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SEASONAL SUCCESSIONS OF PHYTOPLANKTON IN SEVEN LAKE BASINS IN THE EXPERIMENTAL LAKES AREA NORTHWESTERN ONTARIO FOLLOWING ARTIFICIAL EUTROPHICATION.

BY

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This report summarizes the changes in the phytoplankton communities of seven lake basins following artificial enrichment with nitrate, phosphate and carbon. Data presented comes from studies of Lakes 227, 304, 226 (southeast and northwest basins), 261, and 302 (north and south basins) carried out from 1969 to 1973. A total of 280 taxa were identified and a table indicates where they were found and at what season of the year.

Nous résumons ici les changements qui sont intervenus dans les communautés de phytoplancton vivant dans sept bassins des lacs à suite d'un enrichissement artificiel au nitrate, au phosphate et au carbone. Les données que nous présentons résultent des études effectuées entre 1969 et 1973 dans les lacs 227, 304, 226 (bassins sud-est et nord-ouest), 261 et 302 (bassins nord et sud). On a découvert en tout 280 taxa et l'on a établi une liste qui indique à quel endroit et à quelle époque de l'année on les a trouvé.

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INTRODUCTION

This report summarizes the changes in the phytoplankton communitites of seven lake basins in the Experimental Lake Area (E.L.A.) near Kenora, Ontario before and after artificial enrichment.

METHODS

This report is a continuation of studies reported on by Kling and Holmgren (1972) and the methods used are the same.

RESULTS

Table I lists the taxa found in the seven experimental basins.

Lake 227 (Figure 1)

1969

Lake 227 was the first of the seven lake basins to be artifically enriched. Fertilization began in June of 1969 with the addition of PO_4 and NO_3 (Schindler et al. 1971, 1973). Prior to the first fertilization Lake 227 had an estimated live biomass of 1000 mg/m^3, and the Chrysophyceae was the dominant class. Chromulina sp., Dinobryon bavaricum, Dinobryon bavaricum var. vanhoeffenii, Dinobryon borgei, Ochromonas sp., and Kephyrion sp. were the dominant species. In late August, Spondylosium planum, Staurastrum paradoxum and Staurastrum sp., Chlorophyta, became dominant, with a maximum averaged biomass of 4800 mg/m^3. In autumn the standing crop of phytoplankton decreased and the previously dominant Chrysophyceae returned. In mid-November, Lake 227 had a live biomass of 1255 mg/m^3. A slight increase in the Chryptophyceae was recorded in December under early winter ice. Rhodomonas minuta, Cryptomonas pusilla, Cryptomonas sp., and Katablepharis sp. were the major species. The biomass remained approximately 500 mg/m^3 throughout the ice-covered season and dominance did not change during winter.

1970

At the beginning of the 1970 ice-free season, Lake 227 had an average biomass of 1000 mg/m^3 and was dominated by the Chrysophyceans that remained from the winter. Fertilization began in mid-May. In mid-June, the Chlorophyta increased until they represented 31 percent of the standing crop. The species causing this increase were Staurastrum planctonica, Staurastrum paradoxum, Spondylosium sp., Sphaerozosma sp., and Ankistrodesmus falcatus var. spiralis. These species continued to dominate until August. The biomass for this period ranged from 6000 mg/m^3 to 10000 mg/m^3 and chlorophyll a values averaged 45 μg/l. In late August the highest biomass for the 1970 season was recorded at 15,041 mg/m^3 or an estimated live cell count of 54×10^9 cells/l. At this time the Chlorophyta were 71% of the biomass and Cyanophyta were 14%. Spondylosium planum was the major chlorophyte and Oscillatoria redekia was the dominant Cyanophyte. The Cyanophyta increased throughout September. The average biomass fluctuated between 8000-13000 mg/m^3. By October the biomass had declined to 1200 mg/m^3, with Chrysophyceae making up 57% of the biomass and Cryptophyceae 20%. *Ochromonas sp.*, *Chromulina* sp., *Botryococcus braunii*, *Dinobryon cylindricum*, *Mallomonas pumilio* var., and *Mallomonas pumilio* represented the Chrysophyceae while *Cryptomonas ovata*, *Cryptomonas rostratiformis*, *Cryptomonas marssonii*, *Cryptomonas obovata*, and *Katablepharis* sp. composed the Cryptophyceae. Cryptophyceae remained dominant until January 1971. During this time, Cyanophyta averaged 30% of the live biomass, dominated by the species *Osillatoria redekia*.

1971

From January to late March 1971, Chrysophyceae remained dominant, accompanied by some of the Cyanophyta previously mentioned. The biomass for this period averaged 500 mg/m^3. In late March, Euglenophyta increased to more than 10% of the biomass for the first time, represented by *Euglena acus*, *Trachelomonas volvocina* and *Lepocinclis* sp. Chrysophyceae continued to dominate until June when *Oscillatoria redekia* increased sharply. By early July, dominance had changed to Chlorophyta, with *Chlamydomonas* sp. the dominant species. A peak of 7600 mg/m^3 was reached in mid-July with a biomass composed of 42% Chlorophyta, 24% Cyanophyta, 17% Cryptophyta and 12% Chrysophyta. In mid-August during a period of cool, rainy weather, biomass began to decrease and dominance reverted to the chrysophyceans, *Gloeobotrys* sp. and *Mallomonas pumilio*. When warm weather returned in mid-August, Chlorophyta again became dominant, and live biomass reached 7300 mg/m^3, but by September Cryptophyceae had again returned, similar to the autumns of other years.

By late September, Botryococcus braunii, Mallomonas caudata, Heterochromonas sp. and Gloeobotrys sp. had become dominant. Biomass slowly declined to 1000 mg/m^3 throughout the winter.

1972

In 1972, Lake 227 had a spring Chrysophycean maximum of 1400 mg/m^3. By early June the phytoplankton biomass had reached 4000 mg/m^3 and Chlorophyta was the dominant class. Scenedesmus spp., Ankistrodesmus falcatus var. spiralis, Dictyosphaerium elegans and Oocystis submarina var. variables were the major species. This community contined throughout the late summer season. Small peaks of Cyanophyta, mainly Oscillatoria redekia were observed in August and September. The biomass for Lake 227 was extremely high in early summer, reaching 33,000 mg/m^3 by mid-July. Corresponding chlorophyll a values were 132 μg/1. On July 27 the standing crop of phytoplankton measured 63,300 mg/m^3, the highest value ever recorded for the lake.

A sharp decline occurred shortly after this peak biomass, in early August. As in 1971 cool, cloudy weather was closely correlated to the decline. The biomass recovered slowly to 9500 mg/m^3 in October when the chlorophytes Micractinium sp., Oocystis submarina var. variables, Ankistrodesmus falcatus var. spiralis, Spondylosium planum and Scenedesmus sp. were abundant. In contrast to other years, chlorophyte dominance continued until late January, when the typical chrysophyceans returned.

1973

The biomass in early spring of 1973 remained at 3500 mg/m^3

until late May, after which a change of dominance from Chrysophyceae to Chlorophyta occurred and the biomass doubled. Chlorophyta of the species *Dictyosphaerium elegans*, *Oocystis submarina* var. *variables*, *Scenedesmus* sp. and *Ankistrodesmus falcatus* var. *spiralis* dominated the phytoplankton until September. A sharp peak was recorded early in July with values of 22,300 mg/m^3 for biomass and 123 μg/l of chlorophyll *a*. As in 1971 and 1972, cool, cloudy weather was closely correlated with a sharp decline in standing crop in late July. For the remaining part of the summer, the biomass fluctuated from 6000-14,000 mg/m^3. During this period there were small populations of Cyanophyta and Chrysophyta present. In September, *Oscillatoria redekia* became the dominant species of phytoplankton but caused no great increase in live biomass values. Bacillariophyceae were conspicuous, but at no time made up more than 10% of the biomass.

Lake 304 (Figure 2)

1969

Sampling of Lake 304 began in the spring of 1969. Samples were taken from 0 to 5 meters at depth intervals of 1 meter throughout the seasons. At this time, Lake 304 had an average live biomass of 1250 mg/m^3. Eighty-five percent of the biomass was Chrysophyceae. *Botryococcus braunii*, *Chrysoikos* sp., *Pseudokephyrion* sp., *Chromulina* spp., *Dinobryon bavaricum* and *Dinobryon bavaricum* var. *vanhoeffenii* were the dominant chrysophycean species. Biomass values increased slightly throughout the summer, reaching a peak of 3300 mg/m^3 with a corresponding chlorophyll *a* value of 20 μg/l on July 29. Sixty-eight percent of the biomass was composed of chrysophytes during this period and small populations of Chlorophyta, Cryptophyta and Cyanophyta were also present. Spondylosium sp., Arthrodesmus incus and Tetraedron minimum were the chlorophycean species, Cryptomonas marssonii and Cryptomonas obovata represented the Cryptophyceae while the Cyanophyta were composed of Synechococcus sp. and Oscillatoria sp. In early October, biomass decreased to 500 mg/m^3 and for the first time Bacillariophyceae (Synedra acus and Melosira spp.) represented more than 10% of the standing crop of phytoplankton. Biomass increased under ice cover and in mid-December averaged 1200 mg/m^3. Chrysophyceae were still dominant with the same species as mentioned previously. Cryptophycean species, Rhodomonas minuta, Katablepharis sp. and Cryptomonas spp. continued to represent an average of 10% of the standing crop throughout the winter.

1970

Winter biomass for Lake 304 averaged 1000 mg/m^3 and chlorophyll a averaged 10 μg/l in 1970. Chrysophyceae represented 75% of the standing crop with the same species as mentioned in 1969. In early May, Cyanophyta species, Synechococcus sp. and Lyngbya pseudospirulina represented 30% of the live cell biomass. By early June, the Cyanophyta had declined to less than 10% and Chrysophyceae again represented 75%. Species present at this time were Kephyrion boreale, Monomastix sp., Botryococcus braunii, Dinobryon sertularia, Dinobryon divergens, Dinobryon bavaricum, Mallomonas globosa, Mallomonas spp., Mallomonas pumilio, Chrysoikos skuja, Bitrichia sp., Chromulina globosa and

Chrysochromulina parva var. Biomass increased slowly and a maximum integrated value of 2400 mg/m^3 was reached in late September. Biomass decreased to 1500 mg/m^3 by mid-October. Chrysophyceae still dominated, very seldom dropping below 80%. Small populations of Cyanophyta, Chlorophyta and Peridineae were present during the period; no one group made up more than 10% by itself at any one time. Chrysophyceae remained dominant during the ice-covered season with species of *Dinobryon bavaricum*, *Mallomonas pumilio* and *Botryococcus braunii* more common. Euglenophyta were present throughout 1970 but were never an important part of the biomass.

1971

Winter biomass in Lake 304 averaged 500 mg/m^3 and as in 1969 and 1970, Chrysophyceae were dominant. *Botryococcus braunii*, *Mallomonas* sp., *Dinobryon crenulatum*, *Chromulina* sp. and *Chrysoikos* sp. were present. In late March, a slight increase in Cyanophyta was recorded with *Lyngbya pseudospirulina* the major species. Artificial enrichment with NH_4Cl, sucrose and H_3PO_4 began in early May. Species composition of the phytoplankton started to change in late May with a decrease in the Chrysophyta and an increase in the Cryptophyceae mainly the species *Cryptomonas obovata*, *Cryptomonas marssonii*, *Cryptomonas pusilla* and *Katablepharis* sp. Chrysophyceae in early June were 87% of the biomass and the Cryptophyceae were replaced with Cyanophyceae. In mid-June, Cyanophyta became dominant making up 56% of the biomass. *Merismopedia* sp. and *Lyngbya pseudospirulina* represented 75% of the dominant cyanophycean population. *Lyngbya pseudospirulina* was found only at

5 meters during this period and at the surface during fall turn over. Cyanophyta dominance lasted until August when Chlorophyta became dominant with Scenedesmus denticulatus, Arthrodesmus incus, Staurastrum paradoxum and Chlamydomonas sp. During this period, Cyanophyta, represented by the previously mentioned species, composed 21% of the standing crop of phytoplankton. Biomass values reached 14,500 mg/m^3 or a live cell estimate of 50 x 10^9 cells/l. Corresponding average chlorophyll a values for this date were 78 μg/l. The biomass slowly decreased and by October was down to 3200 mg/m^3.

1972

Biomass values averaged 2100 mg/m^3 throughout late winter and Chlorophyta composed 94% of the live biomass. The same species present in late October 1971 dominated throughout the winter of 1972.

In early April, Lake 304 had an average biomass of 1451 mg/m^3 and Chlorophyta were still dominant, composing 76% of the standing crop. Cyanophyta species, chiefly Oscillatoria redekia, composed 16% of the biomass during this period. Chlorophyceae remained dominant up until mid-June. At this time, the biomass reached 19,000 mg/m^3 and was composed of 53% Chlorophyta, 22% Chrysophyceae, 12% Cryptophyceae and 10% Cyanophyta. Annual fertilization, identical to 1971, began in mid-May. The biomass slowly declined throughout late June and early July. During this period, the dominance changed to Cryptophyceae. Cryptomonas erosa, Cryptomonas pusilla, and Rhodomonas minuta were the major cryptophytes at this time. Cryptophyceae remained dominant throughout July, August and early September. Biomass during this period continued to increase and on September 6, a maximum of 23,800 mg/m^3 was reached with corresponding chlorophyll a values of 20.2 μg/l. During this period, 90% of the standing crop of phytoplankton were Cryptophytes. As the season progressed, the biomass decreased and by early October measured 11,000 mg/m^3. Cryptophyceae with the same species previously mentioned and Chlorophyta with *Chlamydomonas* sp., *Scenedesmus denticulatus* and *Ankistrodesmus falcatus* var. *spiralis* now shared a co-dominance both composing 45% of the live phytoplankton. This trend lasted until mid-November when under early winter ice, Chrysophyceae became dominant. Dominant were *Synura uvella*, *Chromulina* sp. and *Dinobryon crenulatum*. During this period, Chrysophyceae composed 48% and Chlorophyta 31%. Biomass under early winter ice was 2900 mg/m^3 and it decreased slowly towards spring.

1973

Biomass in late January was 1500 mg/m^3, but dominance had reverted from Chrysophyceae back to Chlorophyta. *Scenedesmus denticulatus* and *Ankistrodesmus falcatus* var. *spiralis* were the two most abundant species at this time. This dominance was recorded until early May when the dominance again shifted to Chrysophyceae due to *Dinobryon sertularia*, *Bicoeca* sp. and *Chromulina* sp. Fertilization began in early May with the same nutrients as previous years except that PO_4 was not added. Chrysophyceae remained dominant until the end of May when Chlorophyceae became dominant with the same species as in 1972. Chlorophyta at the time composed 41%, Chrysophyceae 28% and for the first time in Lake 304, Peridineae composed more than 10%. Biomass increased throughout June and reached a maximum of 10,783 mg/m^3 on June 27. Chlorophyta were 80% of the biomass and Peridineae with species, Peridinium inconspicum and Gymodinium spp. were 11%. Chlorophytes remained dominant for the remaining part of the season. Biomass decreased sharply, after peaking in June, to 1400 mg/m^3 but increased throughout August and September, averaging 4000 mg/m^3. During this period small populations of chrysophytes were recorded, chiefly Dinobryon cylindricum, Botryococcus braunii, Bitrichia sp., Synura uvella and Mallomonas caudata.

Lake 226 (Figure 3)

Lake 226 has two basins (northeast and southwest) connected by a narrow channel. A vinyl sea curtain was inserted in the narrowest part of the channel in 1973 and each basin was then treated as a separate lake. The northeast basin was fertilized with phosphorus, nitrogen and carbon while the southwest basin received only nitrogen and carbon (Schindler, 1974).

Lake 226 - Southwest 1973

Lake 226 southwest was sampled for the first time in early May of 1973. At this time, it had a live biomass of approximately 1000 mg/m^3 and was dominated by chrysophycean species Synura uvella, Botryococcus braunii, Dinobryon bavaricum, Dinobryon crenulatum, Dinobryon suecicum, Mallomonas pumilio, Mallomonas spp. and Chromulina sp. Chrysophyceae at this time composed 70% of the standing crop of phytoplankton. In mid-May fertilization began with weekly additions of sucrose and $NaNO_3$. Chrysophyceae remained dominant until late July when Diatomeae increased sharply and became co-dominant. Tabellaria fenestrata, Tabellaria flocculosa, Asterionella formosa, Cyclotella sp. and Rhizosolenia eriensis were the major contributors to this increase. Biomass reached a summer maximum at this time of 3200 mg/m^3. Co-dominance between Chrysophyceae and Diatomeae lasted until early September when the chlorophyte species Staurastrum sp. and Spondylosium planum replaced the Diatomeae. Biomass averaged 2900 mg/m^3 and was composed of 37% Chrysophyceae, 26% Chlorophyceae, 16% Cyanophyceae and 12% Diatomeae. Biomass declined slightly through September but increased to 3400 mg/m^3 in early October. This increase was attributed mainly to an increase in Staurastrum paradoxum.

Lake 226 - Northeast 1971

Lake 226 northeast was sampled periodically throughout the 1971 season. Biomass averaged 600 mg/m^3 from May to late August and was dominated by Chrysophyceae species Dinobryon bavaricum, Dinobryon crenulatum, Botryococcus braunii, Synura uvella and Chromulina sp. Throughout this period small populations of Diatomeae, Chlorophyceae and Peridineae were also recorded. In mid-September the average biomass increased to 1683 mg/m^3. Chrysophyceae were still dominant with the same species as previously mentioned.

1973

Lake 226 northeast was not sampled in 1972. Sampling on a regular basis began in early May, 1973. Biomass at this time averaged 850 mg/m^3 and Chrysophyceae were dominating with species Botryococcus braunii, Dinobryon bavaricum, Dinobryon crenulatum, Dinobryon suecicum, Chrysoikos sp. and Synura uvella. In mid-May biomass increased to 2700 mg/m^3. Fertilization began in mid-May with the same amounts of sucrose and $NaNO_3$ as were added to Lake 226 southwest, but PO_4 was added in addition. Biomass continued to increase and in late June peaked at 13,425 mg/m^3. In mid-July Diatomeae became dominant composing 46% of the standing crop of phytoplankton. Tabellaria fenestrata, Tabellaria flocculosa, Synedra acus, Asterionella formosa and Rhizosolenia eriensis were the major diatoms. Biomass at this time had declined to 1900 mg/m^3. Diatomeae dominated until mid-August when Anabaena spiroides became dominant, representing 60% of the standing crop. Cyanophyta increased to 86% of the total biomass by early September; at this time biomass values reached 5500 mg/m^3 with corresponding chlorophyll a values of 28 µg/l. In September dominance shifted slowly from Cyanophyta back to Chrysophytes. Biomass had declined following this change, but by mid-October had again increased to 5469 mg/m^3. Chrysophyceae now represented 64%, Cryptophyceae 10%, and Diatomeae 11%. Biomass declined throughout November to 1000 mg/m^3 under early winter ice and Chrysophyceae remained dominant.

Lake 261 (Figure 4)

1971

Lake 261 was sampled monthly throughout the summer season of 1971 from May onward. In May Lake 261 had a live biomass estimated at 426 mg/m^3. Chrysophyceae were dominant with species Botryococcus braunii, Dinobryon bavaricum, Dinobryon bavaricum var. vanhoeffenii, Dinobryon crenulatum, Mallomonas pumilio and Chromulina sp. Biomass increased slowly, reaching 1000 mg/m^3 by late June. Dominance had changed to Cyanophyta, chiefly Merismopedia glauca, Rhabdoderma lineare, Chroococcus dispersus. In mid-July biomass values reached 1300 mg/m^3 and Chrysophyceae had again become dominant (44% of the standing crop) with the same species as previously mentioned. Cyanophyta were still present composing 37% with the same species as mentioned earlier. Biomass peaked in mid-August at 4300 mg/m^3, with Cyanophyta representing 88%. The species mentioned previously were dominant. Average chlorophyll a values at this time were 8 μg/l. Biomass declined throughout the fall and by mid-December was 100 mg/m^3 with the same species present. At this time the standing crop of phytoplankton was composed of 56% Chrysophyceae, 17% Cyanophyceae and 14% Cryptophyceae.

1972

As in 1971 Lake 261 was sampled monthly throughout the summer season. In early May average live biomass was 528 mg/m^3 and Chrysophyceae were dominant with species Dinobryon cylindricum, Dinobryon divergens, Botryococcus braunii, Mallomonas pumilio, Chrysoikos skuja and Chromulina sp.. Peridineae (Peridinium aciculiferm, Peridinium pusillum, Peridinium inconspicum and Peridinium spp.) for the first time represented more than 10% of the standing crop. Dominance changed to Cyanophyta in early June with the same species that occurred in 1971. Average biomass was 1200 mg/m^3 with a corresponding chlorophyll a value of 6 μg/l. This dominance lasted until late June when Chrysophyta became dominant, composing 78% of the standing crop of phytoplankton. Mallomonas sp., Botryococus braunii and Dinobryon bavaricum were the major chrysophycean species. Cyanophyta became dominant in late July and lasted throughout August. Gloeotheca sp., Chroococcus dispersus and Merismopedia glauca were the major cyanophyte species. Biomass during this time averaged 1600 mg/m^3 and chlorophyll a measured 9 μg/l.

1973

In early May, 1973, Lake 261 was dominated by Chrysophyceae species, *Mallomonas pumilio*, *Synura uvella*, *Dinobryon bavaricum*, *Dinobryon crenulatum* and *Chromulina* sp. and had an averaged biomass of 1050 mg/m^3. Fertilization of Lake 261 began in mid-May with the weekly additions of PO_4. In contrast to the two previous years, Chrysophyceae remained dominant throughout the summer, with small populations of Cyanophyta, Chlorophyta, and Cryptophyta. The highest biomass values for the year occurred on July 31, 2800 mg/m^3, with a chlorophyll a value of 14 μg/l. Euglenophyta (*Trachelomonas hispida*, *Trachelomonas volvocina*, *Euglena acus* and *Euglena* cf. *gracilis*) for the first time represented 10% of the standing crop. Biomass declined slowly throughout the remaining months and by December had reached 870 mg/m^3.

Lake 302 (Figure 5)

Lake 302 has two basins (north and south), connected by two narrow channels. Lake 302 North was artificially enriched below the hypolimnion (8 meters) with weekly additions of NH_4CL, $H_3 PO_4$ and sucrose. Lake 302 South was untreated and used as a control.

Lake 302 South 1972

Sampling of Lake 302 South began in late May 1972. At this time the standing crop of phytoplankton was estimated at 526 mg/m^3 and was dominated by the chrysophyte species *Pseudokephyrion* sp., *Chromulina* sp. and Dinobryon bavaricum. Chrysophyceae remained dominant throughout the full year. In mid-August the highest biomass value for this year was reached at 1231 mg/m^3 with a corresponding chlorophyll a value of 4.8 μg/l. The standing crop was composed of 48% Chrysophyceae, 25% Cyanophyceae, 10% Chlorophyceae and 9% Diatomeae. Chrysophyceae were represented by the same species as previously mentioned while Anabaena sp. and Lyngbya pseudospirulina were the major cyanophyte species. Arthrodesmus incus, Staurastrum spp., Quadrigula closteroides and Ankistrodesmus falcatus var. spiralis represented the chlorophytes and Synedra acus, Tabellaria flocculosa, Asterionella formosa, Cyclotella comta and Rhizosolenia eriensis composed the diatoms. Biomass declined throughout the fall and in mid-October averaged 969 mg/m^3. Chrysophyceae represented 51% with Cyanophyta composing 21% of the live biomass. Chrysophyceae remained dominant throughout the winter months.

1973

In early spring of 1973 Lake 302 South had a live biomass composed of 79% Chrysophyceae, 7% Cryptophyceae and 6% Chlorophyceae with an integrated biomass value of 816 mg/m^3. Synura uvella, Chromulina sp., Botryococcus braunii and Dinobryon sertularia were the chrysophyte species present. Chrysophyceae as in the previous year remained dominant throughout the full year. There was a sharp increase in biomass in mid-May. Biomass peaked at 4725 mg/m^3; chlorophyll a for this time averaged 5.9 μg/l. Mallomonas pumilio, Pseudokephrion sp., Dinobryon bavaricum, Dinobryon bavaricum var. vanhoeffenii, and Dinobryon crenulatum were the major chrysophytes contributing to this peak.

Small populations of Diatomeae were also present throughout most of the season, mainly *Asterionella formosa*, *Tabellaria flocculosa*, *Tabellaria fenestrata*, *Synedra acus*, *Rhizosolenia eriensis* and *Cyclotella* sp. Biomass declined throughout the summer averaging 1500 mg/m^3 by late September. In late October biomass increased to 2800 mg/m^3. This was due to an increase in *Mallomonas pumilio* and *Synedra acus*.

Lake 302 North 1972

Lake 302 North had an early spring biomass of 647 mg/m^3 in 1972. As in the South basin Chrysophyceae dominated the phytoplankton throughout the year. Biomass averaged 1100 mg/m^3 in June, July, and August. Artificial enrichment of 302 North began in early June, with H_3PO_4, NH_4Cl and sucrose pumped below the thermocline into the hypolimnion at a depth of 8 meters. In late August the biomass values increased to 1807 mg/m^3. Chrysophyceae composed 41% of the live biomass with *Chrysosphaerella longispina*, *Botryococcus braunii*, *Uroglena americanam* and *Dinobryon bavaricum* the most important species. Cyanophyta represented 28% with *Anabaena* sp., *Rhabdoderma liniaris*, *Rhabdoderma Gorski* and *Chroococcus limneticus* being important. Biomass then declined in September and October. Cyanophyta continued to represent 27% of the average biomass until late October when the Crytophyceae *Cryptomonas erosa*, *Cryptomonas ovata*, *Katablepharis* sp. and *Rhodomonas minuta*, increased. Cryptoptyceae slowly decreased, being replaced by the diatoms *Rhizosolenia eriensis*, *Cyclotella comta* and *Synedra acus*. Biomass in December was 663 mg/m^3. Chrysophyceae remained dominant through the winter.

1973

Lake 302 North had a live biomass of 2602 mg/m^3 in early May with Chrysophyceae dominating. Mallomonas pumilio, Mallomonas globosa, Chrysoikos sp., Dinobryon crenulatum, Dinobryon bavaricum, Botryococcus braunii, and Synura uvella were the most abundant species present. Biomass doubled by late May (5038 mg/m^3) with an increase in all the above mentioned species. Chlorophyll a for this date averaged 1.8 μg/l. Artificial enrichment began in late May, with the same amounts of fertilizer added as in 1972. Chrysophyceae remained dominant throughout the year, seldom dropping below 50% of the live biomass. Biomass declined after the late spring peak, averaging 1500 mg/m^3 through June and July. In late July an increase in Diatomeae was recorded with Asterionella formosa, Tabellaria flocculosa, Tabellaria fenestrata, Synedra acus and Rhizosolenia eriensis composing 27% of the standing crop of phytoplankton. Biomass had increased to 2075 mg/m^3 in late August, and Diatomeae were replaced by the Cryptophyceae. Cryptomonas erosa, Cryptomonas sp., Katablepharis ovalis and Rhodomonas minuta, these species remained throughout the fall and winter months. Biomass declined to 1048 mg/m^3 by December, with Chrysophyceae dominant as usual.

DISCUSSION

Non-fertilized Lakes

Lakes not fertilized in the Experimental Lakes Area (E.L.A.) are dominated by Chrysophyceae with lesser populations of Cryptophyceae and Diatomeae. Examples of these lakes (239, 383, 228, 302 south) all have an average winter biomass of about 500 mg/m^3 and a summer average biomass of about 1200 mg/m^3. Chlorophyll in these lakes never exceeded 5 µg/l.

Epilimnion Fertilization

All lakes receiving phosphorus and nitrogen in the epilimnion had a major increase in standing crop and changes in species composition. Previous to fertilization these lakes (226 northeast, 227 and 304) were comparable to unfertilized lakes both in species composition and in biomass. After fertilization biomasses ranged from 10,000-63,000 mg/m^3 and chlorophyll values increased to as high as 200 µg/l. Lake 227's standing crop shifted from Chrysophyceaean dominance (*Dinobryon* spp., *Chromulina* spp. and *Chrysococcus* sp.) to Chlorophyeaean dominance (*Oocystis submarina*, *Ankistrodesmus falcatus* var. *spiralis*, *Scenedesmus denticulatus* and *Chlamydomonas* sp.) with large populations of Cyanophyta (*Oscillatoria redekia*) during the summer.

Lake 304 also shifted towards Chlorophyta. *Scenedesmus denticulatus*, *Chlamydomonas* sp. and *Oocystis submarina* were important with large populations of Cyanophyta (*Lyngbya pseudospirulina* at 5 meters and *Merismopedia* sp.) during the period of fertilization.

Cyanophyta became dominant in late summer in Lake 226 northeast in years when fertilizer was added. *Anabaena spiroides* and *Anabaena solitaria* fa. *planctonica* (1974 data) predominated in the phytoplankton populations; both species are nitrogen fixers (R. Flett, personal communication).

Lake 226 southwest received the same amount of C and N as did the northeast basin but had no PO_4 added. Biomass did not increase above control lakes, averaging 2,000 mg/m^3 with summer maximums of 3,200 mg/m^3. Chlorophyll values exceeded 10 μg/l only on two occasions during early June and September (1974 data). Species composition remained dominated by Chrysophyceae species Dinobryon bavaricium, Dinobryon suecicum, Mallomonas pumilio, and Synura uvella. Large populations of Diatomeae were also recorded with species Tabellaria fenestrata, Tabellaria flocculosa, and Asterionella formosa.

Recovery of Lake 304 After PO_4 is Controlled

With the additions of fertilizer (P+N+C) both biomass and composition of the phytoplankton in Lake 304 increased. Biomass values increased to 18,000 mg/m^3 from prefertilization values of 1,200 mg/m^3. In 1973 PO_4 additions were terminated, while nitrogen and carbon continued to be added. Biomass declined slowly, averaging 4,000 mg/m^3 the first summer. Chlorophyta remained dominant but the Cyanophyta disappeared. The large percentage of the chrysophyceans typical of unfertilized lakes returned. Epilimnion chlorophyll values during PO_4 enrichment had reached values as high as 182 μg/l. In the first year after P addition ceased it never exceeded 30 μg/l. In 1974 Chlorophyta was still dominating but more peaks of Chrysophyceae mainly Dinobryon sp. and Peridineae were noticeable. Chlorophyll values during the 1974 summer averaged approximately 20 μg/l with a maximum value of 136 μg/l recorded at 5 meters on the 7 August, which declined to 20 μg/l the following month.

Hypolimnion Fertilization

Lake 302 north was fertilized with C, N and P below the thermocline for 2 years. Previous to fertilization 302 north had an average biomass of 1000 mg/m^3. Chlorophyll values averaged 5 µg/l and Chrysophyceae were dominant with high populations of Diatomeae occurring as well. During the period of enrichment no changes were recorded. In striking contrast to the lakes where epilimnions were fertilized with C, N and P, biomass remained low with summer maximums in the epilimnion up to 6,000 mg/m^3. Epilimnetic chlorophyll never exceeded 10 µg/l and Chrysophyceae continued to dominate the standing crop. Recent investigations using *in vivo* fluorometer by E. J. Fee (personal communication) have shown that massive populations of algae (up to 327 µg/l) exist in the upper hypolimnion of this lake during late summer. This biomass peak is limited to a very narrow depth range and our previous sampling method (taking samples at fixed depths) missed the peak completely. The peak is so massive that the total mass of chlorophyll in the lake was six times higher than estimates made with the old sampling method. *Dinobryon sertularia* var. *protuberans* was the only species present in samples from this peak. Further investigations of this phenomenon are needed.

Epilimnion Fertilization with PO_4

Lake 261 was enriched with PO_4. Previous to fertilization it had a summer dominance of Cyanophyta with species *Merismopedia glauca*, *Chroococus dispersus* and *Rhabdoderma* sp. Biomass averaged 1,500 mg/m^3 and chlorophyll averaged 5 µg/l. After fertilization dominance shifted towards Chrysophyceae. Synura uvella, Dinobryon bavaricum, Dinobryon crenulatum and Mallomonas pumilio. Biomass did not increase significantly. However, E. Fee (personal communication) found a biomass peak of 311 μg/l of chlorophyll in the metalimnion of this lake in 1974. As was the case in L. 302 N, our sampling scheme missed this concentration of chlorophyll and the effect of fertilization with P alone can probably not be judged until the lake is adequately sampled for a period of a year.

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Table I. A species list of 96 genera and 280 taxa found in seven experimental lakes in the Experimental Lakes Area 1969-1973.

			226N	226S	227	261	302N	302S	304	Season
Cyanophyta										
I	1.	Microcystis flos-aquae (Wittrock) Kirchner			x				x	July-September
	2.	Microcystis viridis (A. Braun) Lemmerman	x	x	x	x			x	July-September
	3.	Microcystis sp.			x					July-September
II	1.	Aphanocapsa biformis A. Braun?							x	July-September
	2.	Aphanocapsa elachista W. et G. S. West	x	x	x	x	x	x		July-September
	3.	Aphanocapsa elachista var. plantonica G. M. Smith			x		x	x	x	July-September
	4.	Aphanocapsa delicatissima W. et G.S. West			x	x	x	x	x	All year
	5.	Aphanocapsa grevillei (Hassall) Rabenhorst					x			July-September
III	1.	Aphanothece clathrata W. et G.S. West	x	x	x		x	x	x	All year
	2.	Aphanothece nidulans P. Richt						x		July-March
IV	1.	Pelagoea bacillifera Lauterborn			x				x	June-August
	2.	Pelogoea chlorina Lauterborn			x				x	June-August
V	1.	Chroococcus limneticus Lemmermann	x		x	x	x	x	x	July-March
	2.	Chroococcus turgidus (Kützing) Naegeli							x	July-March
	3.	Chroococcus minimus (Keissler) Lemmermann			x					July-March
	4.	Chroococcus dispersus (Keissler) Lemmermann	x	x	x	x				July-November
	5.	Chroococcus dispersus var. minor G. M. Smith					x	x	x	July-November

			226N	226S	227	261	302N	302S	304	Season
V		(Contd.)								
	6.	Chroococcus turgidauer maximus - G.Huber-Pestalozzi			x					July-March
	7.	Chroococcus limneticus var. subsalsus - Lemmermann			x					July-March
	8.	Chroococcus limenticus var. elegans - G. M. Smith				x				July-March
VI	1.	Radiocystis geminata Skuja	x	x		x	x		x	July-March
VII	1.	Gomphosphosphaeria lacustris Chodat	x		x		x	x		July-March
	2.	Gomphosphosphaeria lacustris var. compacta Lemmermann		x			x	x	x	June-August
	3.	Gomphosphosphaeria aponina Kützing							x	June-August
VIII	1.	Coelosphaerium kretzingianum Naegeli					x	x		July-March
	2.	Coelosphaerium minutissimum -					x			July-March
IX	1.	Merismopedia tenuissima Lemmermann				x	x	x	x	July-March
	2.	Merismopedia punctata Meyen				x				July-March
	3.	Merismopedia glauca (Ehrenberg) Naegeli		x			x	x	x	July-March

			226N	226S	227	261	302N	302S	304	Season
X	1.	Gloeothece linearis var. composita G.M.Smith							x	July-October
	2.	Gloeothece linearis Naegeli							x	July-October
XI	1.	Rhabdoderma lineare Schmidle et Lauterborn	x	x	x	x	x	x	x	July-March
	2.	Rhabdoderma gorskii Woloszynska	x	x	x	x	x	x	x	July-March
XII	1.	Dactylococcopsis lineare Geitler			x	x			x	July-October
	2.	Dactylococcopsis Smithii R. et F. Chodat				x			x	July-October
XIII	1.	Phormidium sp.	x		x				x	June-October
XIV	1.	Aphanizomenon flos-aquae (Linneaus) Ralfs			x				x	August
XV	1.	Anabaena sotilaria f.a planctonica (Brunnth.) Komarek			x		x			July-April
	2.	Anabaena flos-aquae (Ryngbye) Brébisson	x							July-April
	3.	Anabaena circinalis Rubenhorst					x			July-April
	4.	Anabaena spiroides - Klebahn	x	x	x					August-November
XVI	1.	Spirulina laxa G.M. Smith			x					July-September
XVII	1.	Oscillatoria redekei Van Goor			x				x	May-October
	2.	Oscillatoria tenuis Agardh			x				x	May-October
	3.	Oscillatoria limetica Lemmermann			x	x			x	May-October

			226N	226S	227	261	302N	302S	304	Season
XVII	(Contd.)									
	4.	Oscillatoria geminata (Meneghini) Gomont			x				x	May-March
	5.	Oscillatoria amphigranulata Van Goor			x				x	May-March
	6.	Oscillatoria angustissima - W. et G.S. West			x					August
XVIII	1.	Lyngbya pseudospirulina Pascher					x		x	All year
	2.	Lyngbya pseudovacuolata-Vetter			x					July-September
XIX	1.	Pelonema sp.			x					July-October
Chlorophyta										
Protoblepharidinae										
Protoblepharidales										
Protoblepharidaceae										
I	1.	Pyramidomonas tetrarhynechus Schenarda			x	x	x		x	January-May
Euchlorophyinae										
Volvocales										
Chlamydomonadaceae										
II	1.	Chlamydomonas frigida Skuja		x						February-May
	2.	Chlamydomonas spp.	x	x	x	x	x	x	x	February-May
	3.	Chlamydomonas parvula - Gerl.					x		x	February-May

			226N	226S	227	261	302N	302S	304	Season
III	1.	Chlorogonium sp.			x	x				July-October
Volvocaceae										
IV	1.	Pandorina morum (Müller) Bory			x					June-September
V	1.	Volvox aureus Ehrenberg	x	x	x				x	July-September
Chlorodenoraceae										
VI	1.	Chlorangium polychlorum Skuja			x				x	August
Tetrasporales										
Palmellaceae										
VII	1.	Gloecystis planctonica (W. et G.S. West) Lemmermann				x	x			July-October
	2.	Planctosphaeria gelatinosa G. M. Smith			x					July-August
	3.	Phaceomyxa sphagnophila Skuja			x					July-August
VIII	1.	Gloeococcus schroeteri (Chodat) Lemmermann	x	x	x	x	x	x	x	May-October
Characiacea										
Hydrodicxyaceae										
IX	1.	Pediastrum duplex Meyen					x			June-August
	2.	Pediastrum boryanum (Turpin) Meneghini	x		x					June-August
	3.	Pediastrum tetras (Ehrenberg) Ralfs			x					June-October

			226N	226S	227	261	302N	302S	304	Season
Oocystaceae										
X	1.	Chlorella pyrenoidosa (Chick)	x	x	x					April-August
XI	1.	Oocystis submarina var. variablis Skuja	x	x	x	x			x	All year
	2.	Oocystis lacustris Chodat					x			April-August
	3.	Oocystis borgei Snow							x	All year
	4.	Oocystis submarina - Lagern			x		x		x	April-August
	5.	Oocystis gigas - Arch.					x			April-August
XII	1.	Lagerheimia ciliata (Lagerheim) Chodat			x	x				April-August
XIII	1.	Tetraëdron caudatum (Corda) Hansgirg	x		x					July-September
	2.	Tetraëdron minimum (A.B.R.) Hansg.			x					July-September
Coelastraceae										
XIV	1.	Scenedesmus quadricauda Chodat	x		x			x	x	May-October
	2.	Scenedesmus quadricauda var. longispina (Chodat) G. M. Smith			x					April-August
	3.	Scenedesmus denticulatus Lagerheim			x	x			x	July-September
	4.	Scenedesmus brevispina (G.M. Smith) Chodat			x				x	July-September

			226N	226S	227	261	302N	302S	304	Season
XV	1.	Dictyosphaerium pulchellum Wood			x		x	x	x	July-October
	2.	Dictyosphaerium simplex Skuja			x		x	x	x	July-October
	3.	Dictyosphaerium elegans - Bachman	x	x	x	x	x	x	x	July-October
XVI	1.	Crucigenia rectangularis (A.Braun) Gay	x				x			June-August
	2.	Crucigenia tetrapedia (Kirchner) W. et G. S. West					x	x		All year
XVII	1.	Coelastrum cambricum Archer				x			x	May-August
XVIII	1.	Kichnerella lunaris (Kirchner) Moebius				x				May-August
XIX	1.	Ankistrodesmus falcatus (Corda) Ralfs			x	x	x	x	x	All year
	2.	Ankistrodesmus falcatus var. spiralis (W.B. Turner) G.S. West			x		x	x		All year
	3.	Ankistrodesmus acicularis A. Braun			x					April-October
	4.	Ankistrodesmus falcatus var. spiraleformis (W. et G.S. West) G. S. West	x	x		x		x		All year
XX	1.	Quadrigula closteroides (Baulin) Printz	x	x	x	x	x	x	x	July-October
	2.	Quadrigula pfitzeri Schroeder				x			x	July-September

			226N	226S	227	261	302N	302S	304	Season
XXI	1.	Elakothothrix gelatinosa Wille				x	x	x	x	May-October
	2.	Elakothothrix viridis (Snow) Printz			x					May-October
XXII	1.	Planctonema lauterbornii Schmidle			x					August
Desmidiaceae										
XXIII	1.	Closterium pronum Brébisson		x		x				July-September
	2.	Closterium monififerum (Bory) Ehrnb.			x					July-September
	3.	Closterium striolatum West		x						July
	4.	Closterium aciculare West			x				x	July-September
XXIV	1.	Pleurotaenium sp.							x	July-October
XXV	1.	Cosmarium spp.	x	x	x	x	x	x	x	July-October
XXVI	1.	Euastrum denticulatum (Kirchner) Gay	x		x					June-October
	2.	Euastrum sp.		x	x		x	x	x	June-October
	3.	Euastrum pinnatum Ralfs				x				June-October
XXVII	1.	Xanthidium antilopaeum (Brébisson) Kützing				x			x	June-October
	2.	Xanthidium armatum (Brébisson) Rabenhorst			x					June-October
XXVIII	1.	Arthrodesmus incus (Brébisson) Hasslow	x	x	x	x	x	x	x	All year

			226N	226S	227	261	302N	302S	304	Season
XXIX	1.	Staurastrum curvatum W. West	x	x	x	x	x	x	x	August-October
	2.	Staurastrum cuspidatum Brébisson		x	x					July-October
	3.	Staurastrum lunatum var. planctonicum W. et G.S. West			x		x	x		July-October
	4.	Staurastrum paradoxum Meyen			x	x	x	x		July-October
	5.	Staurastrum paradoxum var. parvum W. West			x					July-October
	6.	Staurastrum cerastes Lund				x				July-October
	7.	Staurastrum clevei (Wittrock) Roy et Bisset			x					July-October
	8.	Staurastrum leptocladum Nordstedt							x	July-October
	9.	Staurastrum longimum var. spiniferum Scott et Groenblade			x					July-October
	10.	Staurastrum bullardii G.M. Smith	x	x			x		x	July-October
	11.	Staurastrum setigerum Cleve				x			x	July-October
	12.	Staurastrum arachne Ralfs			x	x			x	July-October
	13.	Staurastrum cf. anatinium Cooke et Wills	x	x						July-October
	14.	Staurastrum cf. anatinium ja. denticulatum G.M. Smith			x					July-October
	15.	Staurastrum elongatum Barker			x	x				July-October
	16.	Staurastrum chaetoceras (Schaöd) G.M. Smith			x					August-October
	17.	Staurastrum boreale W. et G.S. West			x					July-October
	18.	Staurastrum dejectum Bréb			x					July-October
	19.	Staurastrum parvum W. et G.S. West						x		July-October
	20.	Staurastrum pentacerum (Wolle) G.M. Smith				x	x		x	July-October

			226N	226S	227	261	302N	302S	304	Season
XXIX (Contd.)										
	21.	Staurastrum brachiatum Ralfs.			x					July-October
	22.	Staurastrum jaculiferum West			x					July-October
	23.	Staurastrum hystrix Ralfs			x				x	July-October
	24.	Staurastrum inconspicum Nordstedt							x	July-October
	25.	Staurastrum gracile var. nanum Wille	x	x	x	x	x	x	x	July-October
	26.	Staurastrum pachyrhynchum Nordstedt					x	x		July-October
	27.	Staurastrum gladiosum Turner				x				July-October
	28.	Staurastrum brasiliense var. lundelii W. et G.S. West			x					July-October
	29.	Staurastrum brevispinum Brébisson					x		x	July-October
	30.	Staurastrum gemillisparum Nordstedt			x					July-October
	31.	Staurastrum johnsonii W. et G.S. West			x					July-October
	32.	Staurastrum avicula Brébisson			x					July-October
XXX	1.	Sphaerozosma granutatum Roy et Bisset	x	x	x	x	x	x	x	March-October
XXXI	1.	Spondylosium planum (Wolle) W. et G.S. West			x	x			x	March-October
Euglenophyta										
Euglenales										
Euglenaceae										
I	1.	Euglena viridis Ehrenberg	x		x		x		x	February-October
	2.	Euglena acus Ehrenberg	x		x	x	x	x	x	February-October

			226N	226S	227	261	302N	302S	304	Season
II	1.	Lepocincis ovum (Ehrenberg) Lemmermann			x					May-August
III	1.	Phacus caudatus Hübner	x		x				x	May-October
	2.	Phacus longicauda (Ehrenberg) Dujardin	x	x	x		x	x	x	June-August
	3.	Phacus spp.	x	x	x	x				June-October
IV	1.	Trachelomonas volvocina Ehrenberg	x	x	x	x	x	x	x	All year
	2.	Trachelomonas hispida (Perty) Stein			x	x	x	x	x	All year
	3.	Trachelomonas oblonga Lemmermann			x	x				All year
	4.	Trachelomonas bacillifera Playfair			x				x	All year
	5.	Trachelomonas cf. cylindrica E. sec. Playfair			x				x	All year
	6.	Trachelomonas spinosa Stokes							x	July-October
	7.	Trachelomonas superba Suirenko	x	x	x	x	x	x	x	May-October
	8.	Trachelomonas armata var. longispina Playfair				x				July-October
	9.	Trachelomonas sp.			x	x				All year
V	1.	Astasia parvula Skuja			x					All year
Chrysophyta										
a. Chrysophyceae										
Chrysomonadidae										
Chromulinales										
Euchromulinaceae										
I	1.	Chromulina spp.	x	x	x	x	x	x		All year

			226N	226S	227	261	302N	302S	304	Season
II	1.	Chrysococcus rufescens Klebs			x					All year
III	1.	Kephyrion boreale Skuja	x	x	x	x	x	x	x	May-August
IV	1.	Kephyriopsis elegans Hilliard			x					May-October
	2.	Kephyriopsis gracills Hilliard			x					April-August
	3.	Kephyriopsis cordata Hilliard			x					October
Mallomonadaceae										
V	1.	Mallomonas globosa Schiller		x	x		x	x	x	March
	2.	Mallomonas reginae Teiling	x		x	x	x	x		All year
	3.	Mallomonas caudata Iwanoff	x	x	x	x	x	x	x	All year
	4.	Mallomonas acaroides Perty	x	x	x	x	x	x	x	All year
	5.	Mallomonas elongata Reverdin	x	x			x		x	All year
	6.	Mallomonas pseudocoronata Prescott	x		x		x	x		May-October
	7.	Mallomonas pumilio Harris et Bradley		x	x				x	June-March
	8.	Mallomonas pumilio var. Harris et Bradley			x	x	x	x	x	All year
	9.	Mallomonas papillosa Harris et Bradley	x		x					June-August
	10.	Mallomonas heterospina					x			June-September
	11.	Mallomonas akrokomos Ruttner					x	x		June-September
	12.	Mallomonas intermedia Kisselow	x	x	x	x	x	x	x	July-October
	13.	Mallomonas oviformis Nygaard			x					July-September
	14.	Mallomonas lelymene Harris et Bradley	x			x				July-October
	15.	Mallomonas coronata Pemain et Vinnikova			x	x				July-October

			226N	226S	227	261	302N	302S	304	Season
Isochrysidales/Isochrysidaceae										
VI	1.	Synura uvella Ehrenberg et Korschikow	x	x	x	x	x	x	x	May-August
	2.	Synura sphagnicola Korschikow	x	x	x	x	x	x	x	May-July
	3.	Synura adamsii G.M. Smith	x		x		x			July-September
	4.	Synura biorete Huber-pestalozzi	x		x	x				July-September
	5.	Synura lapponica Skuja		x					x	July-October
VII	1.	Dinobryon borgei Lemmermann		x	x		x	x	x	All year
	2.	Dinobryon suecicum var. longispinum Lemmermann			x	x	x	x	x	May-August
	3.	Dinobryon suecicum Lemmermann		x			x			May-August
	4.	Dinobryon crenulatum W. et G.S. West	x	x	x		x	x	x	May-August
	5.	Dinobryon acuminatum Ruttner			x					
	6.	Dinobryon bavaricum Imhof	x	x	x	x	x	x	x	All year
	7.	Dinobryon bavaricum var. vanhöffenii(Bachman) Krieger	x	x	x	x	x	x	x	May-August
	8.	Dinobryon divergens Imhof	x	x	x	x	x	x	x	All year
	9.	Dinobryon divergens var. schaunslandii (Lemmermann) Brunnthaler					x	x		July-December
	10.	Dinobryon cylindricum Imhof	x	x	x				x	All year
	11.	Dinobryon cylindricum var. palustre Lemmermann			x	x				All year
	12.	Dinobryon sertularia Ehrenberg	x	x	x			x	x	May-August
	13.	Dinobryon sertularia var. protruberans (Lemmermann) Krieger	x				x	x	x	May-August

			226N	226S	227	261	302N	302S	304	Season
VII (Contd.)										
	14.	Dinobryon pediforme (Lemmermann) Steineche					x	x		May-August
	15.	Dinobryon sociale Ehrenberg	x	x	x	x	x	x		April-August
	16.	Dinobryon sociale var. stipitatum (Stein) Lemmermann	x		x		x	x		April-August
	17.	Dinobryon sociale var. americanum (Brunnthaler) Bachmann	x	x	x				x	April-December
	18.	Dinobryon campanulastipitum Ahlstrom					x			June-September
VIII	1.	Chrysolykos planctonicus Mack							x	April-July
IX	1.	Chrysoikos skujai (Nauwerck) Willén				x			x	All year
X	1.	Ochromonas spp.			x		x		x	All year
XI	1.	Uroglena americana Calkins	x	x	x		x	x	x	May-October
Chrysosphaerellaceae										
XII	1.	Chrysosphaerella longispina Lauterborn	x	x	x	x	x	x		May-October
Lepochromonadaceae										
XIII	1.	Pseudokephyrion spp.	x	x			x	x		All year

			226N	226S	227	261	302N	302S	304	Season
XIV	1.	Epiphyxis tabellariae (Lemmermann) G.M. Smith	x	x	x			x		All year
	2.	Epiphyxis gracilis Hilliard			x	x			x	June-October
	3.	Epiphyxis spp.					x	x		All year
Rhizochrypidae										
Rhizochrysidales										
Rhizochrysidaceae										
XV	1.	Chrysostephanosphaera globulifera Scherffel				x	x	x		June-October
XVI	1.	Chrysocapsa planctonica (W. et G.S. West) Pascher			x					July-October
Chrysocapsinae										
Chrysocapsales										
Bitrichiaceae										
XVII	1.	Bitrichia chodatii (Reverdin) Chodat	x						x	May-June
Prymesiales										
Prymesiaceae										
XVIII	1.	Chrysochromulina cf. parva Lackey	x	x	x					May-December
Chrysosphaerales										
Stichogloeaceae										
XIX	1.	Stichogloea doederleinii (Schmidle) Wille				x	x	x		August-November

			226N	226S	227	261	302N	302S	304	Season
Craspedomonadales										
Bicoecaceae										
XX	1.	Bicoeca lacustris Clark				x				June-November
	2.	Bicoeca sp	x	x		x	x	x	x	All year
Heterokontae (= Xanthophyceae)										
Oleurochloridaceae										
XXI	1.	Isthomochloron trispinatum (West et West) Skuja	x	x	x	x	x	x	x	May-October
Gloeobotrydaceae										
XXII	1.	Gloeobotrys limneticus (G.M. Smith) Pascher	x	x	x		x	x		May-August
Botryococcaceae										
XXIII	1.	Botryococcus braunii Kützing	x	x	x	x	x	x	x	All year
	2.	Botryococcus protruberans W. et G.S. West				x				June-October
Bacillariophyceae										
centrales										
Coscinodiscaceae										
I	1.	Melosira granulata (Ehrenberg)		x			x	x		

			226N	226S	227	261	302N	302S	304	Season
I (Contd.)										
	2.	Melosira islandica helvetica O. Müeller	x	x	x	x	x	x	x	August
	3.	Melosira italica subarctica O. Müeller			x		x	x		March
	4.	Melosira distans (Ehrenberg) Krieger	x	x		x	x	x	x	All year
II	1.	Cyclotella küetzingiana Thwait			x					All year
	2.	Cyclotella stelligera Cleue	x		x		x			All year
	3.	Cyclotella comta Ehrenberg	x	x	x	x	x	x	x	All year
	4.	Cyclotella ocellata Pantocsele	x				x			All year
	5.	Cyclotella comensis			x		x	x		All year
Soleniaceae										
III	1.	Rhizosolenia eriense A.L. Smith	x	x	x	x	x	x	x	All year
	2.	Rhizosolenia longiseta Zacharias ?					x			All year
Pennales/Fragilariaceae										
IV	1.	Tabellaria fenestrata (lyngbya)Kützing	x	x	x	x	x	x	x	All year
	2.	Tabellaria flocculosa (Rothest)Kützing	x	x	x	x	x	x	x	All year
V	1.	Fragilaria crotonensis Kitton			x					All year
	2.	Fragilaria construens (Ehrenberg) Grunow			x		x		x	All year
	3.	Fragilaria spp.						x	x	All year

			226N	226S	227	261	302N	302S	304	Season
VI	1.	Synedra acus Kützing	x	x	x	x	x	x		All year
	2.	Synedra acus var. radians (Kützing) Hustedt	x		x		x	x	x	All year
	3.	Synedra acus var. angustissima Grunow			x		x	x		All year
	4.	Synedra ulna Ehrenberg				x	x	x	x	August-July
VII	1.	Asterionella formosa Hassall	x	x	x	x	x	x	x	All year
	2.	Asterionella gracillima (Hantzsch) Hassall			x				x	June-October
Pyrrophyta										
Chloromonadophyceae										
Chloromonadales										
Monomastigaceae										
I	1.	Monomastix opisthostigma Scherffel			x					June-July
Cryptophyceae										
Cryptomonadales										
Cryptomonadaceae										
II	1.	Rhodomonas minuta Skuja	x	x	x	x	x	x	x	October-June
	2.	Rhodomonas lacustris Pascher et Ruttner							x	All year

			226N	226S	227	261	302N	302S	304	Season
III	1.	Cryptomonas pusilla Bachmann	x	x	x	x	x	x	x	All year
	2.	Cryptomonas erosa Ehrenberg			x	x	x	x	x	All year
	3.	Cryptomonas ovata Ehrenberg	x	x	x	x	x	x	x	All year
	4.	Cryptomonas tenuis Pascher			x					August
	5.	Cryptomonas obovata Skuja	x	x	x	x	x	x	x	September-June
	6.	Cryptomonas marssonii Skuja	x	x	x		x		x	All year
	7.	Cryptomonas borealis Skuja				x				September-June
	8.	Cryptomonas platyuris Skuja			x				x	April-October
	9.	Cryptomonas rostratiformis Skuja			x	x			x	April-October
IV	1.	Chilomonas paramaecium Entz			x					July-August
Katablysharidaceae										
V	1.	Katablepharis ovalis Skuja	x	x	x	x	x	x	x	All year
Senniaceae										
VI	1.	Sennia parvula Skuja			x					April
	2.	Cryptaulex sp.			x				x	April
Peridineae (Dinophyceae)										
Gymnodenales										
Gymnodinisceae										
I	1.	Amphidinium luteum Skuja			x					All year

			226N	226S	227	261	302N	302S	304	Season
II	1.	Gymnodinium mirabile Penard	x	x	x	x	x	x	x	June-August
	2.	Gymnodinium ordinatum Skuja			x					May
	4.	Gymnodinium cf. lacustre Schiller				x				May-September
	5.	Gymnodinium helveticum Penard		x	x		x	x	x	All year
	6.	Gymnodinium sp	x	x			x	x		All year
	7.	Gymnodinium palustre Schilling	x	x		x	x	x	x	May-September
Peridinales/Glenodiniaceae										
III	1.	Glenodenium pascheri Suckland			x	x			x	February
	2.	Glenodinium spp.	x	x	x					All year
Peridiniaceae										
IV	1.	Peridinium cinctum Ehrenberg				x				June-September
	2.	Peridinium willei Huitfeldt-Kaas	x	x	x	x	x	x	x	All year
	3.	Peridinium palustre (Lindemann) Lefêvre	x		x					June-September
	4.	Peridinium aciculiferrim Lemmermann	x	x	x	x	x	x	x	All year
	5.	Peridinium wisconsiense Eddy	x		x	x	x	x	x	June-October
	6.	Peridinium inconspicum Lemmermann			x	x	x	x		June-October
	7.	Peridinium pusillum (Penard) Lemmermann	x	x	x	x	x	x	x	May-October
	8.	Peridinium goslaviense Woloszynska	x	x	x		x	x	x	June-September
	9.	Peridinium bipes Stein							x	June-October
V	1.	Ceratium hirundenella (Müller) Schrank	x	x	x	x	x	x	x	July-September
	2.	Ceratium carolinianum (Bailey) Jörgensen				x				July-September

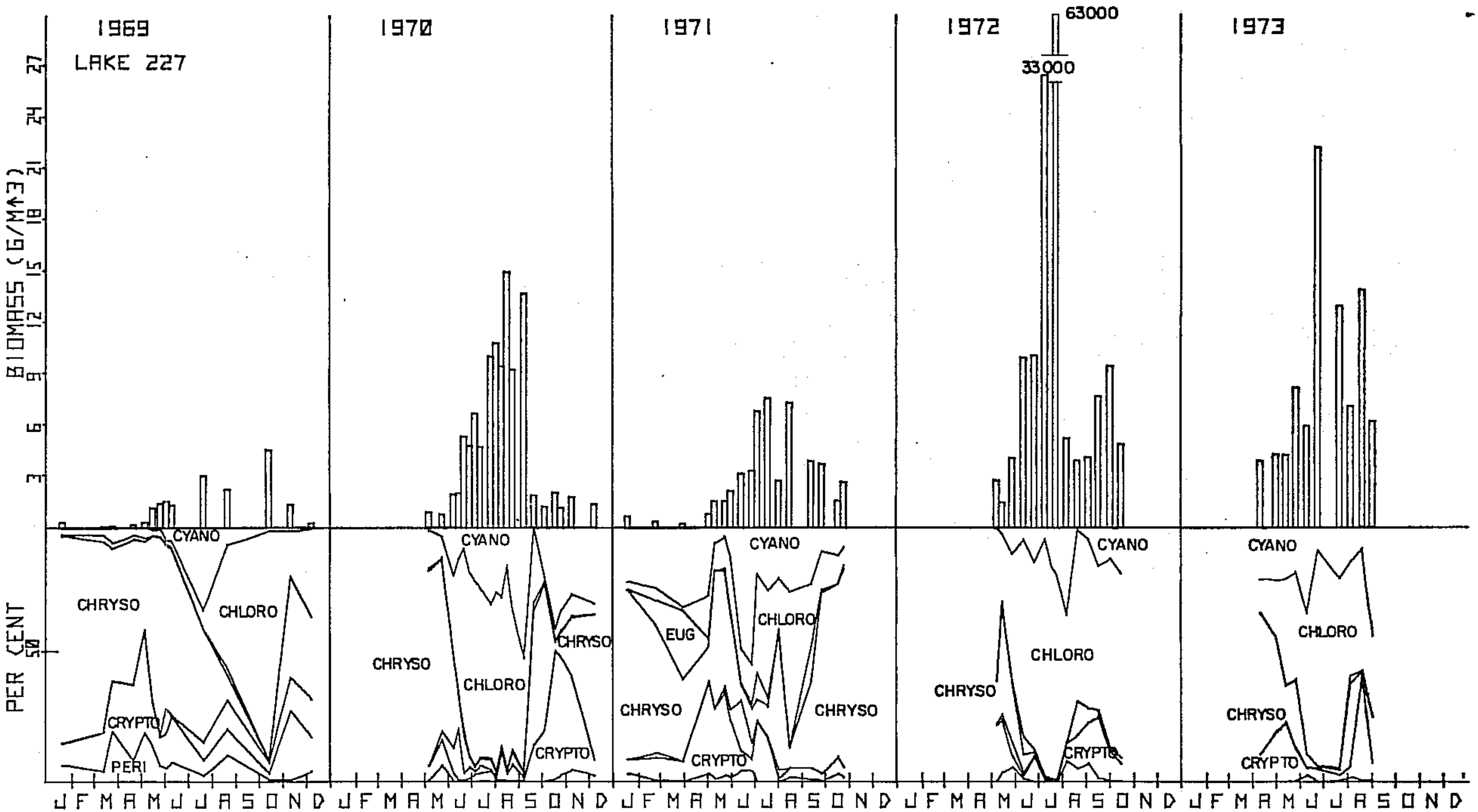

Figure 1. Average phytoplankton volume in the upper 7 meters in Lake 227 in 1969-1973, and accumulative per cent composition.

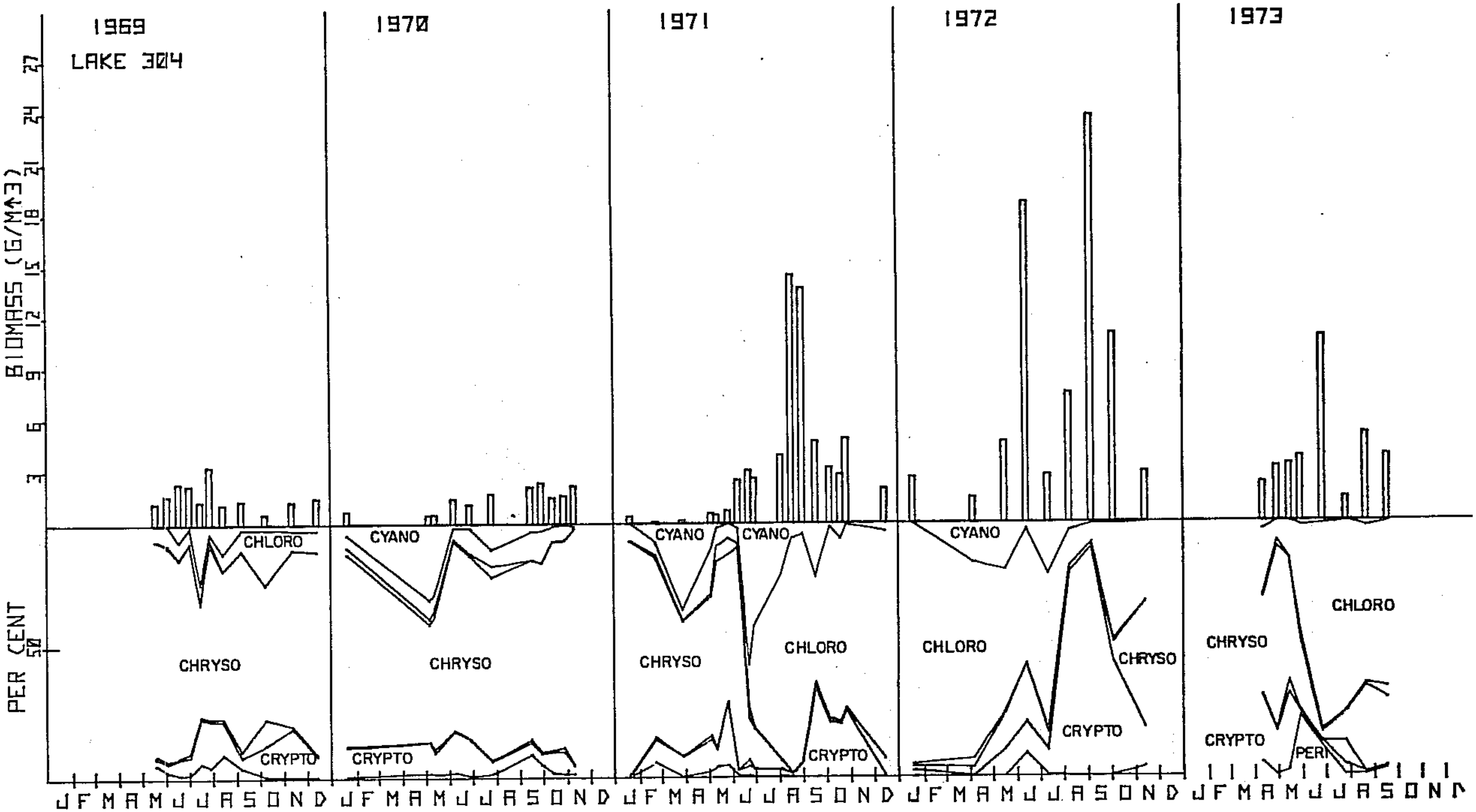

Figure 2. Average phytoplankton volume in the upper 7 meters in Lake 304 in 1969-1973, and accumulative percent composition.

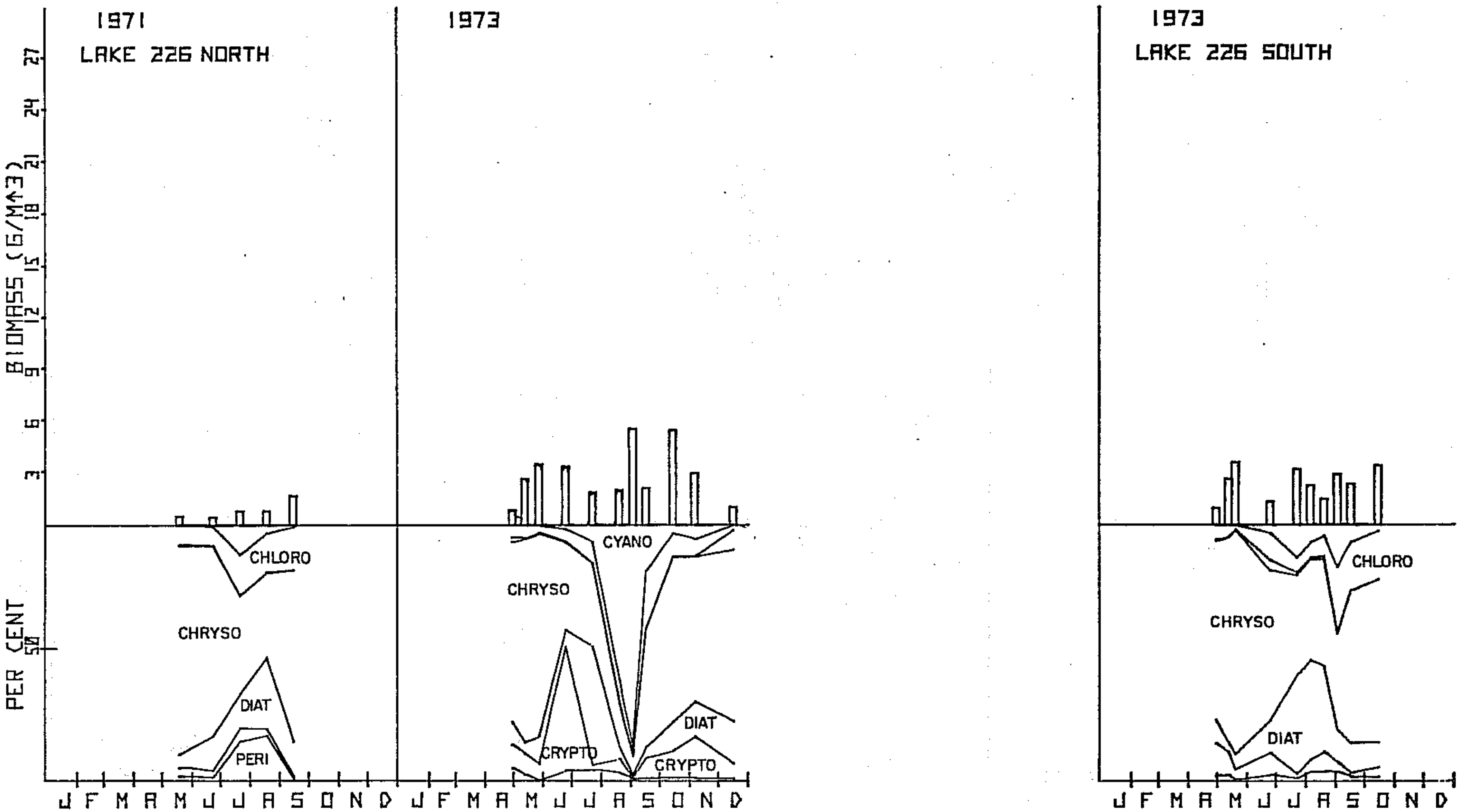

Figure 3. Average phytoplankton volume in the upper 7 meters in Lake 226 South West in 1973 and 226 North East in 1971 and 1973, and accumulative per cent composition.

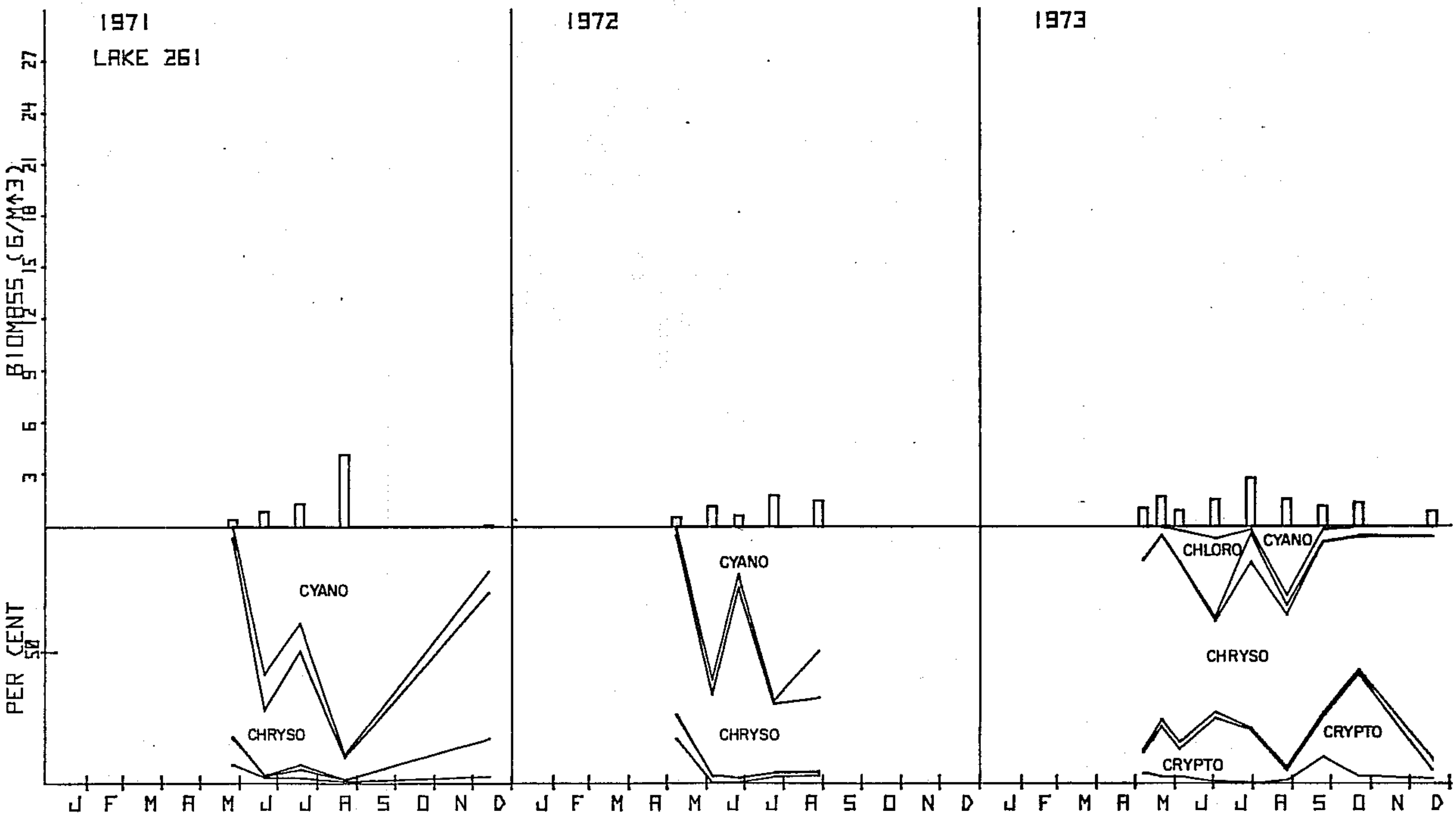

Figure 4. Average phytoplankton volume in the upper 7 meters in Lake 261 in 1971-1973, and accumulative per cent composition.

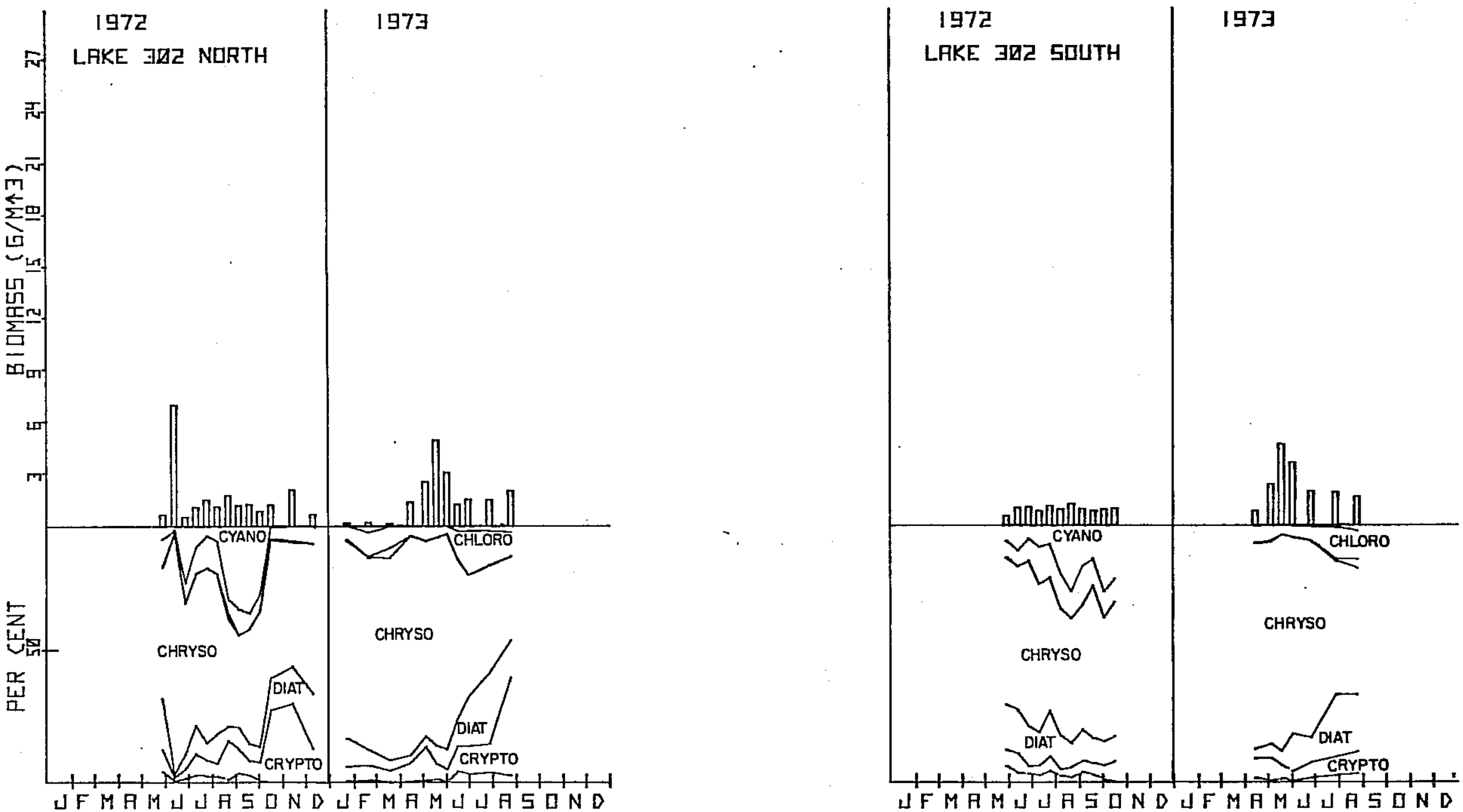

Figure 5. Average phytoplankton volume in the upper 7 meters in Lake 302 South 1972-1973 and Lake 302 North 1972-1973, and accumulative percent composition.