarthra species. This species does not display a pair of ventral fins and so is distinguished from P. dolichoptera. The swim fins do not extend beyond the posterior of the body (if so not by much). These fins are long (FL >100 um) and ovoid in shape (FW >50 um). The vitellarium contains twelve nucleii.					
Polyarthra lg. (large)	Stemberger 1979	JAA	G,L,W	GL6/19/89... W6/6/88...	RO:POL:LG
This is an ad hoc grouping of what could be several species that are larger than 120 um. I want to distinguish this group of large adults (w/eggs) from a group of small adults. This group likely includes several species, such as P.vulgaris or P. dolichoptera.					
Polyarthra remata	Stemberger 1979	JAA	W	W6/6/90	RO:POL:RE
This species was only identified on a single date. I am hesitant to change the Polyarthra (sm.) to P.remata, although P.remata may make up the organisms in P. small. This is a small species (adults with eggs are <120 um). There are four nuclei within their vitellarium. They possess thin swim fins (<25 um wide) that extend slightly beyond the body.					
Polyarthra sm. (small)	Stemberger 1979	JAA	L,W	L6/19/89... W6/7/88...	RO:POL:SM
This species is designated as small (sm.) due to its size (<120 um w/ eggs). I have not taken this group of rotifers out to its constituent species due to the difficulty of identifying them within the counting chamber. It is my feeling that there may be different species of the same size in this category within the lakes at different times of the year.					

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE	COMMENTS (J.A. Aufderheide)
Polyarthra sp.	Stemberger 1979	CEW	G,L	G6/7/88...6/5/90 L6/7/88...6/19/90	RO:POL	This genus is composed of rotifers that are cylindrical or rectangular in shape. They all display cuticular swimming fins, which are attached in four groups to dorsolateral and ventrolateral sections near the anterior end of the organism. The key taxonomic features are the number of nuclei in the vitellarium, the length and width of the swimming fins, and whether the fins extend beyond the body.
Polyarthra vulgaris	Stemberger 1979	JAA	W	W8/28/89 and W6/6/90	RO:POL:VU	This species displays a pair of small ventral fins. The BL is > 120 um and BW > 90 um. The swim fins extend slightly beyond the posterior of the body (FL >80 um). There are eight nucleii present within the vitellarium. The shorter swim fins and the higher body length:width ratio distinguishes this species from P. dolichoptera. I believe that this species may make up the majority of the rotifers classified as Polyarthra lg.
Pompholyx sp.	Stemberger 1979	JAA	W	W6/19/89...	RO:POM	The body of this species is ovate (BL <100 um). The lorica has four lobes when seen in a cross-sectional view. There is no foot present. The eggs are attached to a retractile thread of secreted material (Ruttner-Kolisko, 1974). Therefore the egg is not in contact with the lorica. This species was found in high abundance in a small pond (Cook's Pond) above Lake Waynewood and may be coming downstream during periods of rain.
Rhabdostyla sp.		CEW	L,W	LW6/7/88...	CI:RHA	This is a large (100-200 um) ciliate species that is found in the core lakes. It has not been critically identified. CEW has suggested that this abundant ciliate resembles Rhabdostyla. This ciliate contracts upon death and confounds identification. It is yellow brown in color and the cresent to spiral shaped macronucleus is a prominent feature.
Synchaeta sp.	Stemberger 1979	CEW	G,L,W	GLW6/7/88...	RO:SYN	This is a genus of non-loricated or soft-bodied species. They are similar to Asplanchna with regard to their transparent bodies. They may be between 200-600 um in length (non-contracted or live length). They contract at death, distorting the key taxonomic features. They display a prominent eye-spot and thus could be confused with G.hyptopus (see G.hyptopus). There may be more than a single species that is categorized as Synchaeta sp. The likely species are S.oblonga and S.pectinata. Until I can look at them while still alive and look at their trophi, I am unable to distinguish species.

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Testudinella parva The foot opening of this species is subterminal. The lorica appears smooth. The lateral antennae are located on the posterior third of the body. The BL is > 120 um. The frontal eye spots are quite visible beneath the oral opening.	Stemberger 1979	JAA	L	L10/19/90...	RO:TES:PA
Testudinella reflexa The foot opening of this species is also subterminal. The lateral antennae of this species are located on the anterior third of the lorica. The frontal eye spots are discrete. The lorica is trilobate in a cross-sectional view; thus it appears to be ridged. The BL is >110 um.	Stemberger 1979	JAA	L	L8/2/90...	RO:TES:RE
Testudinella sp. This is a genus of rotifers whose loricas are dorsoventrally flattened. They are similar in size and shape to Ascomorpha ovalis. However, this genus lacks the dark fecal bodies. The loricas are quite thin and thus are transparent. There have been two species identified, T.parva and T.reflexa. There are two frontal eye spots located beneath the oral opening.	Stemberger 1979	JAA	G,L	GL6/7/88...8/2/90	RO:TES
Trichocerca cylindrica This species is cylindrical in shape and elongated (BL >280 um). There is a hooked anterior projection. This species displays a prominent eye spot. There appears to be a single long toe (TL > 250 um).	Stemberger 1979	JAA	L,W	L5/18/90... W10/08/89...	RO:TRI:CY
Trichocerca lophoessa This is also a large bodied species (BL >170 um). It is somewhat smaller then T.cylindrica. This species lacks defined mucrones surrounding its oral cavity. They have two toes of unequal length. The long toe (TL 150 um) is approximately 5X the length of the shorter toe. This species displays a prominent eye spot.	Stemberger 1979	JAA	W	W1/19/91...	RO:TRI:LO
Trichocerca lg. (large) This is an artificial grouping to separate large species of Trichocerca from obvious much smaller species. This classification lasted until I was confident in my identification of the various species. The two most likely species within this group are T.cylindrica and T.multicrinis.	Stemberger 1979	JAA	L,W	L6/6/89...5/18/90 W6/7/88...10/8/89	RO:TRI:LG

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Trichocerca multicrinis This large bodied Trichocerca was easily distiguished from others based on its ovoid shape. This species has a BL >160 um and is approximately half as wide. This species also appears to have a single toe (TL >75 um). The shorter toe is barely noticeable (TL <7 um).	Stemberger 1979	JAA	L,W	L6/6/89... W6/19/89...	RO:TRI:MU
Trichocerca porcellus This species is not as large as T.cylindrica (BL 175 um), but is much thicker. Its body is curved. The shortest toe is approximately 3/4 the length of the longer toe (long TL 50 um). There are well developed mucrones surrounding the oral cavity.	Stemberger 1979	JAA	L	L2/24/91...	RO:TRI:PO
Trichocerca pusilla This species has been identified as T. rousseleti. T. pusilla is a short and stout bodied rotifer (>130 um.). It is only slightly larger than T. rousseleti. However, it is the toe length that differentiates the two species. The toe of T. rousseleti is shorter (30 um) than that of T. pusilla (60-80 um). T. pusilla also lacks the nine mucrones of T. rousseleti.	Stemberger 1979	JAA	L,W	LW1/1/92...	RO:TRI:PU
Trichocerca rousseleti This is a small bodied Trichocerca (BL >110 um). There are nine mucrones on its anterior margin. These mucrones are folds and not spinelike. The longest toe is >30 um.	Stemberger 1979	JAA	L,W	LW6/6/90...	RO:TRI:RO
Trichocerca similis This species is small and cylindical (BL >180 um). The mucrones are long and slender. They are almost spinelike and are similar in length (>30 um). The longest toe is more than 1/3 longer (46 um) than the shorter toe. This species is most likely to have been the dominant Trichocerca classified as T.sm (small).	Stemberger 1979	JAA	G,L,W	G7/3/90... L4/30/90... W12/27/89...	RO:TRI:SI
Trichocerca sm. (small) This classification distinguishes obviously small species from larger ones (see T.lg (large)). The most likely species classified within this group are T.similis and T.rousseleti.	Stemberger 1979	JAA	L,W	L6/6/89...4/30/90 W6/7/88...12/27/89	RO:TRI:SM

I. MICROZOOPLANKTON FROM THE 48 um MESH SAMPLES (Note that in 1991-93 more of the Macrozooplankton were counted in this sample--see ZOOPLANKTON text section.)

SPECIES NAME	COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Trichocerca sp.	This genus has been said to be heterogeneous with many distinctive species. The species in these lakes all have toes of unequal length. The organisms within this group have soft or semi-loricas. Many forms display a helical twist in the lorica. Many of the species have mucrones or folds that are characteristics common to that particular species. Many species display an eye spot.	Stemberger 1979	JAA	G,L	GL6/7/88...GL6/6/89	RO:TRI
Trichotria sp.	This is a cylindrical genus. The key taxonomic feature is the presence of heavy dorsal spines coming from the first joint of the foot. The toes are approximately 1/3 of the body length. One specimen was positively identified in Lake Waynewood. I have sketched another that might be of a contracted specimen. This genus is said to be primarily littoral in habit.	Edmondson 1959	JAA	W	W7/2/90...	RO:TRT
Tropocyclops prasinus	This is a small species of cyclopoid (>1000 um). They have 12 antennial segments. The fifth leg has only one segment. It has a single inner spine and two outer setae. The inner spine of the fourth leg is less than twice as long as the terminal segment. This species was originally counted as small cyclopoid copepods.	Edmondson 1959	JAA	L,W	L11/11/89... W8/1/89...	CY:TRO:PR
Unknown(unidentified) ciliate	I have made little attempt to classify ciliates even to the genus level. It is my belief that there are many ciliate genera present within the lakes.		JAA	G,L,W	GLW 6/7/88...	CI:SPP
Wolga sp.	This species has a faceted dorsal surface. The lateral antennae lie under a spinelike projection. Only one specimen of this species was found.	Edmondson 1959	JAA	W	W1/26/90 only	RO:WOL

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE	COMMENTS (J.A. Aufderheide)
Bosmina sp.	Edmondson 1959	CEW	L,W	LW7/19/88...	CL:BOS	The body of this small cladoceran is often oval or rounded. the carapace valves cover the body. The antennules of this species are large (compared to body size) and fixed to the carapace. They are nearly parallel to each other and curve towards the body. The body is typically smaller than 500 um. Due to their small size, they should be counted in the 48 um. samples. An attempt was made to distinguish between adults and juveniles by counting the ones with eggs as Bosmina (E). This differentiation of these and other cladocera (Chydorus) was first started 9/10/89. CEW identified B. longirostris from 1988 samples (CL:BOS:LO)
Ceriodaphnia sp.	Pennak 1978	GG	W	W8/28/89...	CL:CER	These are small animals (<1mm). They have oval or round valves ending with a short spine. The head is small and posteriorly depressed or flattened. The eye nearly fills the head vertex. The antennules are small and fixed. There is no postanal extension of the postabdomen. The organisms within this genus have not been taken to species. They appear infrequently in the PCLP samples from Waynewood.
Chaoborus flavicans	Cook 1956	JAA	L,W	LW6/6/89...	DI:CHA:FL	The dorsal process of this organism is only a single segment. the prelabral appendages are more than four times longer than they are broad. They are leaf-like in shape. There is a small spike between the 1st and 2nd mandibular teeth. The antenna has a seta 1/4 to 1/3 the distance from the distal end. The mandibular fan has 10-12 setae. This is a large (up to 15mm) species that tends towards a yellow coloration in the late instars.
Chaoborus punctipennis	Cook 1956	JAA	G,L,W	GLW6/7/88...	DI:CHA:PU	This is a smaller species of Chaoborus (<12mm). The prelabral appendages are > 15 times longer than they are wide. There isn't a small spike between any of the three mandibular teeth. The antennal seta is approximately in the middle of the antenna and is between 21-26 um in length.
Chaoborus spp.	Cook 1956	CEW,JAA	G,L,W	GLW6/7/88...	DI:CHA	This is a genus of cryptic dipteran larvae. Their antennae are prehensile with strong apical spines. There is a pair of darkly colored hydrostatic organs located in the thoracic and the seventh abdominal segment. The species present in the core lakes are C.flavicans and C.punctipennis.

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Chydorus sp. This is another small cladoceran that is counted in the 202 um samples. The fornices of the carapace come together to form a beak-like rostrum. This rostrum partially covers the anntenules. This genus is similar to Bosmina in shape, tend to be more ovoid. It is uncommon for us to find representatives of this genus in our open-water samples.	Edmondson 1959	AY,JAA	G,L,W	GLW6/7/88...	CL:CHY
Cyclops scutifer This is a medium-sized cyclopoid copepod (females <1.4mm). The fourth and fifth metasomal segments are laterally extended into pointed wings. The caudal ramus is at least four times as long as it is broad. The outer lateral seta is 1/4 the distance from the terminus of the ramus. This seta is approximately parallel to the outer terminal seta of the caudal ramus. There are hairs along the inner margin and the ramus is heavily ridged. The fifth leg is made up of two segments. The outer terminal seta is 1/3 the length of the other seta.	Edmondson 1959	CEW	G,L,W	GL6/7/88... W4/29/90...	CY:CYC:SC
Daphnia ambigua This is a small species (1 mm). The ventral valve surface is rounded. A toothed crest may be present in both the mature and immature forms. An ocellus is present beneath the eye. The swimming hair arising from the base of the second joint of the three-jointed ramus of the antenna is the same length as the other swimming hairs. All of the teeth of the three pectins of the postabdominal claw are of equal length.	Brooks 1957	JAA	L	L7/7/90...	CL:DAP:AM
Daphnia catawba The body of this species is elongated and ovoid in shape (1-2mm). The spine is less than 1/2 of the valve length. The interspinule distance is twice as great as the spinule length. There is an ocellus present. The optic vesicle is separate from the head margin. The teeth of the middle pectin of the post abdominal claw are stout and greater than three times as long as the teeth of the distal pectin	Brooks 1957	JAA	G,L	GL7/7/90...	CL:DAP:CA
Daphnia rosea The body of this daphnid is rounded, similar to that of D. ambigua. However, D. rosea is much larger (1-2mm). The posterior spine is thin and less than 1/2 of the valve length. An ocellus is present. The optic vesicle is separate from the margin of the head. The second abdominal process of the postabdomen is approximately 1/2 the length of the first abdominal process. All of the teeth of the three pectins are of equal length. Nockenzahne may be present in the immature forms.	Brooks 1957	JAA	L	L7/7/90...	CL:DAP:RO

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME / COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Daphnia spp.	Edmondson 1959	CEW	G,L,W	GLW6/7/88...	CL:DAP
This genus consists of typically large (0.75-2.2mm) organisms with oval or elliptical bodies. Their carapace consists of two valves that close dorsally with a posterior spine. Spinules are present on the posterioventral surface of the valves. The females display a distinct and pointed rostrum. The antennules are small and fixed. The males have large moveable antennules, each with stout anterior setae. These organisms have not been rigorously identified for the regular counts, due to the difficulty of quick identification.					
Daphnia (E) /eggs		GG	G,L,W	GLW9/10/89...	CL:DAP
This classification is an attempt to estimate the number of adults. We felt that in order to calculate an egg ratio value we would need to eliminate the juveniles from this calculation. Since we are only counting adults with eggs we would expect our egg ratio to be an overestimate. A similar category has been made for the other cladocerans and they will not be included into this list.					
Diacyclops thomasi	Edmondson 1959	JAA	W	W10/19/90...	CY:DIA:TH
This cyclopoid species is between 0.9 and 1.1 mm length. The first antenna is made up of 17 segments. The caudal ramus lacks hair along its inner margin and is five times longer than it is broad. There are two outer lateral setae. The longer one is 2/3 the distance from the base. The shorter seta is 1/3 the distance from the base. The fifth leg is made up of two segments. The inner spine of the terminal segment is $<1/3$ the length of the terminal seta. The outer terminal spine of the endopod of the fourth leg is two times the length of the inner spine. This species dominates the cyclopoids from Nov.'89 to March '90, not M.edax as originally counted. This species was subsequently counted as Cyclops bicuspidatus before adopting the present nomenclature.					
Diaphanosoma sp.	Pennak 1978	GG	G,L,W	GLW9/24/89...	CL:DIA
These Cladocera have a bivalved carapace that covers the mouth and legs (usual form). The antennae are large and thickened. The dorsal ramus has two joints and the ventral ramus has three joints. This organism does not have a rostrum or fornices. The eye is large and there is no ocellus present. the antennules are small and truncated. The olfactory setae are terminal. There are no anal spines on the postabdomen. Organisms of this genus have not been formally taken to species.					

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Diaptomus minutus	Edmondson 1959	CEW	G,L	GL6/7/88...	CA:DIA:MI
This is a small calanoid species (females < = 1.1mm). The female fifth leg endopod is <1/2 the length of exopod 1. There are only two setae on exopod 2. The lateral spine of the male right fifth leg is 1/2 the distance from the base to the terminus of exopod 2. The right endopod is <1/4 of the length of exopod 1. On exopod 2 of the left fifth leg there is a stout pointed process, which is approximately the same size as the distal process.					
Diaptomus oregonensis	Edmondson 1959	CEW	W	W6/7/88...	CA:DIA:OR
This species is between 1.25-1.5 mm in length. The male left fifth leg extends to the base of the terminal claw of the right fifth leg. The length of exopod 2 of the left fifth leg is 3/4 the length of exopod 1. The inner process of exopod 2 is 1/3 the length of the distal process. There are two setae on exopod 2 of the female fifth leg. The endopod extends down to exopod 2. There are two terminal setae on the endopod of the female fifth leg.					
Diaptomus spatulocrenatus	Edmondson 1959	CEW	G	G6/7/88...	CA:DIA:SP
This is a large calanoid species (females <1.6mm). The metasomal wings of the female display a well developed lobe on the inner side of both wings. The genital segment has only a slight lateral pertuberance. However, there is a ventrally directed flange on the right side of the segment. The endopod of the female fifth leg displays two terminal setae and extends down to exopod 2. There are three terminal setae on exopod 2 of the female fifth leg. The left endopod of the male fifth leg is spatulated. The lateral spine of the right fifth leg is 3/4 the length of the terminal claw.					
Eucyclops agilis	Edmondson 1959	JAA	L	L1/26/90 only	CY:EUC:AG
This species is long (<1.2mm) and thin. A single male has been identified. The fifth leg consists of a single segment. There is a terminal spine (>30 um) and two long terminal setae (>70um). the first antenna are 12 segments in length. The outer lateral seta of the caudal ramus is <1/4 the distance from the terminus of the ramus. There is a second smaller seta located near the larger seta. The males lack the conspicuous lateral spinules on the caudal ramus that is found with the females.					

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE	COMMENTS (J.A. Aufderheide)
Holopedium gibberum	Edmondson 1959	CEW	L,W	LW6/7/88...	CL:HOL:GI	The body of this organism is large (<2.5 mm), but is laterally compressed. The carapace is very thin and forms a high back when seen from the side. The mouth and legs are not covered by the carapace. The antennules are small and fixed. The antennae of the female are uniramous, curved, with two joints and with annulations near their base. The eye is small and with many lenses. The ventral margins of the valves have fine spines. The entire organism is typically encased in a spherical gelatinous envelope.
Leptodora kindtii	Edmondson 1959	CEW	G,L,W	GLW6/7/88...	CL:LEP:KI	This is a large cryptic cladoceran with an elongated body (7-18 mm). The carapace is reduced to a small brood sac. The antennae display a heavy basal joint and have four other joints. They are very long and display numerous setae. The eye is large and fills the anterior end of the organism. There are six pairs of prehensile and cylindrically jointed legs. The first pair is longer than the others. The body consists of four segments. the first contains the head and thorax and the remaining three are abdominal. The last segment contains the stomach. The postabdomen is not reflexed as with most other cladocerans. Only one species has been described for this genus (Focke 1844).
Macrocyclops albidus	Edmondson 1959	JAA	L,W	W1/19/91 (JAA) L12/30/92 (PLS)	CY:MAC:AL	This is a large cyclopoid species (females >1.5 mm). The first antennae is made up of 17 segments. There is a smooth hyaline membrane on the terminal segment. The caudal ramus is without hair along its inner margin and is twice as long as it is broad. The outer lateral seta is 80% of the distance from the base. The terminal setae are much longer than the ramus length (longest >7X ramus length). The fifth leg is made up of two segments. There are two long spines (>70um) and a median seta on the terminal segment. The seta on the basal segment is the same length as the median segment (100 um). The distal inner seta of the fourth leg endopod is > 1/3 the length of the other inner seta. This organism has not been counted in the database.
Mesocyclops edax	Edmondson 1959	CEW	L,W	LW6/7/88...	CY:MES:ED	This is a medium sized cyclopoid (females >1mm). The terminal segment of the first antennae has a sharply notched hyaline membrane. The fifth leg is made up of two segments. The inner spine of the terminal segment is longer than the terminal seta. The caudal ramus is < four times as long as it is broad with hairs along its inner margin. The outer lateral seta is 2/3 the distance from the base. It is not parallel to the outer terminal seta. This species is dominant during the summer in Lacawac and Waynewood.

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME	COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Microcyclops varicans rubellus		Pennak 1989	PLS	L,W	L9/11/92.. W/8/25/92	CY:MIC:VA
Orthocyclops modestus	This is a medium sized cyclopoid (0.75-1.1mm). The first antennae of this organism are made up of 16 segments. The fifth leg is made up of three segments. The two terminal setae cross each other near the exopod. There is a single long seta (>35um) on the middle segment. The width of the caudal ramus is 1/3 the length. The outer lateral seta is near the middle of the ramus and appears to be perpendicular. There is a heavy dorsal ridge, which extends from the point of attachment of this seta. There are hairs along the inner margin of the ramus. This species is rare and has not been recognized by the counters. Only one species has been described for this genus (Herrick 1883). This species is common in the meta- and hypolimnetic waters of Lake Lacawac and may have been misidentified as a copepodid of another species. I have found that this species is prevalent in my 1990 samples from Lake Lacawac.	Edmondson 1959	JAA	G,L,W	G3/25/90... L7/3/91... W5/12/92	CY:ORT:MO
Polyphemus pediculus	The body of this cladoceran is short and compressed. The carapace does not cover the body, but makes up a globular brood sac. The caudal process of the postabdomen is elongated and displays two terminal setae. There are four pairs of legs with subcylindrical (slightly flattened) joints. The antennae are stout with one ramus made up of three joints and the ohter made up of four joints. The antennules are small and fixed to the ventral side of the head. The head is large and filled with a large eye. There has been only one species described for this genus (Linne 1761).	Edmondson 1959	CEW	G	G6/7/88...	CL:POL
Tropocyclops prasinus	This is a small species of cyclopoid (>1000 um). They have 12 antennial segments. The fifth leg has only one segment. It has a single inner spine and two outer setae. The inner spine of the fourth leg is less than twice as long as the terminal segment. This species was originally identified as small cyclopoid copepods.	Edmondson 1959	JAA	L,W	LW8/1/89...	CY:TRO:PR
Unidentified cyclopoid	The unidentified cyclopoid in Waynewood is most likely Diacyclops thomasi. I'm basing this suggestion on the abundance of D.t. in Waynewood in the late summer and early fall (JAA obs.)		AMS	W	W7/31/89	CY:UNID

I. MACROZOOPLANKTON FROM THE 202 um MESH SAMPLES (Note that in 1991-93 some Macrozooplankton counts were transferred to the 48-um sample.)

SPECIES NAME COMMENTS (J.A. Aufderheide)	TAXONOMIC REFERENCE	PCLP INVESTIGATOR WHO IDENTIFIED THIS SPECIES	LAKES RECORDED	LAKES AND DATES RECOGNIZED	SPECIES CODE
Unid. cyclopoid (blue) It is possible that this organism is not a cyclopoid, but a harpacticoid. From the samples that have a Unid.cycl.(blue) in the datasheets, I have found a dark gray organism that may have been blue. Until I find a recently preserved blue organism I will not be able to positively identify it.		AMS	L,W	LW7/3/89	
Unid. cyclopoid (small) It is very likely that this organism is T.prasinus.		GG	W	W8/28/89	
Unid. cyclopoid (very small) It is very likely that this organism is also T.prasinus.		KSB	W		

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