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SEASONAL SUCCESSIONS OF PHYTOPLANKTON IN SEVEN LAKE BASINS IN THE EXPERIMENTAL LAKES AREA, NORTHWESTERN ONTARIO, FOLLOWING ARTIFICIAL EUTROPHICATION. DATA FROM 1977 to 1979

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Findlay, D.L. 1981. Seasonal successions of phytoplankton in seven lake basins in the Experimental Lakes Area, Northwestern Ontario, following artificial eutrophication. Data from 1977 to 1979. Can. MS Rep. Fish. Aquat. Sci. 1627: iv + 40 p.

This report summarizes the changes in the phytoplankton communities of seven lake basins following artificial enrichment with nitrogen, phosphate and carbon. Data presented comes from studies of Lakes 227, 304, 226 (north and south basins), 261, and 302 (north and south basins) carried out from 1977 to 1979. Included are 14 figures showing total biomass and % composition and 14 lakes listing common species found throughout the study.

Key words: phytoplankton; planktonic algae; biomass; lakes; eutrophication; enrichment.

RESUME

Findlay, D.L. 1981. Seasonal successions of phytoplankton in seven lake basins in the Experimental Lakes Area, Northwestern Ontario, following artificial eutrophication. Data from 1977 to 1979. Can. MS Rep. Fish. Aquat. Sci. 1627: iv + 40 p.

Ce rapport résume les changements qui se sont produits au sein des populations de phytoplancton dans sept bassins, à la suite de leur enrichissement artificiel en azote, en phosphate et en carbone. Les données proviennent de l'étude des lacs 227, 304, 226 (bassins nord et sud), 261, et 302 (bassins nord et sud), effectuée entre 1977 et 1979. Le rapport comprend aussi 14 illustrations de biomasses totales et de leur composition (en pourcentages), ainsi que les noms de 14 lacs et des espèces communes que l'on y a retrouvées au cours de l'étude.

Mots-clés: phytoplancton; algues planctoniques; biomasse; lacs; eutrophisation; enrichissement.

INTRODUCTION

This report summarizes the seasonal successions of phytoplankton communities in seven lake basins in the Experimental Lakes Area (ELA) near Kenora, Ontario, from 1977 to 1979. Six of the seven basins have been subjected to nutrient addition of various types. The effects of artificial eutrophication and the recovery of lakes after artificial eutrophication are also discussed.

METHODS

This report is a continuation of studies reported by Kling and Holmgren (1972), Findlay and Kling (1975), and Findlay (1978). The methods used for sampling, counting and identification are as described in Findlay (1978).

BACKGROUND TO EXPERIMENTS

LAKE 227

Area 5.00 ha
Volume 2.21 x $10^5 m^3$
Mean Depth 4.4 m

Object of the experiment:
1969-1974: to test the hypothesis that carbon is not the biomass limiting nutrient.
1975-1979: to test if altering the N:P ratio of artificial nutrient additions from 15:1 to 5:1 (by weight) would cause the appearance of nitrogen fixing blue greens.

	C g/m^2/yr	N g/m^2/yr	P g/m^2/yr	Artificial Nutrient Ratio (by wgt) C N P
1969-1974		7 ($NaNO_3$)	0.50 (H_3PO_4)	0:14: 1
1975-1979		2.25 ($NaNO_3$)	0.46 (H_3PO_4)	0: 5: 1

LAKE 226 NORTH

Area 8.3 ha
Volume 4.72 x $10^5 m^3$
Mean Depth 5.7 m

Object of the experiment:
1973-1979: to test the hypothesis that phosphorus addition would cause the lake to become eutrophic and that a low ratio (5:1 by weight) of N:P would encourage the appearance of blue green algae capable of fixing atmospheric nitrogen.

	C g/m^2/yr	N g/m^2/yr	P g/m^2/yr	Artificial Nutrient Ratio (by wgt) C N P
1973-1979	3.69 (sucrose)	1.808 ($NaNO_3$)	0.34 (H_3PO_4)	10: 5: 1

LAKE 226 SOUTH

Area 7.8 ha
Volume 4.885 x $10^5 m^3$
Mean Depth 6.3 m

Object of the experiment:
1973-1979: to use as a control for the north basin and to test the hypothesis that carbon and nitrogen without phosphorus would not cause eutrophication.

	C g/m^2/yr	N g/m^2/yr	P g/m^2/yr	Artificial Nutrient Ratio (by wgt) C N P
1973-1979	3.69 (sucrose)	1.93 ($NaNO_3$)		10: 5: 0

LAKE 261

Area 5.6 ha
Volume 1.60 x $10^5 m^3$
Mean Depth 2.9 m

Object of the experiment:
1973-1976: to test the hypothesis that phosphorous, by itself, causes eutrophication.
1977-1979: to monitor the lake's recovery.

	C g/m^2/yr	N g/m^2/yr	P g/m^2/yr
1973-1976			0.246 (H_3PO_4)

1977-1979 no additions

LAKE 302 NORTH

Area 12.8 ha
Volume 7.32 x $10^5 m^3$
Mean Depth 5.7 m

Object of the experiment:
1972-1976, 1978: to test the hypothesis that discharging nutrients (C, N, P) below the thermocline will reduce the eutrophying effects which occur if nutrients are discharged into the epilimnion.

	C g/m²/yr	N g/m²/yr	P g/m²/yr	Artificial Nutrient Ratio (by wgt) C N P
1972-1976	3.73 (sucrose)	2.79 (NH_4CL)	0.536 (H_3PO_4)	7: 5: 1
1978	3.73 (sucrose)	2.79 (NH_4CL)	0.536 (H_3PO_4)	7: 5: 1

LAKE 302 SOUTH

Area 10.9 ha
Volume 5.54 x $10^5 m^3$
Mean Depth 5.1 m

Object of the experiment:
1972-1976, 1978: used as a control for the north basin which received C, N and P below the thermocline.
1972-1976, 1978: No additions

LAKE 304

Area 3.6 ha
Volume 1.15 x $10^5 m^3$
Mean Depth 3.2 m

Object of the experiment:
1971-1972: to test the hypothesis that additions of carbon would enhance eutrophication. This experiment was used as a comparison to Lake 227 which received no carbon and was naturally low in carbon.
1973-1974: to test the hypothesis that the deletion of phosphorus would reduce the eutrophying effects of enrichment.
1975-1976: to monitor the effects of extremely high loading rates of nitrogen and phosphorous.
1977-1979: to study the recovery from artificial enrichment.

	C g/m²/yr	N g/m²/yr	P g/m²/yr	Artificial Nutrient Ratio (by wgt) C N P
1971-1972	5.5 (sucrose)	5.2 (NH_4CL)	0.4 (H_3PO_4)	13.8:13: 1
1973-1974	5.5 (sucrose)	5.2 (NH_4CL)	(H_3PO_4)	
1975-1976		14.48 ($NaNO_3$)	1.01 (H_3PO_4)	0:14: 1
1977-1979	No additions			

RESULTS

LAKE 227

1977

Epilimnion (Fig. 1, Table 2): In early May, 1977, Lake 227 had an average epilimnetic biomass of 9,040 mg/m³. Chrysophyceae were 81% of the biomass and Cyanophyceae 14%. Fertilization began in mid May with weekly additions of $NaNO_3$ and H_3PO_4 at a N:P ratio of 5:1 by weight. At this time, species composition shifted to 35% chrysophytes, 30% cyanophytes, 14% cryptophytes and 13% chlorophytes. By early June, biomass had increased to 10,900 mg/m³. This increase correlates with a small bloom of Synedra acus, a diatom, which increased to 42% of the total biomass at this time. Biomass declined during June and by late June was 5,400 mg/m³. In early July, Chlorophyceae were 76% of the biomass of 6,600 mg/m³. Biomass increased throughout July to 16,800 mg/m³. Cyanophycean species first appeared in mid August and by late August they represented 77% of the total biomass of 36,000 mg/m. Aphanizomenon gracile was the dominant species. In early September, biomass reached 66,200 mg/m³, the highest biomass ever seen in the Experimental Lakes Area. Cyanophytes continued to represent over 70% of the biomass throughout most of September. In early October, biomass decreased to 6,350 mg/m³ consisting of 28% cyanophytes, 25% chrysophytes and 20% Peridineae. After this, Peridineae increased in abundance, representing 51% of the biomass by mid October and 66% by the end of the month. Total biomass increased to 21,400 mg/m³ by this time and sampling was discontinued because of the onset of ice-cover.

Metalimnion (Fig. 2, Table 3): The metalimnion in Lake 227 had an early spring biomass of 3,040 mg/m³. Chrysophyceae were 49% of the biomass, but Oscillatoria Redekei, a cyanophyte, was 26%. By mid May biomass had doubled to 7,900 mg/m³ and species composition had shifted to 32% chrysophytes, 23% chlorophytes, 23% cyanophytes and 11% cryptophytes. Biomass continued to increase throughout May and early June reaching 14,000 mg/m³ with species composition unaltered. Biomass then declined slightly, but by the end of June it had increased to 27,400 mg/m³. Chrysophyceae dominated (34%), but Peridineae (22%) and Cyanophyceae (21%) were also important. Biomass continued to increase and reached the yearly metalimnetic maximum in early August (34,234 mg/m³). Chlorophytes were 53% and cyanophytes were 38% of the biomass. By late August, Cyanophyceae increased to 67% of the total biomass of 33,400 mg/m³. Sampling was subsequently discontinued due to deepening of the epilimnion.

Hypolimnion: In 1977, the hypolimnion in Lake 227 was sampled only once (18 May) because light penetration was too low to allow photosynthesis in the hypolimnion for the rest of the summer. At this time the biomass was 4,430 mg/m³ and was 32% cryptophytes, 31% chlorophytes, 16% cyanophytes and 11% chrysophytes.

1978

Epilimnion (Fig. 1, Table 2): In early May 1978, the standing crop of 3,300 mg/m^3 was composed of 33% Cryptophyceae, 26% Cyanophyceae, 21% Chrysophyceae and 17% Chlorophyceae. Fertilization began in mid May with weekly additions of $NaNO_3$ and H_3PO_4 at a N:P ratio of 5:1 by weight and by late May several chlorophycean species became dominant and Chlorophyceae continued to dominate throughout the remainder of the year. In mid June biomass was 8,375 mg/m^3. Biomass declined to 4,210 mg/m^3 in mid July, then increased to 11,631 mg/m^3 by the end of the month. Biomass declined throuhgout August and in mid September was 5,590 mg/m^3. At that time, chlorophytes were 55% of the biomass and Cyanophyceae were 25%. In late September, biomass increased to 8,900 mg/m^3 and composed of 40% chlorophytes, 31% cyanophytes and 20% chrysophytes. Biomass decreased to 5,580 mg/m^3 in mid October at which point sampling was discontinued. Biomass estimates for 1978 were the lowest since artificial eutrophication began. Cyanophyceae did not dominate for the first time since the nitrogen to phosphorous ratio was reduced to 5:1 in 1975.

Metalimnion (Fig. 2, Table 3): The metalimnion in Lake 227 was not sampled until mid June because the depth of the epilimnion exceeded the depth of the euphotic zone. In mid June, biomass was recorded at 13,030 mg/m^3. Cryptophyceae were 51% of the biomass while Cyanophyceae and Chlorophyceae made up 22% and 14%, respectively. By mid July, Cyanophyceae increased to 65% of the standing crop with Oscillatoria Redekei being the major species. Biomass at this time was 13,050 mg/m^3. In early August the maximum yearly biomass of 16,815 mg/m^3 was recorded. By mid August, biomass had declined to 11,275 mg/m^3 and species composition shifted to a co-dominance of chlorophytes and cryptophytes. Biomass continued to decline reaching 9,890 mg/m^3 in mid September by which time Cryptophyceae had become dominant, representing 47% of the standing crop. Sampling was discontinued at this time due to fall mixing.

1979

Epilimnion (Fig. 1, Table 2): In mid May, 1979, the epilimnion was dominated by small chlorophytes (Chlamydomonas spp. and Chlorogonium maximum) and biomass averaged 2,360 mg/m^3. Artificial enrichment began in mid May with weekly additions of $NaNO_3$ and H_3PO_4 being added at a N:P ratio of 5:1 by weight. By late May, Chrysophyceae dominated with large populations of Chlorophyceae and Cyanophyceae remaining; biomass decreased at this time. In mid June, chlorophytes were 69% of the biomass with Scenedesmus denticulatus, Scenedesmus quadricauda, Chlamydomonas sp., and Oocystis lacustris being the major species. In late June, large populations of Oscillatoria Redekei and Oscillatoria limnetica appeared, becoming the dominant species by mid July. Biomass was 2,000 mg/m^3 at this time. By mid July biomass had increased to 8,740 mg/m^3 and the cyanophytes Oscillatoria limnetica, Anabaena c.f. cylindrica and Anabaena solitaria f.a. planctonica dominated. Biomass increased steadily throughout late July and early August, reaching 53,340 mg/m^3 in mid August. At this time, biomass was 96% Cyanophyceae of which 69% was Anabaena c.f. cylindrica and 26% was Oscillatoria limnetica. Cyanophyceae continued to dominate the standing crop throughout the remainder of August and September, decreasing to 41% by early October. Biomass declined throughout this period reaching 6,810 mg/m^3 in early October, when Chlorophyceae became dominant. They continued to dominate for the remainder of the ice-free season. In October, biomass fluctuated from 5,415 mg/m^3 to 8,010 mg/m^3.

Metalimnion (Fig. 2, Table 3): Sampling of the metalimnion began in late May, at which time the biomass was 1,360 mg/m^3 composed of 56% chlorophytes, 21% cyanophytes, and 16% chrysophytes. Chlorophyceae dominated throughout June and early July with Scenedesmus denticulatus as the dominant species. Biomass increased to 2,500 mg/m^3 in late June, then declined. Dominance shifted in late July to Cyanophyceae (Oscillatoria limnetica), which constituted 50% of the standing crop. Chlorophyceae biomass decreased to 37%. Cyanophyceae continued to dominate the plankton community for the remainder of the season, with Anabaena c.f. cylindrica becoming the dominant species. In early September, this species comprised 92% of the total biomass. Biomass increased from 3,140 mg/m^3 in late July to 32,175 mg/m^3 in late August when cyanophytes became dominant. Biomass then decreased through September averaging 20,660 mg/m^3 by mid September. Sampling ceased at this time because of fall mixing.

LAKE 226 SOUTH

1977

Epilimnion (Fig. 3, Table 4): In early May the biomass was 2,745 mg/m^3. Chrysophyceae were 57%. Artificial enrichment began in mid May with weekly additions of sucrose and $NaNO_3$. By mid May dominance had shifted to Diatomeae (Rhizosolenia eriensis) and biomass increased to 4,740 mg/m^3. Diatomeae dominated throughout June and early July, at times representing as much as 63% of the standing crop. Biomass increased to 7,760 mg/m^3 in early June then decreased. In late July, dominance shifted to Chlorophyceae (Spondylosium planum and Chlamydomonas sp). Biomass increased to 9,800 mg/m^3 by early August with the plankton assemblage being composed of 52% Chlorophyceae, 24% Chrysophyceae, and 13% Cyanophyceae. In late August Chlorophyceae and Cyanophyceae were co-dominant. By mid September cyanophytes (Anabaena solitaria f.a. planctonica and Oscillatoria limnetica) were 66% of the standing crop. Cyanophycean dominance lasted until early October when Chrysophyceae (Dinobryon sertularia) became co-dominant. Chrysophyceae dominated throughout October as Cyanophyceae decreased in importance.

Metalimnion (Fig. 4, Table 5): In early May the metalimnion biomass was 3,460 mg/m3 and was composed of 49% Chrysophyceae, 31% Diatomeae, and 8% Peridineae. By mid May, Diatomeae became dominant with Rhizosolenia eriensis being the major species. Biomass increased to 9,050 mg/m^3 in mid June when the diatoms Rhizosolenia eriensis and Cyclotella glomerata composed 63% of the standing crop. Diatomeae remained dominant until late July when Chrysophyceae (Synura spp.) became co-dominant. Chrysophyceae dominated from early August until mid September at which time dominance shifted to Cyanophyceae (Oscillatoria limnetica). Populations of

Chrysophyceae and Diatomeae were also present. Sampling ceased at this time due to deepening of the epilimnion.

Hypolimnion (Fig. 5, Table 6): The early spring biomass of 2,785 mg/m^3 was dominated by Chrysophyceae but substantial populations of Diatomeae and Chlorophyceae were also present. In early June Diatomeae (Rhizosolenia eriensis, Cyclotella glomerata, Synedra acus) dominated. Diatoms continued to dominate until mid July when sampling was terminated due to deepening of the metalimnion.

1978

Epilimnion (Fig. 3, Table 4): In early May the epilimnion biomass (1,080 mg/m^3) was dominated by Chrysophyceae (49%) and Cryptophyceae (43%). Fertilization began in mid May with weekly additions of sucrose and $NaNO_3$, as in previous years. Chrysophyceae continued to dominate throughout June and was 77% of the total biomass of 3,920 mg/m^3 in early July. Dominance shifted to diatoms in mid July. By mid August the standing crop had shifted to 36% Chrysophyceae, 31% Diatomeae, and 16% Cyanophyceae. In September, cyanophytes (Anabaena solitaria f.a. planctonica and Oscillatoria Redekei) dominated and biomass peaked at 4,680 mg/m^3. Cyanophyceae gave way to Chrysophyceae in late September and chrysophytes dominated for the remainder of the sampling season.

Metalimnion (Fig. 4, Table 5): The metalimnion was dominated by Chrysophyceae for the entire sampling season. Small populations of Cryptophyceae and Diatomeae were present throughout the season with a noticeable pulse of Cyanophyceae (Anabeana c.f. Levanderi, Oscillatoria Redekei, and Oscillatoria limnetica) in late August and September. Biomass ranged from 1,150 mg/m^3 in early spring to 5,695 mg/m^3 in the fall. Sampling ceased in late September as the metalimnion mixed with the epilimnion.

Hypolimnion (Fig. 5, Table 6): The hypolimnion was sampled three times in early spring and summer. Chrysophyceae dominated with small populations of Cryptophyceae, Chlorophyceae and Diatomeae appearing occasionally. Biomass increased from 1,181 mg/m^3 in mid May to 10,335 mg/m^3 in early July. This large increase in biomass was due to a rapid increase in Dinobryon sertularia and Chrysochromulina spp., chrysophytes, and Cyclotella comta, a diatom. Sampling was terminated in early July because the depth of the metalimnion exceeded the 1% light level.

1979

Epilimnion (Fig. 3, Table 4): The standing crop (1,100 mg/m^3) in mid May was dominated by Chrysophyceae with small populations of Cryptophyceae and Chlorophyceae. Artificial enrichment began in late May with weekly additions of sucrose and $NaNO_3$. Chrysophyceae continued to dominate the plankton assemblage throughout June, July and August; major species were Chrysochromulina parva, Dinobryon bavaricum, Uroglena americana, Chrysococcus sp., and Salpingoeca frequentissima. In addition to the dominant chrysophytes, populations of chlorophytes (Chlorella cf mucosa, Dictyosphaerium simplex, Chlamydomonas spp., Spondylosium planum), diatoms (Cyclotella glomerata, Synedra acus), and cryptophytes (Rhodomonas minuta, Cryptomonas erosa, Katablepharis ovalis) were present. Biomass ranged from 964 mg/m^3 in early July to 2,150 mg/m^3 in late July. Early in September Chlorophyceae became co-dominant with the already dominant Chrysophyceae. This co-dominance continued until mid September at which time Chrysophyceae became the dominant group. Chrysophyceae dominated for the remainder of the ice-free season with biomass averaging 1,440 mg/m^3 from mid September until late October.

Metalimnion (Fig. 4, Table 5): During May through September the metalimnion was dominated by Chrysophyceae. Populations of Peridineae, Diatomeae, Chlorophyceae, Cyanophyceae, and Cryptophyceae appeared occasionally throughout this period. Biomass fluctuated from 1,200 mg/m^3 to 2,175 mg/m^3, averaging 1,780 mg/m^3. In early October, Cryptophyceae became co-dominant with the existing chrysophycean population, each constituting 41% of the total biomass which was 1,415 mg/m^3. Sampling ceased in early October due to deepening of the epilimnion.

Hypolimnion (Fig. 5, Table 6): Sampling of the hypolimnion in Lake 226 south did not begin until mid June because the depth of the metalimnion exceeded the 1% light level until then.

Chrysophyceae dominated the standing crop during the three times the hypolimnion was sampled. Small populations of Diatomeae, Cryptophyceae, and Cyanophyceae occurred occasionally. Biomass ranged from 3,790 mg/m^3 to 7,835 mg/m^3.

LAKE 226 NORTH

1977

Epilimnion (Fig. 6, Table 7): Chrysophyceae represented 81% of the early spring biomass of 3,155 mg/m^3 standing crop. By mid May, biomass decreased to 1,825 mg/m^3 of which chrysophytes were 66%. Fertilization began in mid May with weekly additions of sucrose, $NaNO_3$ and H_3PO_4 being added at a N:P ratio of 5:1 by weight. Biomass increased to 4,870 mg/m^3 in mid June. Chrysophytes were 46% of the total biomass with diatoms and chlorophytes composing an additional 25% and 27%, respectively. In late June, a slight decrease in biomass was recorded (3,245 mg/m^3). Chlorophycean species increased to 32% while chrysophytes declined to 37%. By mid July, chlorophytes dominated the plankton assemblage and biomass increased to 6,880 mg/m^3. Biomass increased to 7,500 mg/m^3 by late July and in early August declined, with a decrease in chlorophytes and an onset of a Cyanophyceae bloom, mainly Oscillatoria Redekei, Oscillatoria limnetica and Anabaena solitaria fa. planctonica. Throughout August and early September biomass fluctuated between 5,300 and 6,300 mg/m^3 with dominance shifting from Oscillatoria Redekei in mid August to Anabeana solitaria fa. planctonica in early September, and in mid September to Oscillatoria limnetica. At this time biomass increased to 8,710 mg/m^3 and Cyanophyceae represented 80% of the standing crop. Cyanophyceae continued to dominate until mid October when Chrysophyceae became dominant and biomass decreased to 4,500 mg/m^3. At this time sampling was discontinued due to decreasing light penetration.

Metalimnion (Fig. 7, Table 8): Chrysophyceae were 75% of the early spring biomass of 4,140 mg/m^3. Biomass ranged from 2,000 mg/m^3 to 5,600 mg/m^3 during June, July and August and Chrysophyceae dominated with small populations of Diatomeae and Cryptophyceae. In mid September, dominance shifted to Oscillatoria limnetica, a cyanophyte, at which time biomass averaged 5,600 mg/m^3. Due to deepening of the epilimnion, sampling was discontinued.

Hypolimnion (Fig. 8, Table 9): During the early summer Chrysophyceae dominated with populations of Cryptophyceae present. Small populations of Chlorophyceae and Peridineae appeared in early spring and populations of cyanophycean species were present in early July. Biomass fluctuated from 1,800 mg/m^3 to 4,000 mg/m^3. Sampling ceased in mid July because the hypolimnion was below the 1% light level.

1978

Epilimnion (Fig. 6, Table 7): In early May, 1978, Lake 226 north had an epilimnetic biomass of 1,010 mg/m^3. Chrysophyceae were 58% and Cryptophyceae were 32% of the early spring standing crop of 1,010 mg/m^3. Artificial enrichment began in mid May with weekly additions of sucrose, $NaNO_3$ and H_3PO_4 being added at a N:P ratio of 5:1 by weight. Biomass increased steadily throughout June and early July reaching 5,840 mg/m^3 on July 12th. In mid June, Cyanophyceae (Oscillatoria limnetica and Anabaena solitaria fa. planctonica) were 31% of the standing crop and by mid July, Cyanophyceae represented 81% of the standing crop, of which 68% was Anabaena solitaria fa. planctonica and 24% was Oscillatoria limnetica. Biomass decreased to 2,080 mg/m^3 in late July and cyanophytes decreased to 68% of the standing crop. In mid August biomass increased to 11,990 mg/m3 and cyanophycean species represented 96% of the total biomass. This increase correlated with the appearance of a new cyanophycean species (in the E.L.A. Area), Anabaena c.f. Levanderi. Biomass continued to increased and reached a yearly epilimnetic maximum of 17,390 mg/m^3 in early September. Throughout the remainder of September cyanophytes decreased to 65% of the standing crop and biomass decreased to 6,500 mg/m^3. Biomass continued to decrease and by mid October was 3,450 mg/m^3. Cyanophyceae represented 38% of the biomass with Chrysophyceae and Cryptophyceae representing 32% and 20%, respectively.

Metalimnion (Fig. 7, Table 8): The biomass was 1,475 mg/m^3 in mid May when sampling began. Chrysophyceae made up 69% of the standing crop; Cryptophyceae were 24%. Biomass increased throughout June and early July reaching 7,310 mg/m^3, a metalimnetic yearly maximum. Chrysophyceae were 60% of the biomass and Cyanophyceae represented 21%. In mid July, the biomass decreased to 2,515 mg/m^3 and the composition shifted to 45% cyanophytes and 30% chrysophytes. Cyanophyceae continued to dominate and, in mid August, represented 58% of the biomass with Anabaena solitaria fa. planctonica being the major species. Biomass at this time increased to 4,620 mg/m^3. Sampling was discontinued at this time due to deepening of the epilimnion in relation to the 1% light level.

Hypolimnion (Fig. 8, Table 9): The hypolimnion was sampled twice in 1978. The first was in mid May when a biomass of 1,675 mg/m^3 was recorded. The standing crop was 63% Chrysophyceae, 21% Cryptophyceae and 9% Chlorophyceae. In early June the biomass was 4,320 mg/m^3. Cryptophyceae (mainly Cryptomonas spp.) were dominant. Sampling ceased at this time because the hypolimnion was below the euphotic zone.

1979

Epilimnion (Fig. 6, Table 7): In mid May, 1979, the standing crop was 1,875 mg/m^3 of which 58% were Chrysophyceae, 27% Cryptophyceae, 8% Peridineae, and 7% Chlorophyceae. Fertilization began at this time with weekly additions of sucrose, $NaNO_3$ and H_3PO_4. Biomass increased to 4,840 mg/m^3 by late June. Chrysophyceae continued to dominate the standing crop until early July when dominance shifted to Chlorophyceae (Spondylosium planum) with large populations of Cyanophyceae (Anabaena c.f. cylindrica) and Chrysophyceae. By late July, Chlorophyceae represented 60% of the biomass (5,940 mg/m^3); Spondylosium planum was 46% of the total. Chlorophyceae continued to dominate throughout August with biomass excalating to 11,815 mg/m^3 late in the month. Biomass decreased in early September at which time the standing crop consisted of 60% Chlorophyceae (Spondylosium planum), 22% Cyanophyceae, and 14% Cryptophyceae. Dominance shifted to Cyanophyceae in mid September, Anabaena c.f. levanderi and Anabaena c.f. cylindrica being the dominant cyanophycean species. Biomass decreased in early September to 5,150 mg/m^3. Cyanophycean dominance lasted until early October, when dominance reverted to Chrysophyceae (Dinobryon sociale, Chrysochromulina parva) which constituted 58% of the biomass. Cyanophyceae and Chlorophyceae added an additional 15% and 12%, respectively; biomass increased slightly at this time. Chrysophyceae dominated the epilimnion for the remainder of the ice-free season with populations of chlorophytes, cyanophytes and diatoms occurring. Biomass decreased to 4,980 mg/m^3 by late October.

Metalimnion (Fig. 7, Table 8): In 1979, sampling began in late May. Chrysophyceae dominated with large populations of Cryptophyceae present and biomass averaged 3,955 mg/m^3. Chrysophycean dominance lasted until late July when Cyanophyceae (Anabaena c.f. cylindrica) and Chlorophyceae (Spondylosium planum) were co-dominant. Biomass increased to 5,015 mg/m^3 at this time. By early August, Chlorophyceae dominated the standing crop which was 48% chlorophytes, 30% cyanophytes, and 10% cyrptophytes. Chlorophyceae continued to dominate and, by early September, constituted 73% of the biomass of which Spondylosium planum represented 63%. Biomass peaked at this time reaching 17,295 mg/m^3. Biomass decreased rapidly and by mid September was 3,620 mg/m^3. Chlorophyceae were 37% of the biomass with 27% Cyanophyceae, 15% Chrysophyceae, and 13% Cryptophyceae. Sampling was terminated at this time.

Hypolimnion (Table 9): The hypolimnion was sampled only once in 1979 in mid June. Biomass was 2,185 mg/m^3 and the phytoplankton community was dominated by Chrysophyceae (51%) with a large population of Cryptophyceae present (41%).

LAKE 304

1977

Epilimnion (Fig. 9, Table 10): Artificial enrichment of Lake 304 was discontinued in 1977. Sampling was continued for two years to follow its recovery.

Sampling began in early May (1977). At this time, the biomass of 720 mg/m^3 was 37% cryptophytes, 33% chrysophytes and 22% chlorophytes. Biomass increased throughout May and reached 3,050 mg/m^3 in early June. Cyanophyceae (Aphanizomenon flos-aquae) were 66% of the biomass with chrysophytes and cryptophytes representing an additional 15% and 10%, respectively. By early July, dominance shifted to Chrysophyceae and biomass decreased to 2,595 mg/m^3. Chrysophyceae continued to dominate until late September at which time Cryptophyceae became dominant. Biomass increased from late July until late August reaching 5,925 mg/m^3 then declined throughout September and October to 2,745 mg/m^3.

Metalimnion (Fig. 10, Table 11): The early spring biomass was 22,780 mg/m^3. Cryptophyceae were 73% of the standing crop with Cryptomonas ovata and Cryptomonas erosa being the major species. Biomass increased throughout May and, in early June, a yearly metalimnetic maximum was recorded (25,570 mg/m^3). Cryptophytes were 89% of the standing crop. By early July, biomass began to slump and, in early August, a biomass of 1,085 mg/m^3 was recorded. Species composition shifted to a dominance of Euglenophyceae. Biomass increased throughout August reaching 13,160 mg/m^3. Euglenophyceae remained dominant representing 86% of the biomass. Sampling ceased at this time due to fall mixing of the epilimnion.

1979

Epilimnion (Fig. 9, Table 10): Chrysophyceae (Uroglena americana, Chrysochromulina parva, Dinobryon divergens, and Dinobryon sertularia) dominated from mid May until late October constituting from 50% to 92% of the standing crop. Small populations of Cryptophyceae, Peridineae, and Cyanophyceae appeared occasionally. Biomass fluctuated from a minimum of 660 mg/m^3 in mid June to a maximum of 5,810 mg/m^3 in late September. By late October, dominance shifted to Cryptophyceae which represented 53% of the standing crop. Biomass averaged 5,150 mg/m^3 at this time.

Metalimnion (Fig. 10, Table 11): Biomass in mid May was 860 mg/m^3 composed of 55% Chrysophyceae, 19% Cryptophyceae, and 17% Chlorophyceae. In early June, biomass decreased to 255 mg/m^3 (the lowest value ever recorded at E.L.A.) and Chrysophyceae constituted 84% of the standing crop. By mid June, biomass increased to 925 mg/m^3 with dominance shifting from chrysophytes to cryptophytes which represented 70% of the biomass. Chrysophyceae and Cryptophyceae became co-dominant in early July each representing 36% of the standing crop with Chlorophyceae and Cyanophyceae composing an additional 12% and 10%, respectively. This trend continued until mid August when the plankton assemblage was 37% Euglenophyceae, 33% Cryptophyceae, and 20% Chlorophyceae. Euglena acus, a euglenophyte, represented 36% of the standing crop at this time with biomass increasing to 2,930 mg/m^3. Due to deepening of the epilimnion, sampling was discontinued in mid August.

LAKE 261

1977

Epilimnion (Fig. 11, Table 12): In 1977, fertilization of Lake 261 with H_3PO_4 was discontinued. Sampling was continued for three years to follow its recovery. Sampling began in mid May when a biomass of 3,315 mg/m^3 was recorded. The phytoplankton population was represented by 51% chrysophytes, 29% chlorophytes and 17% cryptophytes. Biomass decreased to 1,800 mg/m^3 in early June and dominance shifted to chlorophytes (Crucigeniella rectangularis). Chlorophyceae continued to dominate throughout June and July and biomass increased, reaching a yearly maximum of 4,020 mg/m^3. In August Cyanophyceae (Chroococcus limneticus) constituted 40% of the standing crop and chlorophytes were 37%. Cyanophyceae dominance lasted until late August when several chrysophycean species appeared, representing 62% of the biomass which was 2,410 mg/m^3. Throughout September and October, Chrysophyceae dominated with small populations of cyanophytes, chlorophytes, cryptophytes and dinoflagellates occurring. Biomass fluctuated from 1,725 mg/m^3 to 2,680 mg/m^3 during this time.

Metalimnion (Fig. 12, Table 13): In early May Chlorophytes were 52% and chrysophytes were 33% of the biomass of 3,245 mg/m^3. By early June, biomass doubled (6,708 mg/m^3) and chlorophytes continued to dominate with a large population of chrysophytes present. Biomass decreased in July and was composed of 45% chlorophytes, 29% chrysophytes, 12% cyanophytes and 9% cryptophytes. In early August, biomass was 2,390 mg/m^3. Chlorophyceae and Chrysophyceae were co-dominant with a small population of Cryptophyceae present. In late August, Cryptophyceae were 62% of the total biomass which peaked at 7,890 mg/m^3. Sampling was discontinued at this time due to fall mixing of the epilimnion.

1978

Integrated (0-7 m) (Fig. 11, Table 12): Lake 261 was sampled four times using a pump (Shearer, 1978) to integrate from 0 to 7 meters. As in 1977, Lake 261 was not fertilized with H_3PO_4.

In early spring the biomass was 1,695 mg/m^3. Chrysophyceae were 73% of the biomass and Chlorophyceae an additional 16%. In mid June, biomass increased to 2,500 mg/m^3 and Chrysophyceae were 85% of the standing crop with Dinobryon spp. being the major species. Biomass continued to remain in this range but in early August Cyanophyceae were 56% of the standing crop. In early October, a biomass of 1,045 mg/m^3 was recorded and Chrysophyceae dominated constituting 52% of the biomass with cyanophytes and chlorophytes representing 25% and 13%, respectively.

1979

Epilimnion (Fig. 11, Table 12): In mid May, biomass was 1,105 mg/m^3 and was dominated by Chrysophyceae (Dinobryon sertularia). By early June, biomass decreased to 500 mg/m^3, then increased to 860 mg/m3 in mid June. Species composition shifted at thismtime to 49% Chrysophyceae and 39% Chlorophyceae. Biomass continued to increase until mid July at which time a large population of cyanophycean species (Chroococcus limneticus) appeared in addition to the already dominant chrysophytes and chlorophytes. This trend continued until late August when dominance shifted to Chroococcus limneticus and Synechococcus linearis (cyanophytes) which constituted 46% of the total standing crop. Biomass ranged from 950 mg/m^3 to 1,350 mg/m^3 throughout this period. By mid September, species composition began to revert to Chrysophyceae which dominated the epilimnion for the remainder of the ice-free season. Biomass decreased from 1,670 mg/m^3 to 850 mg/m^3 in late October.

Metalimnion (Fig. 12, Table 13): The metalimnion in Lake 261 was dominated by Chrysophyceae for the entire sampling season, 1979. In addition, small populations of Peridineae, Cryptophyceae, Chlorophyceae, and Cyanophyceae appeared periodically. Chrysococcus sp., Dinobryon sertularia, Dinobryon bavaricum, Chromulina sp., Botryococcus protruberans, and Uroglena americana dominated the chrysophycean populations. Biomass fluctuated from an early spring value of 950 mg/m^3 to a metalimnetic maximum of 4,335 mg/m^3 in early July. Sampling stopped in late September when the depth of the epilimnion exceeded the 1% light level.

LAKE 302 SOUTH

1978

Epilimnion (Fig. 13, Table 14): In early May the epilimnetic biomass was 675 mg/m^3. Chrysophyceae dominated with a small population of chlorophytes present. Biomass remained low throughout May and early June. In late June, biomass reached a yearly maximum of 2,170 mg/m^3 at which time Chrysophyceae constituted 92% of the standing crop. Chrysophyceae continued to dominate for the remainder of the ice-free season with populations of chlorophytes and diatoms occurring throughout the season. Biomass fluctuated between 900 mg/m^3 and 1,200 mg/m^3 from July until late October when sampling ceased.

Metalimnion (Fig. 13, Table 14): In late spring the biomass was 1,150 mg/m^3. Chrysophyceae were 79% of the biomass and Cryptophyceae 11%. Biomass increased steadily throughout June and, in mid July, a yearly metalimnetic maximum biomass of 5,725 mg/m^3 was recorded. Chrysophyceae were 87% of the standing crop. Biomass decreased in early August to 3,665 mg/m^3 and species composition shifted to 73% chrysophytes, 13% chlorophytes and 10% cryptophytes. By mid Setpember Cryptophyceae (Cryptomonas rostratiformis and Cryptomononas erosa) were 72% of the total biomass of 4,525 mg/m^3 and Chlorophyceae 15%. Sampling of the metalimnion was discontinued at this time because the epilimnion was mixed below the 1% light level.

Hypolimnion (Fig. 13, Table 14): The hypolimnion was sampled twice (31 May and 28 June). Chrysophyceae were over 70% of the total biomass. Chlorophyte and diatom populations were also present. Biomass on the two dates were 960 mg/m^3 to 1,210 mg/m^3, respectively.

LAKE 302 NORTH

1978

Epilimnion (Fig. 14, Table 15): In early May the standing crop of 1,250 mg/m^3 was 63% Chrysophyceae and 26% Chlorophyceae. Fertilization began in mid May with weekly additions of sucrose, NH_4Cl and H_3PO_4 being pumped below the thermocline (8 meters). Biomass increased throughout June reaching 3,130 mg/m^3 with chrysophytes dominating, constituting 89%of the standing crop. Biomass decreased throughout July and in early August was recorded at 803 mg/m^3 (40% chrysophytes and 32% chlorophytes). In late August, biomass doubled to 1,750 mg/m^3. This increase correlates with an increased in diatoms, mainly Rhizosolenia eriensis. Throughout September and early October biomass remained constant (1,315 mg/m^3) as did species composition. In late October dominance shifted to 59% Cryptophyceae with Cryptomonas spp. being the major species. At this time biomass increased to 3,176 mg/m^3.

Metalimnion (Fig. 14, Table 15): The metalimnion was dominated by chrysophycean species during the entire sampling season, with small populations of chlorophytes and cryptophytes present. Biomass fluctuated from 3,000 mg/m^3 to 4,200 mg/m^3 from May until late July. In early August a decrease in biomass was recorded (1,031 mg/m^3) but, by late August biomass increased to 3,690 mg/m^3. Sampling was discontinued due to fall mixing of the epilimnion.

Hypolimnion (Fig. 14, Table 15): The hypolimnion was sampled twice in 1978. In late May the biomass was 3,526 mg/m^3. Chrysophyceae dominated with several species contributing. In late June biomass was 5,343 mg/m^3 and Chrysophyceae continued to dominate representing 58% of the biomass with an additional 32% being represented by chlorophytes. Sampling was discontinued at this time because the metalimnion extended below 1% light level.

DISCUSSION

Epilimnetic fertilization with C , N and P

Biomass in Lakes 226 North and 227 in 1977 1979 are two times higher than those recorded for Lake 226 North with the exception of 1978 when they were equal. These estimates for Lake 227 are 200 to 700% higher (Table 1) than prefertilization estimates for this lake, control lakes in the Experimental Lakes Area and Lake 226 South.

Biomass in Lake 226 North is two to three times higher than in the south basin, which receives the same fertilization with N and C but no H_3PO_4. Biomass in the south basin of 226 has shown an increase since additions of C and N started (Table 1). The extremely high values in 1977 are due to a rip in the curtain separating the two basins (which was not discovered for several weeks) allowing the two basins to mix. This increase in biomass correlates well with total dissolved Phosphorus for the south basin (Fig. 15). Biomass values from 1973 to 1979 have increased 45% from the lowest value to the highest (Table 1). This increase in biomass may be stimulated by phosphorous seeping through and over the curtain (since the curtain is not watertight). No immediate response was seen because of the low amounts seeping in but over a period of time a significant accumulation built up.

Biomass estimates for Lake 226 north appear to be very stable averaging 5,400 mg/m^3. This is two to three times higher than estimates for our control lakes as well as for the south basin (1978 and 1979).

As previously documented (Findlay and Kling 1975; Findlay 1978), both Lake 227 and Lake 226 North have cyanophycean blooms which occur in midsummer and last into the fall. Lake 226 north has had a cyanophycean population (Anabaena spp.) capable of nitorgen fixation (Flett 1976), since fertilization began in 1973. In Lake 227 cyanophytes (capable of nitrogen fixation) did not dominate until 1975, when the N:P ratio in fertilizer was shifted to 5:1 by weight from the ratio of 15:1 used in 1969-1974 (Schindler 1977). Since then, nitrogen fixing species of Anabaena and Aphanizomenon have been the dominant Cyanophyceae. It is apparent that phosphorous is the nutrient which influences the phytoplankton biomass the greatest, but the ratio between it and nitrogen is critical in determining whether blue green dominance will occur (Schindler 1977).

Hypolimnetic fertilization

Lake 302 North was fertilized and sampled only in 1978 in the 1977-1979 period. As in previous years, fertilizer was pumped below the thermocline.

Mean epilimnetic biomass for 1978 is comparable to prefertilization estimates and lower than any other year of fertilization (Table 1). Biomass estimates for the north basin are also very comparable to the south basin which receives no enrichment.

The mean hypolimnetic biomass (302 North), however, was higher in 1978 than the two previous years of fertilization (1975, 1976) which are comparable to the biomass estimates for the south basin.

There appears to be no significant change in species composition throughout the euphotic zone when comparing 1978 with 1975 and 1976 (Findlay 1978) or with the south basin (Figs. 14 and 15). Chrysophyceae continued to dominate with populations of Chlorophyceae, Diatomeae and Cryptophyceae present.

It appears that pumping the fertilizer below the thermocline has prevented epilimnetic algae blooms, at least until late fall when turnover occurs (Schindler et al. 1980).

Recovery from epilimnetic enrichment with C, N and P

In the fall of 1976, Lake 304 received its last addition of C, N and P. In 1977 and 1979 it was sampled to monitor its recovery.

There was a slight decrease in mean epilimnetic biomass in 1977 (Table 1) and a significant decrease in 1979, when biomass estimates decreased to prefertilization estimates. Species composition also changed significantly following the termination of enrichment. During years of enrichment and one year after (1977) Lake 304 had a summer bloom of Cyanophyceae, usually Anabaena or Aphanizomenon. In 1979 this bloom was insignificant in relation to the other plankton populations present. In 1977 and 1979 Cryptophyceae became dominant in mid-October with large populations of Chrysophyceae present. This was similar to the species composition prior to fertilization.

The most drastic effect was seen in the metalimnion. Biomass values remained high in 1977 (Table 1) but decreased significantly by 1979 (Fig. 9). Species composition also shifted, with Chrysophyceae and Cryptophyceae dominating until fall, when a large population of Euglenophyceae occurred. This assemblage was similar to that found during prefertilization years. During years of enrichment Chlorophyceae was the dominant group in this zone.

Water quality in Lake 304 has recovered to prefertilization values as did species composition over the course of three years.

Recovery from epilimnetic enrichment with H_3PO_4

Artificial enrichment of Lake 261 ceased in 1977. It has been monitored for 3 years (1977-1979) to study the recovery from H_3PO_4 additions.

Mean biomass in the epilimnion indicates that there was a decrease of over 2x between 1977 and 1979, after fertilization ceased. 1979 values are comparable with those obtained prior to fertilization (Table 1).

Since enrichment ceased (1977) species composition has also reverted to that recorded by Findlay and Kling (1975), when Chrysophyceae usually dominated and large populations of Cyanophyceae were present and occasionally dominating.

It appears from the data presented that fertilization with H_3PO_4 did accelerate eutrophication and that within 2 years after enrichment ceased the standing crop returned to its prefertilization status.

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Table 1. Mean biomass for ice-free seasons.

		Mean Biomass mg/m³										
Lake	Strata	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
227	Epi	1966	5692	3709	13317	10139	10242	9711	11509	13390	6595	14048
	Meta								13885	17003	12811	10619
	Hypo							11535	6347			
226 North	Epi			836		3342	5000	8570	5597	5335	5504	5509
	Meta								2008	3620	4224	6308
	Hypo							6288	2640	2854	2997	
226 South	Epi					2589	2666	3005	3498	5672	2953	1526
	Meta								5034	6627	4040	1743
	Hypo							5954	5499	4928	4553	5462
302 North	Epi				1658	2460	5212	2155	3255		1708	
	Meta								3146		3221	
	Hypo							3031	4111		4435	
302 South	Epi				935	2716	2439	1907	2314		1041	
	Meta								4519		3505	
	Hypo							3628	3951		1085	
304	Epi	1693	1441	4456	11481	4712	3511	3295	4320	3418		2627
	Meta								6374	14332		1069
	Hypo							5739	7934			
261	Epi			1781	1128	1523	2531	2008	2859	2653	1893	1217
	Meta								2869	4671		2743
	Hypo							4969	3491			

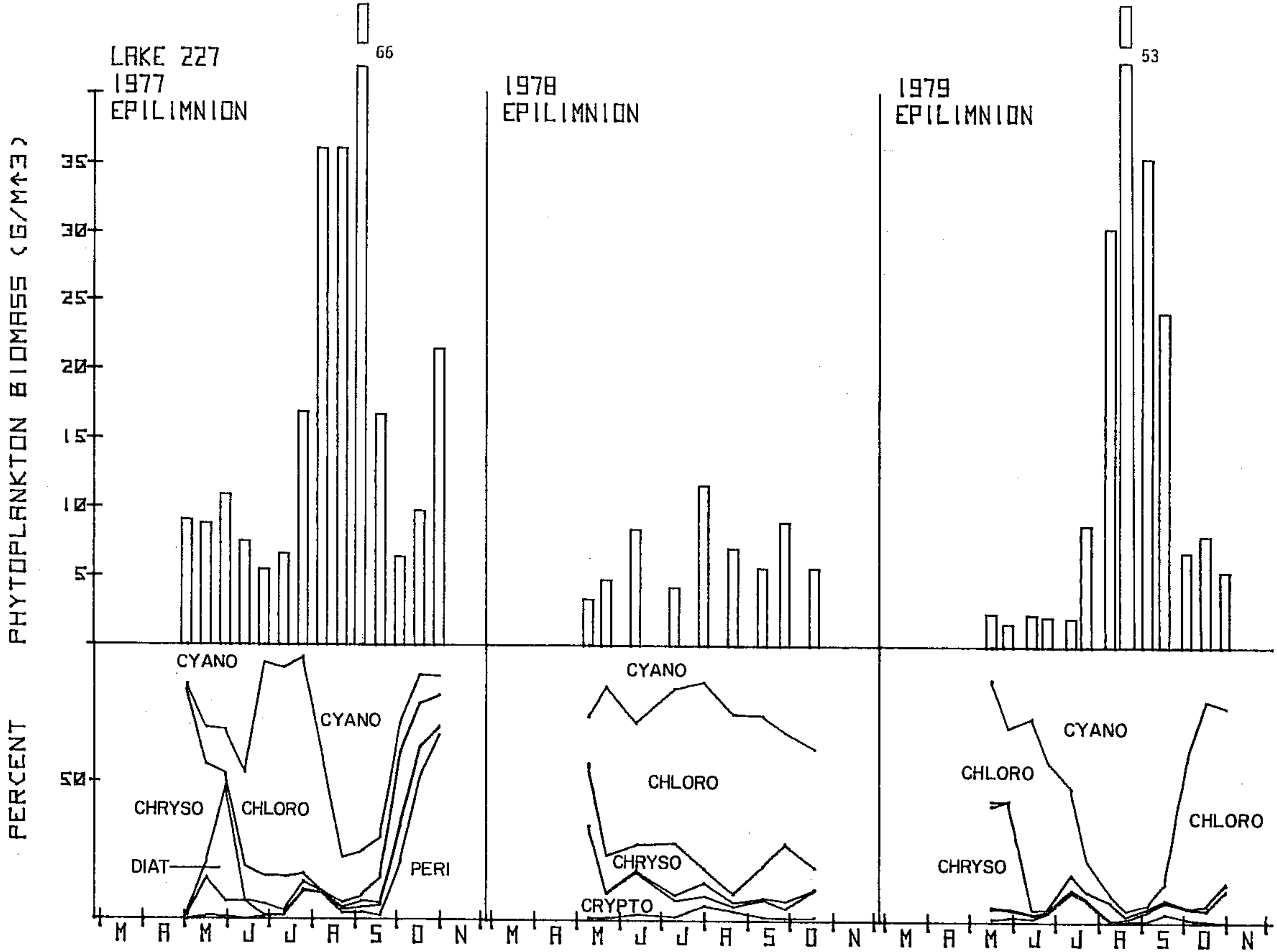

Fig. 1. Average phytoplankton volume in the epilimnion of Lake 227 in 1977-1979, and accumulative percent composition.

Table 2. Lake 227

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1977	May	*Oscillatoria Redekei* Van Goor	*Dictyosphaerium simplex* Skuja *Scenedesmus denticulatus* Lager. *Monoraphidium contortum* (Thur.) *Komárková-Legnerová* *Spondylosium planum* West *Scenedesmus quadricauda* Bréb.	*Dinobryon sertularia* Ehr. *D. sociale* Ehr. *Chrysochromulina parva* Lackey	*Cryptomonas erosa* Ehr. *C. rostratiformis* Skuja *Katablepharis ovalis* Skuja	
	Jun-Oct	*Oscillatoria Redekei* Van Goor	*Spondylosium planum* West *Oocystis submarina* var. *variabilis* Skuja	*Chrysochromulina parva* Lackey	*Cryptomonas erosa* Ehr.	
	Jul-Oct	*Aphanizomenon flos-aquae* Ralfs *Anabaena solitaria* f.a. *planotonica* (Brunnth.)Komar.	*Dictyosphaerium simplex* Skuja *Staurastrum Bullardii* Smith *S. paradoxum* Meyen *Scenedesmus quadricauda* Bréb.		*Cryptomonas ovata* Ehr.	*Peridinium inconspicum* Lemm. *Gymnodinium* sp.
	Oct	*Gomphosphaerium lacustris* Chodat				*G. mirabile* Penard.
Epi 1978	May-Oct	*Oscillatoria Redekei* Van Goor	*Chlamydomonas* sp. *Monoraphidium contortum* (Thur.) *Komárková-Legnerová* *Dictyosphaerium simplex* Skuja *Scenedesmus quadricauda* Bréb.	*Chrysochromulina parva* Lackey	*Cryptomonas obovata* Skuja *C. ovata* Ehr. *C. rostratiformis* Skuja *C. erosa* Ehr.	
	Jun-Oct		*Oocystis submarina* var. *variabilis* Skuja			
	Jul-Oct	*Aphanizomenon gracile* Lemm.	*Spondylosium planum* West *Dictyosphaerium pulchellum* Wood			*Peridinium inconspicum* Lemm.
	Aug-Oct	*Anabaena, Solitaria f.a.*). *plantonica* (Brunnth.) Komar.	*Staurastrum* sp.			
Epi 1979	May-Jun	*Oscillatoria Redekei* Van Goor	*Chlamydomonas* sp. *Chlorogonium maximum* Skuja	*Synura* spp *Salpingoeca frequentissima* Lemm. *Chrysochromulina parva* Lackey		
	Jun-Jul	*Oscillatoria limnetica* Lemm.	*Scenedesmus denticulatus* Lager. *S. quadricauda* Bréb. *Oocystis lacustris* Chodat			
	Jul-Oct	*Anabaena cylindrica* Lemm. *A. Solitaria f.a. planctonica* (Brunnth.) Komar.				*Peridinium inconspicum* Lemm.
	Oct	*Oscillatoria Redekei* Van Goor	*Oocystis submarina* var. *variabilis* Skuja *Scenedesmus denticulatus* Lager. *S. quadricauda* Bréb. *Oocystis lacustris* Chodat		*Cryptomonas erosa* Ehr.	

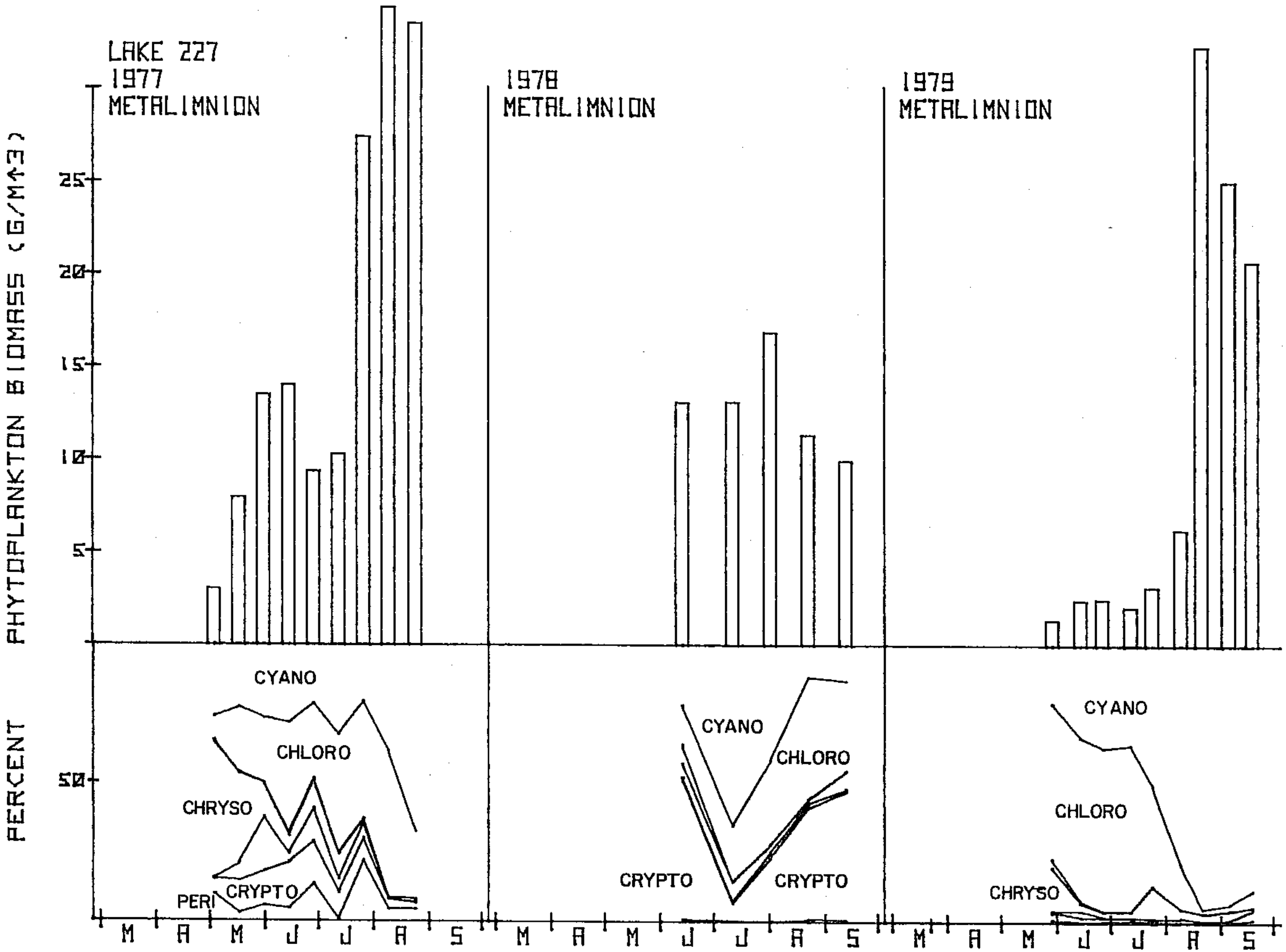

Fig. 2. Average phytoplankton volume in the metalimnion of Lake 227 in 1977-1979, and accumulative percent composition.

Table 3. Lake 227

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Meta 1977	May	*Oscillatoria Redekei* Van Goor	*Dictyosphaerium simplex* Skuja *Monoraphidium Contortum* (Thur.) *Kemárková-Legnerová* *Scenedesmus quadricauda* Bréb. *S. denticulatus* Lager. *S. brevispina* Chodat	*Dinobryon sertularia* Ehr.	*Cryptomonas erosa* Ehr. *Cryptomonas obovata* Skuja *C. erosa* Ehr. *C. rostratiformis* Skuja	*Gymnodinium* sp.
	Jun-Aug	*Oscillatoria Redekei* Van Goor *Anabaena solitaria* f.a. *planctonica* (Brunnth.) Komar.	*Dictyosphaerium simplex* Skuja *Oocystis submarina* var. *variabilis* Skuja *Dictyosphaerium pulchellum* Wood *Staurastrum paradoxum* Meyen	*Chrysochromulina parva* Lackey	*C. ovata* Ehr. *Cryptomonas erosa* Ehr.	*Gymnodinium* sp.
	Jul-Aug		*Scenedesmus quadricauda* Bréb.			
	Aug		*Spondylosium planum* West			
Meta 1978	Jun-Sept	*Oscillatoria Redekei* Van Goor	*Chlorogonium maximum* Skuja *Dictyosphaerium simplex* Skuja *Chlamydomonas* spp. *Scenedesmus brevispina* Chodat		*Cryptomonas obovata* Skuja	
	Jul-Sept		*Oocystis submarina* var. *variabilis* Skuja	*Chrysochromulina parva* Lackey		
	Aug-Sept	*Aphanizomenon gracile* Lemm.	*Dictyosphaerium pulchellum* Wood *Staurastrum* sp.			*Peridinium inconspicum* Lemm.
Meta 1979	May-Jul	*Oscillatoria Redekei* Van Goor	*Chlorogonium maximum* Skuja *Scenedesmus brevispina* Chodat *Dictyosphaerium pulchellum* Wood	*Chrysochromulina parva* Lackey		
	Jun-Sept		*Scenedesmus denticulatus* Lager. *S. quadricauda* Bréb.			
	Jul-Sept	*Oscillatoria limnetica* Lemm. *O. Redekei* Van Goor *Anabaena cf. cylindrica* Lemm.	*Oocystis lacustris* Bréb. *Chlamydomonas* sp.			
	Aug-Sept	*A. cf. Levanderi* Lemm.				

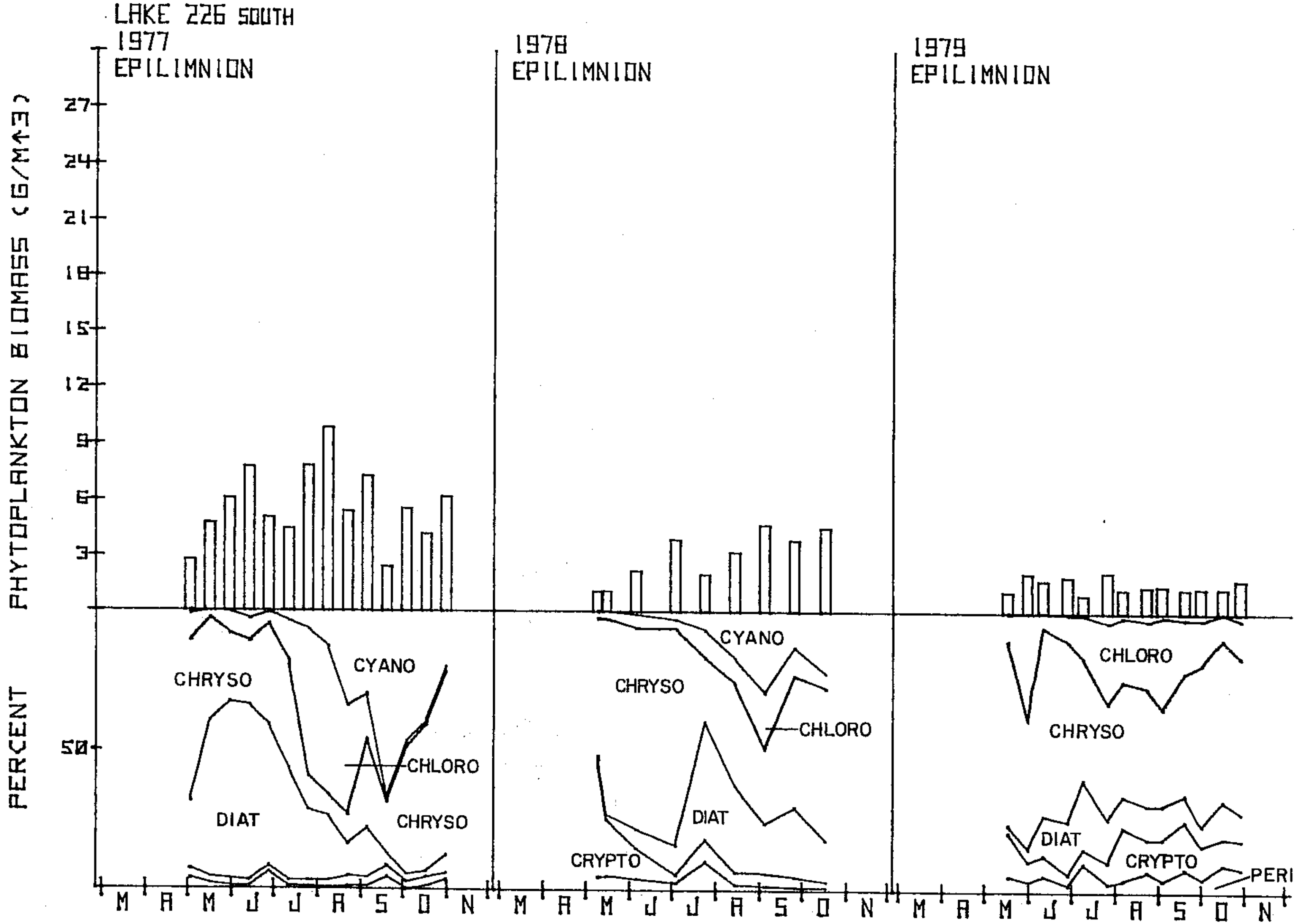

Fig. 3. Average phytoplankton volume in the epilimnion of Lake 226 south in 1977-1979, and accumulative percent composition.

Table 4. 226 South

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1977	May		Monoraphidium setiforme Komar.	Uroglena americana Catkins Dinobryon sertularia Ehr. D. bavaricum var. Vanhoeffenii Krieger D. sociale Ehr. Chrysochromulina parva Lackey	Rhizosolenia eriensis Smith Synedra acus Kütz. Cyclotella comta Kütz.	
	Jun-Oct	Oscillatoria Redekei Van Goor		Chrysosphaerella longispina Laut.	Cyclotella glomerata Back.	
	Jul-Oct		Spondylosium planum West Chlamydomonas sp. Dictyosphaerium simplex Skuja	Dinobryon divergens Imhof D. crenulatum West Chrysochromulina spp		
	Aug-Oct	Oscillatoria limnetica Lemm.	Paulschulzia pseudovolvox Skuja Teilingia granulata (Roy et Biss) Bourr. See Bourrelly 1969		Synedra acus Kütz.	
	Sept-Oct	Anabaena solitaria f.a. planctonica Brun.		Synura spp Dinobryon sertularia Ehr. Botryococcus Braunii Kütz.	Tabellaria flocculosa Kütz.	
	Oct					
Epi 1978	May			Chrysochromulina parva Lackey		Rhodomonas minuta Skuja
	Jun			Dinobryon sertularia Ehr. D. bavaricum var. Vanhoeffenii Krieger		Cryptomonas erosa Ehr
	Jul			Uroglena americana Catkins Dinobryon sociale var. americanum Back.	Tabellaria flocculosa Kütz. Cyclotella glomerata Back.	
	Aug	Oscillatoria Redekei Van Goor			Synedra acus Kütz.	
	Sept	Anabaena solitaria f.a. planctonica	Spondylosium planum West Dictyosphaerium pulchellum Wood Chlamydomonas sp. Teilingia granulata (Roy & Biss) Bourr.	Chrysosphaerella longispina Laut.		
	Oct	Oscillatoria limnetica Lemm.		Synura uvella Dinobryon sertularia var. protruberans Krieger		
Epi 1979	May-Sept		Chlamydomonas sp. Scenedesmus brevispina Chodat Chlorella sp.	Dinobryon sertularia Ehr. Chrysochromulina parva Lackey Dinobryon bavaricum Imhof		Cryptomonas erosa Ehr.
	Jun-Sept			Uroglena americana Catkins Mallomonas sp.	Cyclotella glomerata Back. Synedra acus Kütz.	
	Jul-Aug		Dictyosphaerium simplex Skuja			
	Aug-Sept		Spondylosium planum West	Salpingoeca frequentissima Lemm.		Rhodomonas minuta Skuja Katablepharis ovalis Skuja
	Oct		Teilingia granulata (Roy & Biss) Bourr. Spondylosium planum West Scenedesmus denticulatus Lager.	Dinobryon bavaricum Imhof Chrysococcus sp. Chrysochromulina spp Salpingoeca frequentissima Lemm.	Cyclotella comta Kütz.	Cryptomonas erosa Ehr.

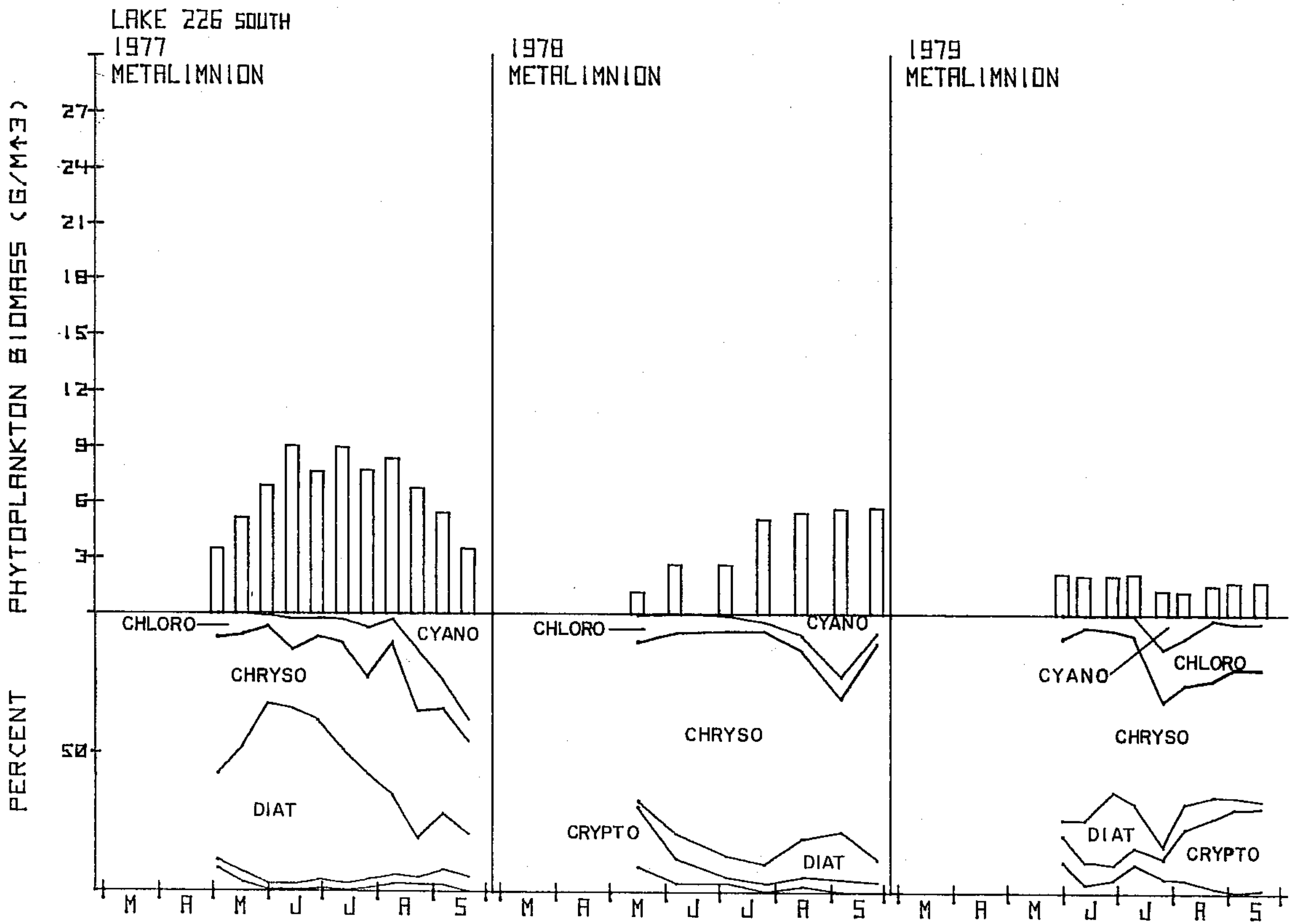

Fig. 4. Average phytoplankton volume in the metalimnion of Lake 226 south in 1977-1979, and accumulative percent composition.

Table 5. Lake 226 south

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Meta 1977	May-Sept		*Chlamydomonas* sp. *Scenedesmus denticulatus* Lager.	*Dinobryon sertularia* Ehr. *Chrysochromulina* spp *Dinobryon sociale* Ehr. *Chromulina* sp. *Chrysococcus* sp. *Synura* spp *Uroglena americana* Catkins *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger	*Rhizosolenia eriensis* Smith *Cyclotella comta* Kütz. *Cyclotella glomerata* Back. *Synedra acus* Kütz.	*Cryptomonas erosa* Ehr.
	Jun-Sept	*Oscillatoria Redekei* Van Goor	*Scenedesmus brevispina* Chodat	*D. divergens* var. *Schauinslandii* (Lemm) Brunnth.		*Katablepharis ovalis* Skuja
	Jul-Sept		*Spondylosium planum* West *Ankistrodesmus falcatus* Ralfs			
	Aug-Sept	*Oscillatoria limnetica* Lemm.	*Gloeococcus Schroeteri* Lemm. *Teilingia granulata* (Roy & Biss) Bourr		*Tabellaria flocculosa* Kütz.	
	Sept	*Anabaena* cf. *Levanderi* Lemm. *A. solitaria* f.a. *planctonica* Brun.	*Scenedesmus* sp.			
Meta 1978	May-Sept			*Chrysochromulina* sp. *Chromulina* sp.		*Cryptomonas erosa* Ehr.
	Jun-Sept		*Scenedesmus brevispina* Chodat	*Dinobryon sertularia* Ehr. *Uroglena americana* Catkins *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger		
	Jul-Sept			*Chrysosphaerella longispina* Laut. *Dinobryon bavaricum* Imhof	*Cyclotella comta* Kütz. *Tabellaria flocculosa* Kütz. *Cyclotella glomerata* Back.	
	Aug-Sept	*Oscillatoria Redekei* Van Goor	*Chlamydomonas* sp.	*Dinobryon sertularia* Ehr.		
	Sept	*Anabaena* cf. *Levanderi* Lemm. *Oscillatoria limnetica* Lemm.		*Mallomonas pseudocoronata* Prescott	*Synedra acus* Kütz.	
Meta 1979	May-Jul		*Scenedesmus brevispina* Chodat	*Chrysochromulina* sp. *Dinobryon bavaricum* Imhof *D. sertularia* var. *protuberans* Krieger *Chrysochromulina parva* Lackey	*Cyclotella glomerata* Back.	*Cryptomonas erosa* Ehr. *C. rostratiformis* Skuja
	Jun-Sept			*Uroglena americana* Catkins		
	Jul-Sept			*Synura* spp *Dinobryon bavaricum* Imhof *Chrysochromulina parva* Lackey *Kephyrion boreale* Skuja	*Cyclotella glomerata* Back.	
	Aug-Sept	*Chroococcus limneticus* Lemm.	*Spondylosium planum* West *Scenedesmus denticulatus* Lager.	*Chrysochromulina* spp		*Cryptomonas erosa* Ehr. *C. ovata* Ehr. *C. rostratiformis* Skuja
	Sept-Oct		*Scenedesmus brevispina* Chodat	*Ochromonas sphagnalis* Conr.		

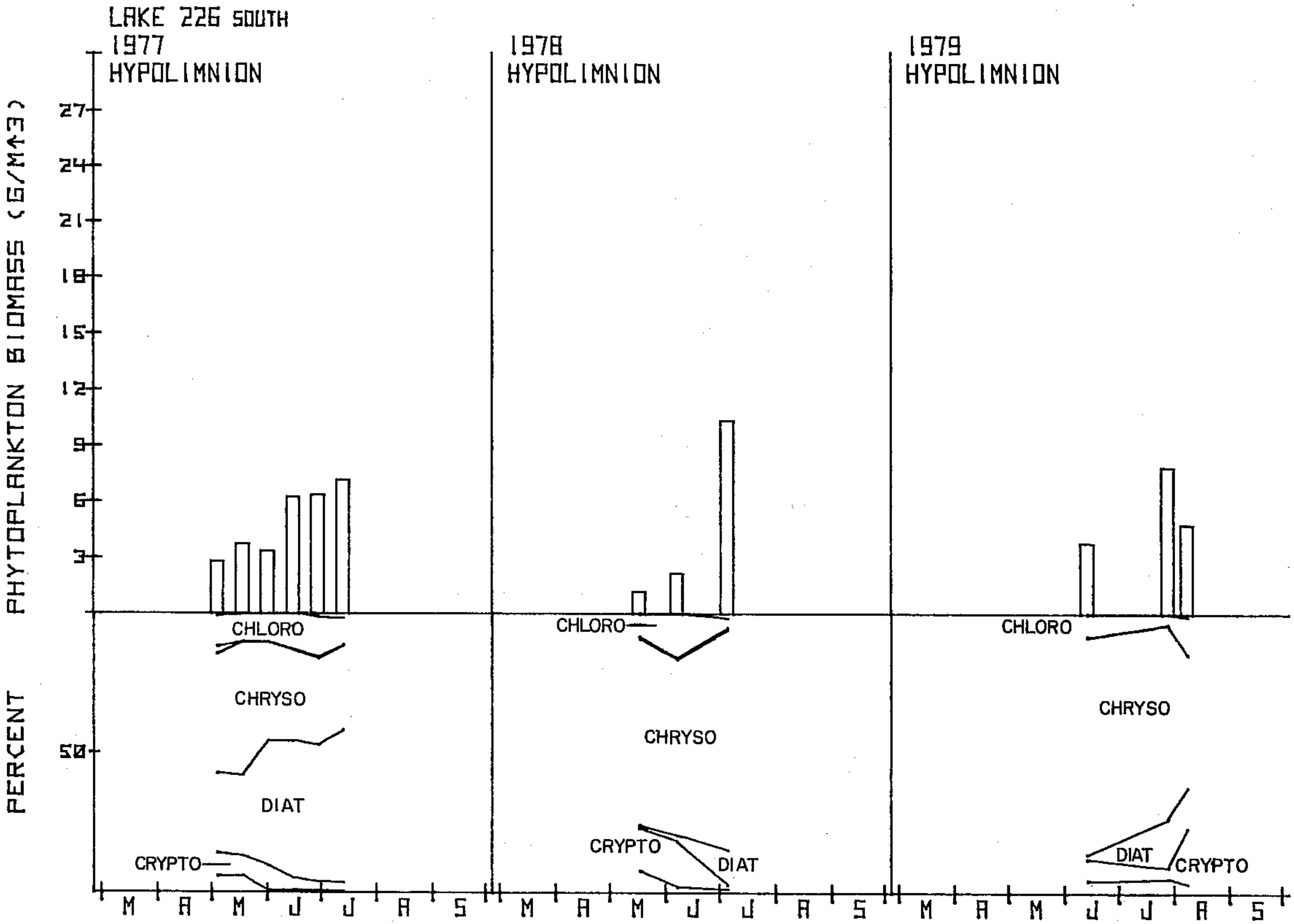

Fig. 5. Average phytoplankton volume in the hypolimnion of Lake 226 south in 1977-1979, and accumulative percent composition.

Table 6. Lake 226 south

Depth/Year	Date	Common Species: Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae	Peridineae
Hypo 1977	May-Jul	*Chlamydomonas* sp.	*Synura* spp *Chromulina* sp. *Chrysococcus* sp. *Uroglena americana* Catkins *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger *D. sertularia* Ehr.	*Rhizosolenia eriensis* Smith *Cyclotella comta* Kütz. *Cyclotella glomerata* Back.	*Cryptomonas erosa* Ehr.	*Peridinium* sp.
	Jun-Jul	*Scenedesmus brevispina* Chodat *S. denticulatus* Lager.	*Mallomonas pseudocoronata* Prescott *Chrysolchromulina* spp	*Synedra acus* Kütz.	*Cryptomonas obovata* Skuja	
Hypo 1978	May-Jul		*Chrysococcus* sp. *Chromulina* sp.		*Cryptomonas erosa* Ehr.	
	Jun-Jul	*Scenedesmus brevispina* Chodat				
	Jul		*Dinobryon sertularia* Ehr.	*Cyclotella comta* Kütz.		
Hypo 1979	Jun	*Scenedesmus brevispina* Chodat	*Chrysochromulina* spp *Chrysococcus* sp. *Kephyrion boreale* Skuja *Chrysochromulina parva* Lackey	*Cyclotella glomerata* Back.	*Cryptomonas obovata* Skuja *Rhodomonas minuta* Skuja *Katablepharis ovalis* Skuja	*Peridinium aciculiferum* Lemm.
	Aug	*Scenedesmus brevispina* Chodat	*Dinobryon sertularia* Ehr. *Chrysochromulina* parva	*Cyclotella glomerata* Back.	*Cryptomonas erosa* Ehr. *C. rostratiformis* Skuja *C. ovata* Ehr.	*Peridinium aciculiferum* Lemm.

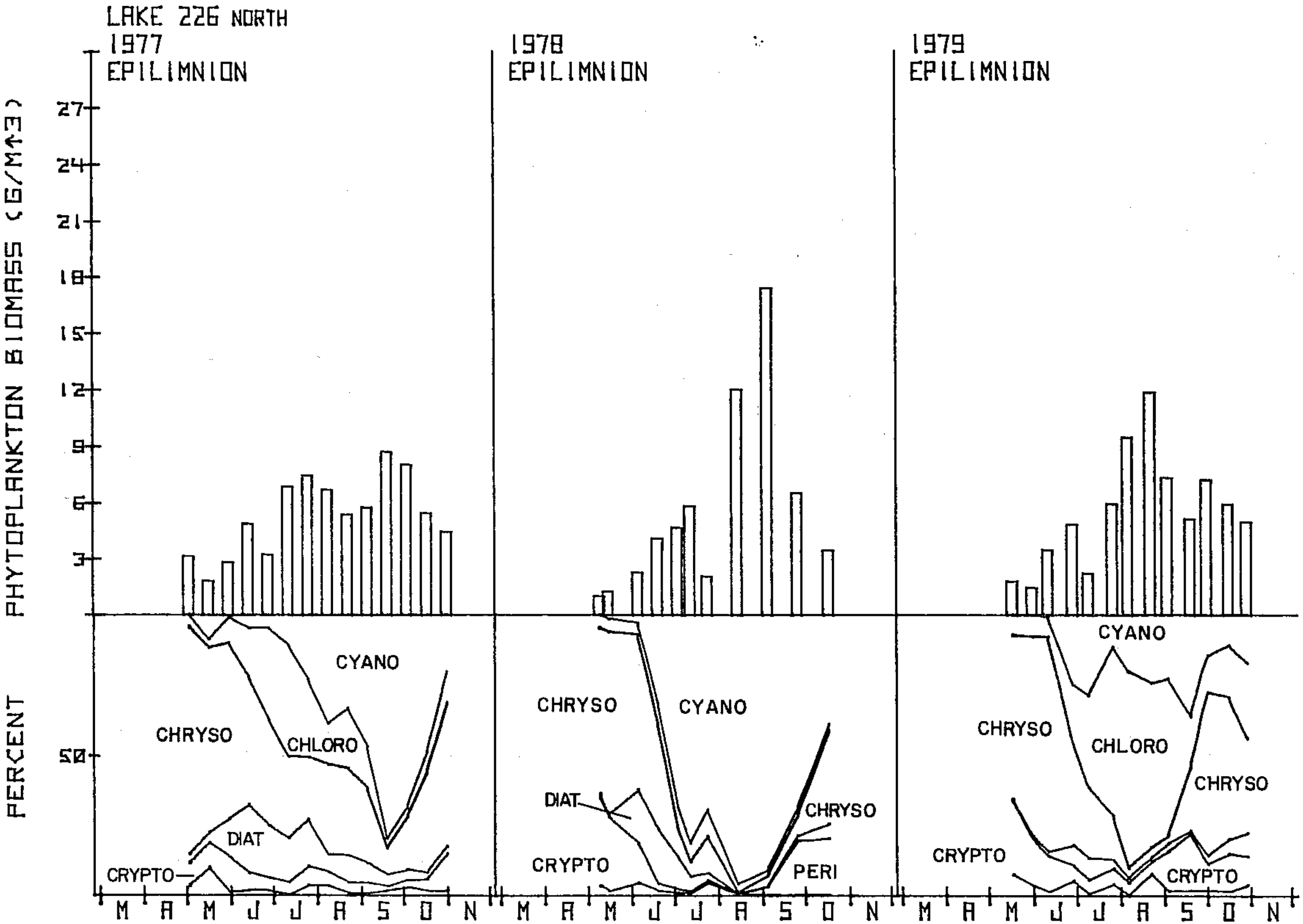

Fig. 6. Average phytoplankton volume in the epilimnion of Lake 226 north in 1977-1979, and accumulative percent composition.

Table 7. Lake 226 north

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1977	May		*Monoraphidium setiforme* Komar.	*Uroglena americana* Catkins *Synura* spp *Chrysochromulina* spp *Dinobryon sertularia* Ehr. *Chrysochromulina parva* Lackey *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger	*Rhizosolenia eriensis* Smith	*Rhodomonas minuta* Skuja
	Jun-Oct		*Spondylosium planum* West		*Cyclotella glomerata* Back.	
	Jul-Oct	*Oscillatoria Redekei* Van Goor	*Scenedesmus denticulatus* Lager.		*Synedra acus* Kütz.	*Cryptomonas erosa* Ehr.
	Aug-Oct	*Anabaena* sp. *A. solitaria* f.a. *planctonica*(Brunnth) Komar			*Tabellaria flocculosa* Kütz.	
	Sept-Oct	*Oscillatoria limnetica* Lemm.		*Dinobryon bavaricum* Imhof		
	Oct		*Chlamydomonas* sp.	*D. sertularia* Ehr.		
Epi 1978	May			*Chrysochromulina* spp		*Rhodomonas minuta* Skuja *Cryptomonas erosa* Ehr.
	Jun			*Uroglena americana* Catkins *Dinobryon sertularia* Ehr. *Mallomonas* spp	*Synedra acus* Kütz. *Tabellaria flocculosa* Kütz.	
	Jun-Oct	*Oscillatoria limnetica* Lemm.	*Dictyosphaerium simplex* Skuja	*Dinobryon sociale* var. *americanum*(Brunnth.) Bachm.		
		Anabaena solitaria f.a. *planctonica*(Brunnth.) Komar	*Chlamydomonas* sp.		*Rhizosolenia eriensis* Smith	
	Jul-Oct	*Oscillatoria Redekei* Van Goor				
	Aug-Oct	*Anabaena cf. Levandari* Lemm.				
	Sept-Oct			*Chrysochromulina* spp *Chrysococcus* sp.	*Synedra acus* Kütz.	*Cryptomonas erosa* Ehr. *Katablepharis ovalis* Skuja
Epi 1979	May-Jun			*Chrysococcus* sp. *Dinobryon sertularia* Ehr. *Synura* *Chrysochromulina* sp. *Dinobryon bavaricum* Imhof *D. sertularia* var. *protruberans* Krieger		*Cryptomonas rostratiformis* Skuja
	Jun-Oct	*Anabaena solitaria* f.a. *planctonica*(Brunnth.)Komar	*Scenedesmus brevispina* Skuja *Dictyosphaerium simplex* Skuja *Spondylosium planum* West	*Uroglena americana* Catkins *Salpingoeca frequentissima* Lemm.	*Synedra acus* Kütz.	
		A. cf. cylindrica Lemm. *Oscillatoria limnetica* Lemm.	*Chlamydomonas* sp.	*Chryosochromulina* spp		*Cryptomonas erosa* Ehr. *Katablepharis ovalis* Skuja
		Anabaena cf. Levandari Lemm.	*Scenedesmus denticulatus* Lager.			
		Oscillatoria Redekei Van Goor	*Dictyosphaerium pulchellum* Wood	*Dinobryon sociale* Ehr. *D. bavaricum* Imhof *D. sertularia* Ehr.	*Cyclotella comta* Kütz. *Rhizosolenia eriensis* Smith	

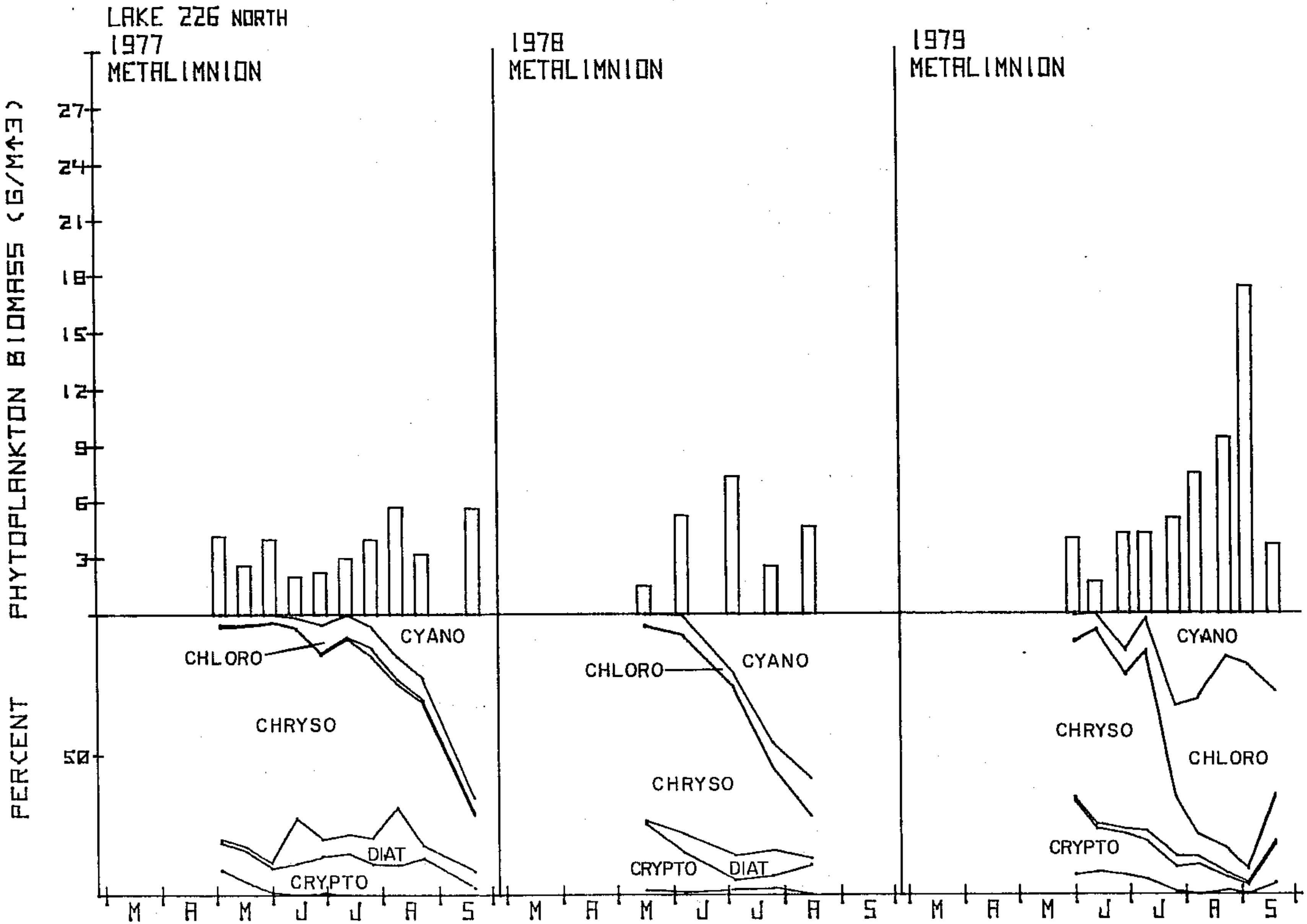

Fig. 7. Average phytoplankton volume in the metalimnion of Lake 226 north in 1977-1979, and accumulative percent composition.

Table 8. Lake 226 north

Depth/Year	Date	Common Species Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Meta 1977	May-Sept			*Chrysochromulina* sp. *Dinobryon sertularia* Ehr. *Mallomonas pseudocoronata* Prescott *Uroglena americana* Catkins *Synura* spp *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger		*Cryptomonas erosa* Ehr. *Rhodomonas minuta* Skuja
	Jun-Sept		*Spondylosium planum* West	*D. sertularia* var. *protruberans* Krieger	*Rhizosolenia eriensis* Smith	*Cryptomonas rostratiformis* Skuja
	Jul-Sept	*Oscillatoria Redekei* Van Goor		*Chrysococcus* sp.	*Synedra acus* Kütz.	
	Aug-Sept	*Anabaena solitaria* Klebahn *Oscillatoria limnetica* Lemm.				
	Sept				*Tabellaria flocculosa* Kütz	
Meta 1978	May			*Chrysochromulina* spp *Chrysococcus* sp. *Chromulina* sp. *Chrysochromulina parva* Lackey		*Cryptomonas erosa* Ehr.
	Jun		*Dictyosphaerium pulchellum* Wood	*Uroglena americana* Catkins *Dinobryon sertularia* Ehr.	*Cyclotella glomerata* Back.	*Katablepharis ovalis* Skuja
	Jul	*Oscillatoria Redekei* Van Goor *Anabaena solitaria* f.a. *planctonica* Brun.		*Synura* spp	*Tabellaria flocculosa* Kütz. *Rhizosolenia eriensis* Smith	
	Aug	*A.* cf. *Levanderi* Lemm.	*Chlamydomonas* sp. *Spondylosium planum* West			*Cryptomonas ovata* Ehr.
Meta 1979	May-Aug			*Chrysococcus* sp. *Dinobryon sertularia* var. *protruberans* Krieger *Uroglena americana* Catkins *Salpingoeca frequentissima* Lemm. *Chrysochromulina* spp		*Cryptomonas rostratiformis* Skuja *C. erosa* Ehr. *Katablepharis ovalis* Skuja
	Jun-Aug	*Anabaena* cf. *Levanderi* Lemm.				
	Jul-Sept	*A.* cf. *cylindrica* Lemm. *Oscillatoria Redekei* Van Goor *Anabaena* cf. *Levanderi* Lemm.	*Spondylosium planum* West *Scenedesmus denticulatus* Lager. *Chlamydomonus* sp.			
	Aug-Sept	*Oscillatoria limnetica* Lemm.				
	Sept			*Chrysochromulina* spp		*Cryptomonas erosa* Ehr.

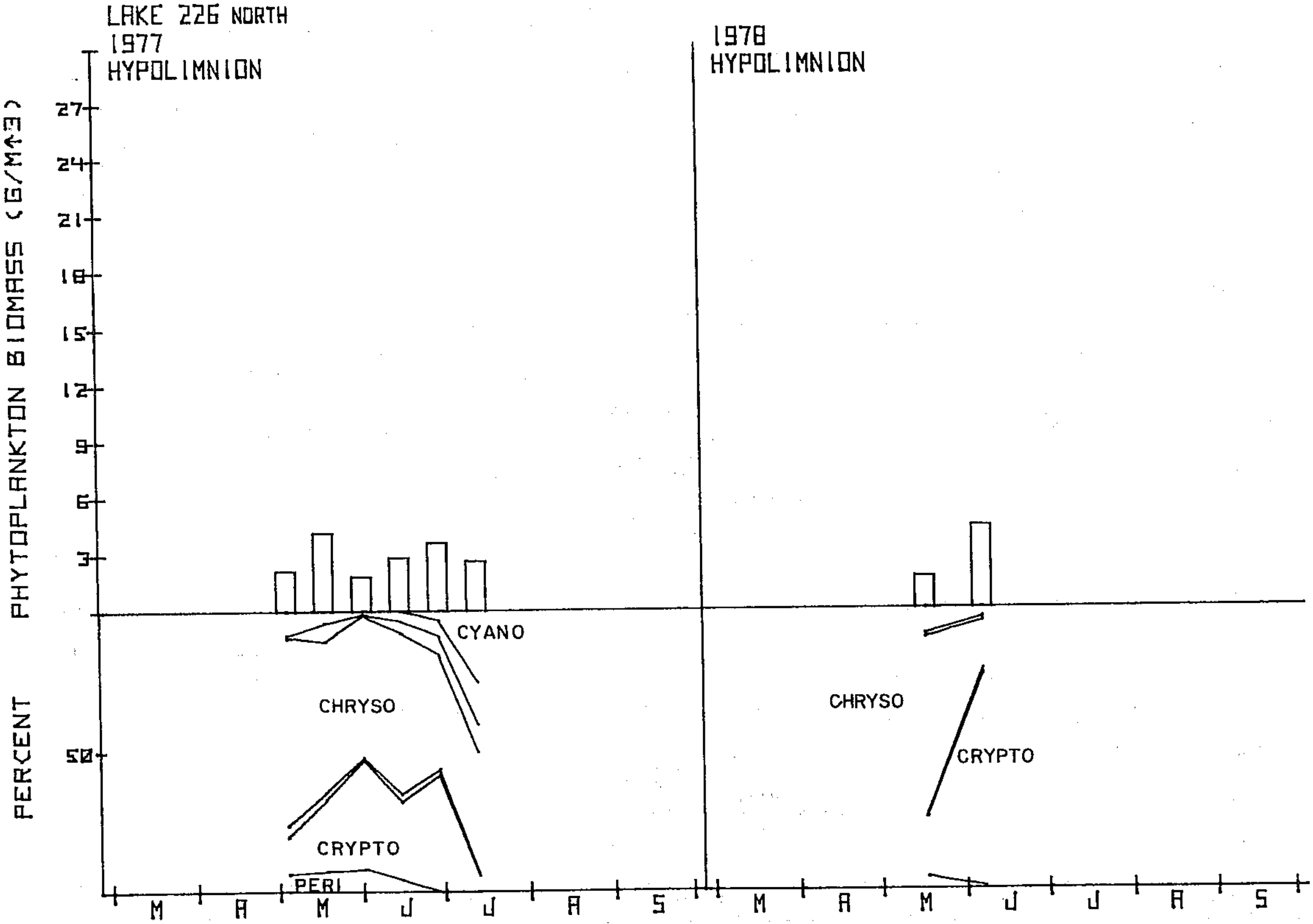

Fig. 8. Average phytoplankton volume in the hypolimnion of Lake 226 north in 1977 and 1978, and accumulative percent composition.

Table 9. Lake 226 north

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Hypo 1977	May-Jul			*Dinobryon borgei* Lemm. *Chrysochromulina* spp *Dinobryon sertularia* Ehr. *Ochromonas* sp.	*Cryptomonas erosa* Ehr.	
	Jun-Jul	*Oscillatoria Redekei* Van Goor	*Monoraphidium setiforme* Komar. *Chlamydomonas* sp.	*Synura* spp Korsch. *Uroglena americana* Catkins *Mallomonas Pseudocoronata* Prescott	*Cryptomonas ovata* Ehr. *C. rostratiformis* Skuja *Katablepharis ovalis* Skuja *Cryptomonas* sp.	*Peridinium* sp. *P. Willei* Huit.-Kass
	Jul	*Synechococcus aeruginosus* Naeg.				
Hypo 1978	May-Jun		*Chlamydomonas* sp.	*Chrysochromulina* sp. *Chromulina* sp. *Chrysococcus* sp.	*Cryptomonas erosa* Ehr.	
	Jun			*Synura* spp Korsch. *Uroglena americana* Catkins	*Cryptomonas ovata* Ehr. *C. rostratiformis* Skuja *Katablepharis ovalis* Skuja	
Hypo 1979	Jun			*Dinobryon sertularia* var. *protruberans* Krieger *Salpingoeca frequentissima* Lemm. *Kephyrion boreale* Skuja	*Cryptomonas rostratiformis* Skuja *C. erosa* Ehr. *C. obovata* Skuja *Katablepharis ovalis* Skuja	

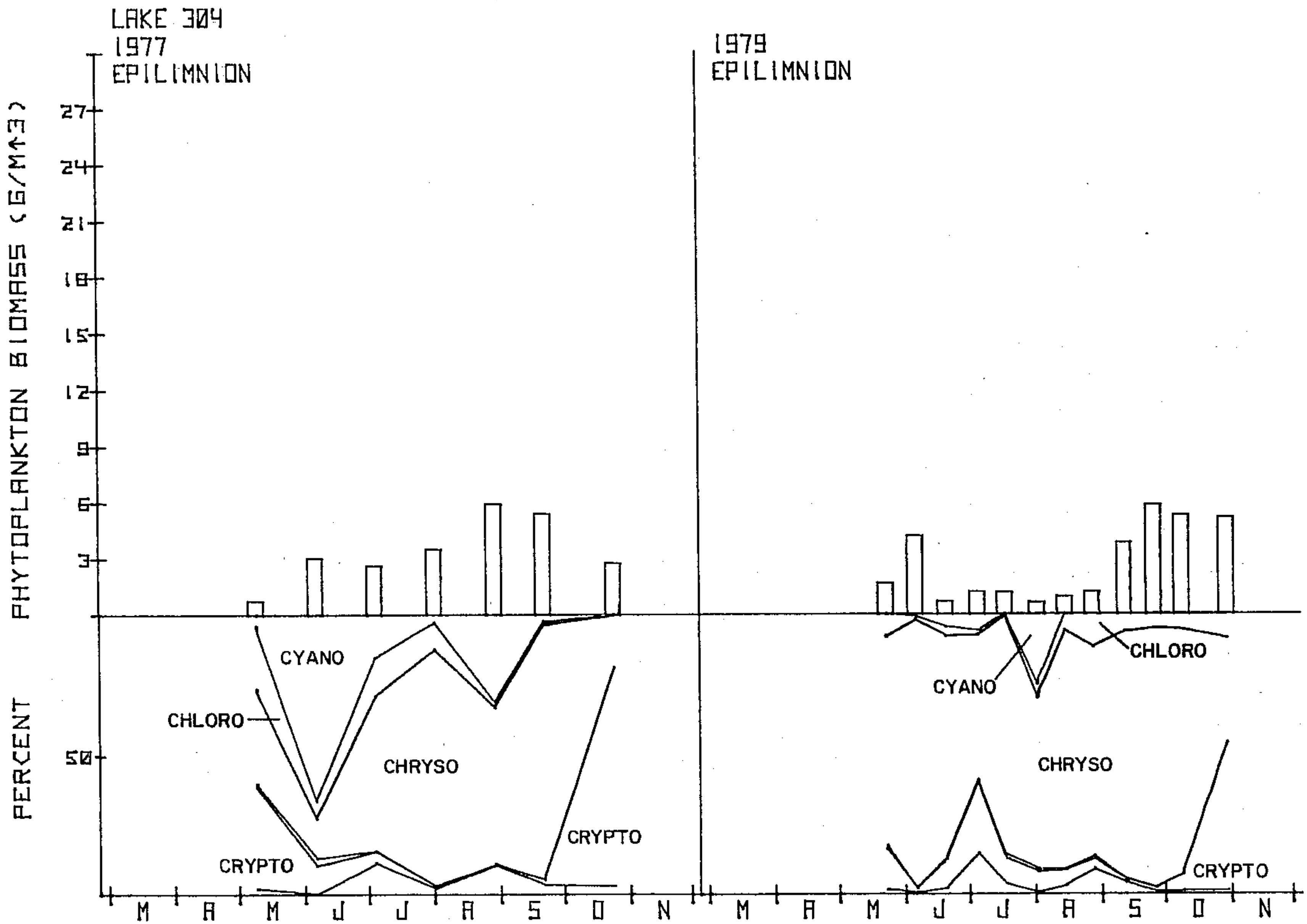

Fig. 9. Average phytoplankton volume in the epilimnion of Lake 304 in 1977 and 1979, and accumulative percent composition.

Table 10. Lake 304

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1977	May-Oct			*Chromulina* sp. *Dinobryon sertularia* Ehr.	*Cryptomonas erosa* Ehr.	
	Jun-Oct	*Aphanizomenon flos-aquae* Ralfs	*Paulschulzia pseudovolvox* Skuja			
	Jul-Oct	*Anabaena solitaria f.a. planctonica* (Brunnth) Komar.	*Gloeococcus Schroeteri* Lemm.	*Chrysochromulina* spp *Dinobryon divergens* Imhof *Chrysococcus* sp.		*Peridinium* sp.
	Aug-Oct	*Anabaena solitaria f.a. planctonica* (Brunnth) Komar	*Staurastrum paradoxum* Meyen		*Cryptomonas ovata* Ehr.	*Gymnodinium* sp. *Peridinium Willei* Huit.-Kass
	Oct				*C. rostratiformis* Skuja	
Epi 1979	May-Sept		*Chlamydomonas* sp.	*Uroglena americana* Catkins *Chrysococcus* sp.	*Cryptomonas ovata* Ehr.	
	Jun-Sept			*Chrysochromulina* spp	*Cryptomonas erosa* Ehr. *C. rostratiformis* Skuja	
	Jul-Aug	*Anabaena* sp.		*Dinobryon sertularia* Ehr. *D. divergens* Imhof	*Rhodomonas minuta* Skuja	*Gymnodinium* sp.
		A. circinalis Rabenh.	*Gloeococcus Schroeteri* Lemm.	*Dinobryon bavaricum* Imhof		
			Monoraphidium setiforme Komark. *Chlamydomonas* sp.	*D. sertularia* Ehr. *Chrysochromulina* spp *Salpingoeca frequentissima* Lemm.	*Cryptomonas erosa* Ehr. *C. ovata* Ehr.	

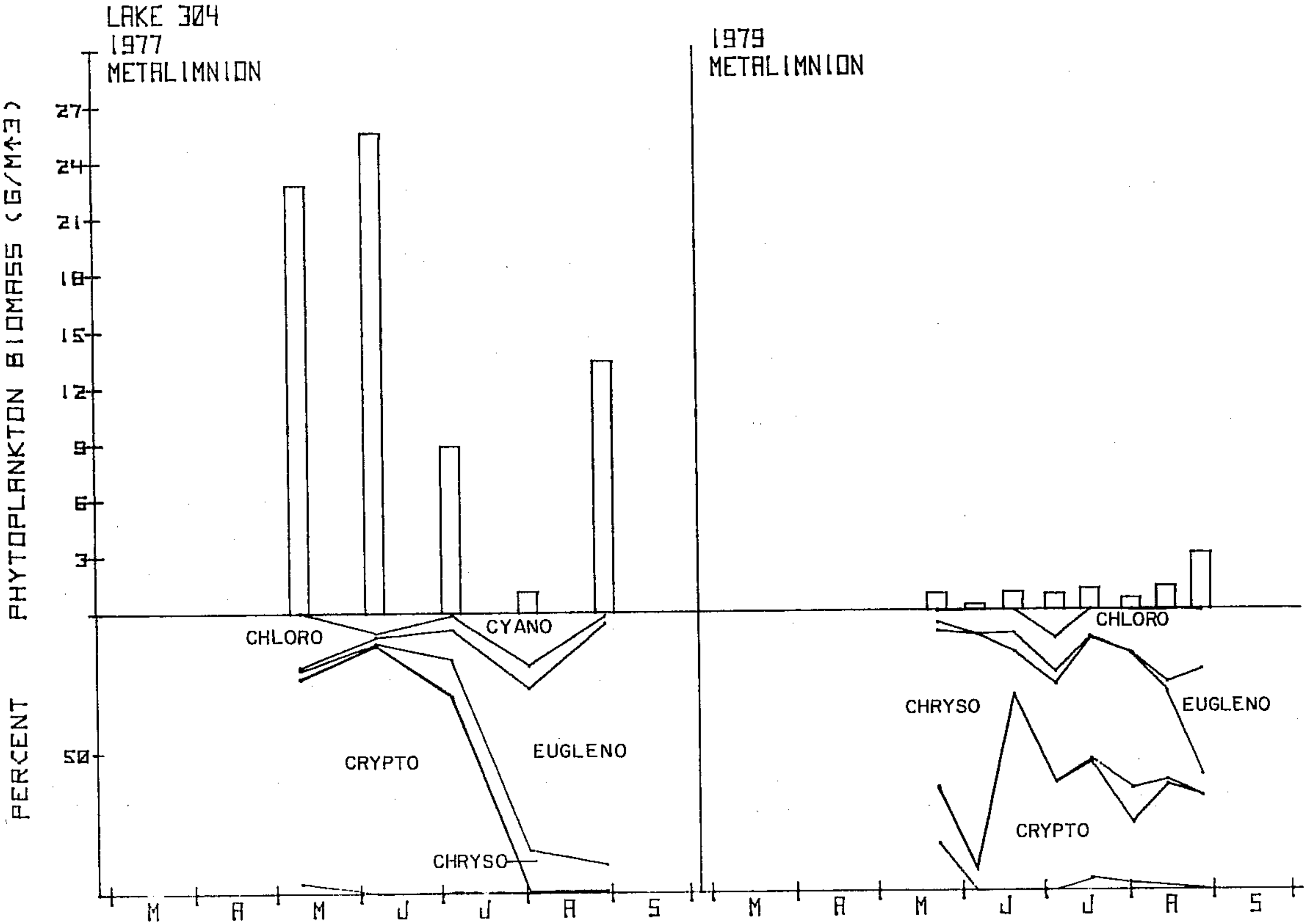

Fig. 10. Average phytoplankton volume in the metalimnion of Lake 304 in 1977 and 1979, and accumulative percent composition.

Table 11. Lake 304

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Euglenophyceae	Chrysophyceae	Cryptophyceae
Meta 1977	May-Sept		*Chlamydomonas* sp.	*Euglena acus* Ehr.	*Dinobryon sertularia* Ehr.	*Cryptomonas ovata* Ehr. *C. erosa* Ehr.
	Jun-Sept	*Aphanizomenon flos-aquae* Ralfs				
	Jul-Sept		*Gloeococcus Schroeteri* Lemm.	*Trachelomonas volvocina* Ehr.	*Dinobryon sociale* Ehr.	
	Aug			*Astasia* sp.	*D. divergens* Imhof	
Meta 1979	May				*Dinobryon sertularia* Ehr. *Chrysococcus* sp. *Mallomonas caudata* Iwanoff *Uroglena americana* Catkins	*Cryptomonas erosa* Ehr.
	Jun					*Cryptomonas* sp.
	Jul	*Anabaena Solitaria f.a. planctonica* (Brunnth.) Komar.	*Monoraphidium setiforme* Komar.			*C. erosa* Ehr. *C. rostratiformis* Skuja
			Scourfieldia cordiformis Takeda	*Euglena acus* Ehr.	*Chrysochromulina* spp *Salpingoeca frequentissima* Lemm.	*C. erosa* Ehr. *C. obovata* Skuja *C.* sp.

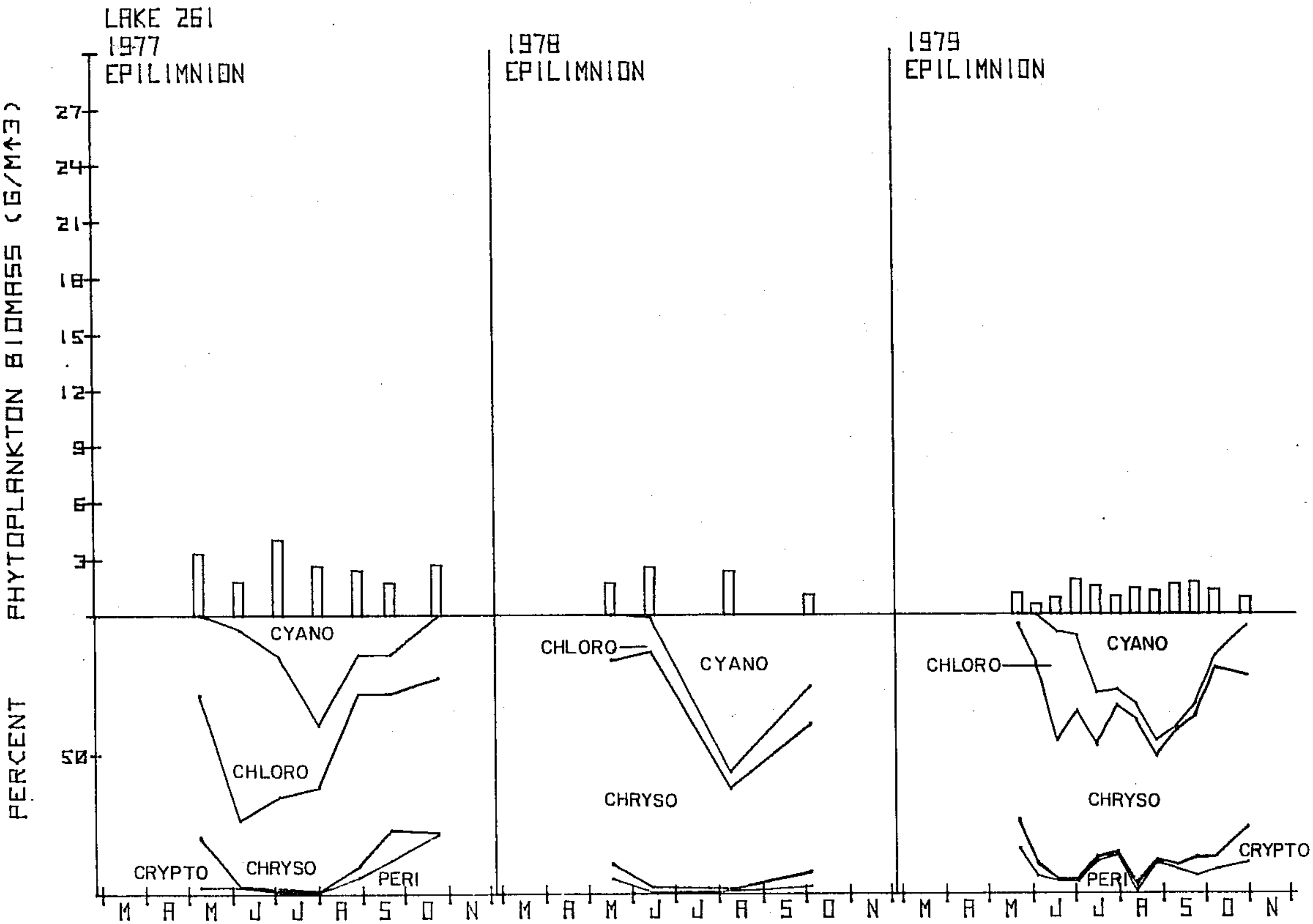

Fig. 11. Average phytoplankton volume in the epilimnion of Lake 261 in 1977-1979, and accumulative percent composition.

Table 12. Lake 261

Depth/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
		Common Species				
Epi 1977	May		*Dictyosphaerium simplex* Skuja	*Dinobryon sertularia* Ehr. *D. bavaricum* var. *Vanhoeffenii* Krieger *Chrysochromulina* spp *Chrysococcus* sp. *Chromulina* sp.	*Crypiomonas erosa* Ehr.	
	Jun-Aug		*Crucigeniella rectangularis* (Nağ) Komar *Gloeococcus Schroeteri* Lemm.	*Botryococcus Braunii* Kütz. *Uroglena americana* Catkins		
	Jul-Aug	*Chroococcus limneticus* Lemm. *Merismopedia glauca* Naeg.		*Chrysococcus* sp. *Chromulina* sp.		
	Aug		*Oocystis lacustris* Chodat	*Dinobryon bavaricum* var. *Vanhoeffenii* Krieger *Chrysosphaerella longispina* Laut.		*Gymnodinium* sp.
	Sept	*Chroococcus limneticus* Lemm. *Merismopedia glauca* Naeg.	*Oocystis lacustris* Chodat *Gloeocystis planctonica* Lemm. *Dictyosphaerium simplex* Skuja *Gloeococcus Schroeteri* Lemm.	*Botryococcus Braunii* Kütz. *Synura* spp *Dinobryon sertularia* Ehr.	*Gonyostomum semen* Dies.	*G.* sp.
0-7m 1978	May		*Dictyosphaerium simplex* Skuja	*Dinobryon sociale* var. *stipitatum* Lemm. *Chrysococcus* sp. *Uroglena americana* Catkins	*Cryptomonas erosa* Ehr.	*Gymnodinium mirabile* Penard
	Jun		*Gloeococcus Schroeteri* Lemm.	*Dinobryon sertularia* Ehr. *Chrysosphaerella longispina* Laut.		
	Aug-Oct	*Chroococcus limneticus* Lemm.		*Botryococcus Braunii* Kütz.		
Epi 1979	May			*Dinobryon sertularia* Ehr.	*Cryptomonas erosa* Ehr. *C. ovata* Ehr.	*Peridinium aciculiferum* Lemm.
	Jun-Jul	*Chroococcus limneticus* Lemm.	*Dictyosphaerium simplex* Skuja *Gloeococcus Schroeteri* Lemm.	*Botryococcus Braunii* Kütz. *Chromulina* sp. *Chrysococcus* sp. *Botryococcus protruberans* West		*Gymnodinium* sp.
		Chroococcus limneticus Lemm. *Synechococcus linearis* (Nağ) Komar.		*Chromulina* sp. *Botryococcus Braunii* Kütz.		*Gymnodinium* sp.
				Synura spp *Dinobryon sertularia* var. *protruberans* Krieger	*Cryptomonas erosa* Ehr.	*Peridinium Willei* Huit.-Kass
		Chroococcus limneticus Lemm.	*Dictyosphaerium simplex* Skuja	*Synura uvella* Ehr. and Korsh. *Dinobryon sertularia* var. *protruberans* Krieger *Botryococcus Braunii* Kütz. *Salpingoeca frequentissima* Lemm.	*C. erosa* Ehr.	*P. Willei* Huit.-Kass *Gymnodinium* sp.

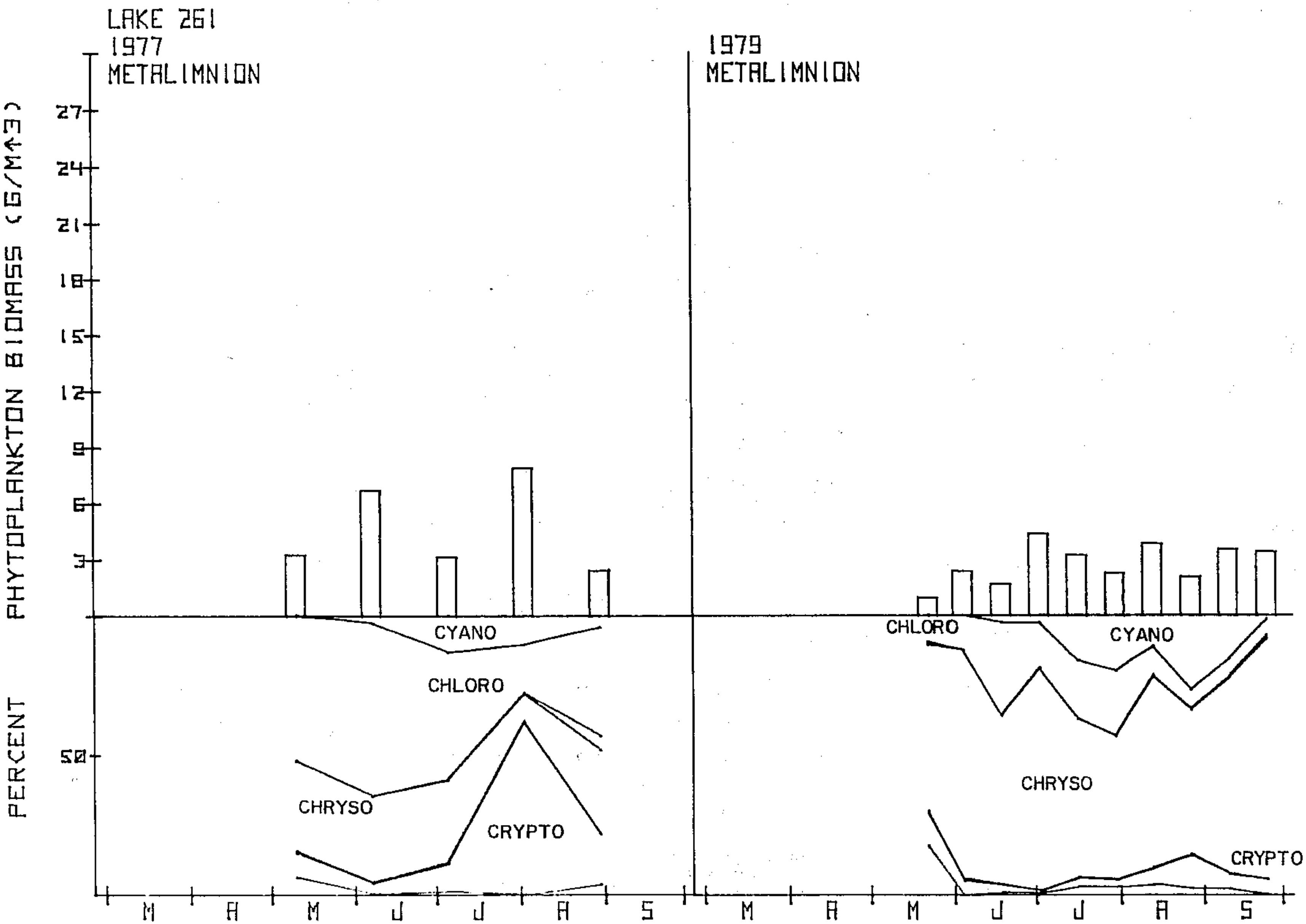

Fig. 12. Average phytoplankton volume in the metalimnion of Lake 261 in 1977 and 1979, and accumulative percent composition.

Table 13. Lake 261

Depth/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
		Common Species				
Meta 1977	May		*Dictyosphaerium simplex* Skuja	*Chrysococcus* sp. *Chromulina* sp. *Dinobryon sertularia* Ehr. *Chrysoikos Skujai* Willen	*Cryptomonas erosa* Ehr.	*Peridinium aciculiferum* Lemm.
			Crucigeniella rectangularis (Näg) Komar. *Dictyosphaerium simplex* Skuja	*Uroglena americana* Catkins *Dinobryon bavaricum* Imhof		
	Jul-Aug	*Merismopedia glauca* Naeg.	*Oocystis lacustris* Chodat	*Chrysochromulina parva* Lackey	*Cryptomonas erosa* Ehr.	
	Aug		*Gloeococcus Schroeteri* Lemm. *Dictyosphaerium pulchellum* Wood		*Gonyostomum semen* Dies.	
Meta 1979	May		*Dictyosphaerium simplex* Skuja *Gloeococcus Schroeteri* Lemm.	*Chrysococcus* sp. *Dinobryon sertularia* Ehr. *Chrysococcus* sp. *Dinobryon bavaricum* Imhof *D. sertularia* Ehr. *Mallomonas caudata* Iwanoff *Chromulina* sp. *Uroglena americana* Catkins *Chrysosphaerella longispina* Laut.	*Cryptomonas rostratiformis* Skuja	*Peridinium aciculiferum* Lemm.
	Jul-Sept	*Chroococcus limneticus* Lemm.		*Botryococcus protruberans* West *Uroglena americana* Catkins *Chrysosphaerella longispina* Laut. *Synura* spp		
	Aug-Sept	*Synechococcus linearis* (Näg) Komar. *Merismopedia glauca* Naeg. *Chroococcus limneticus* Lemm.			*Cryptomonas erosa* Ehr.	

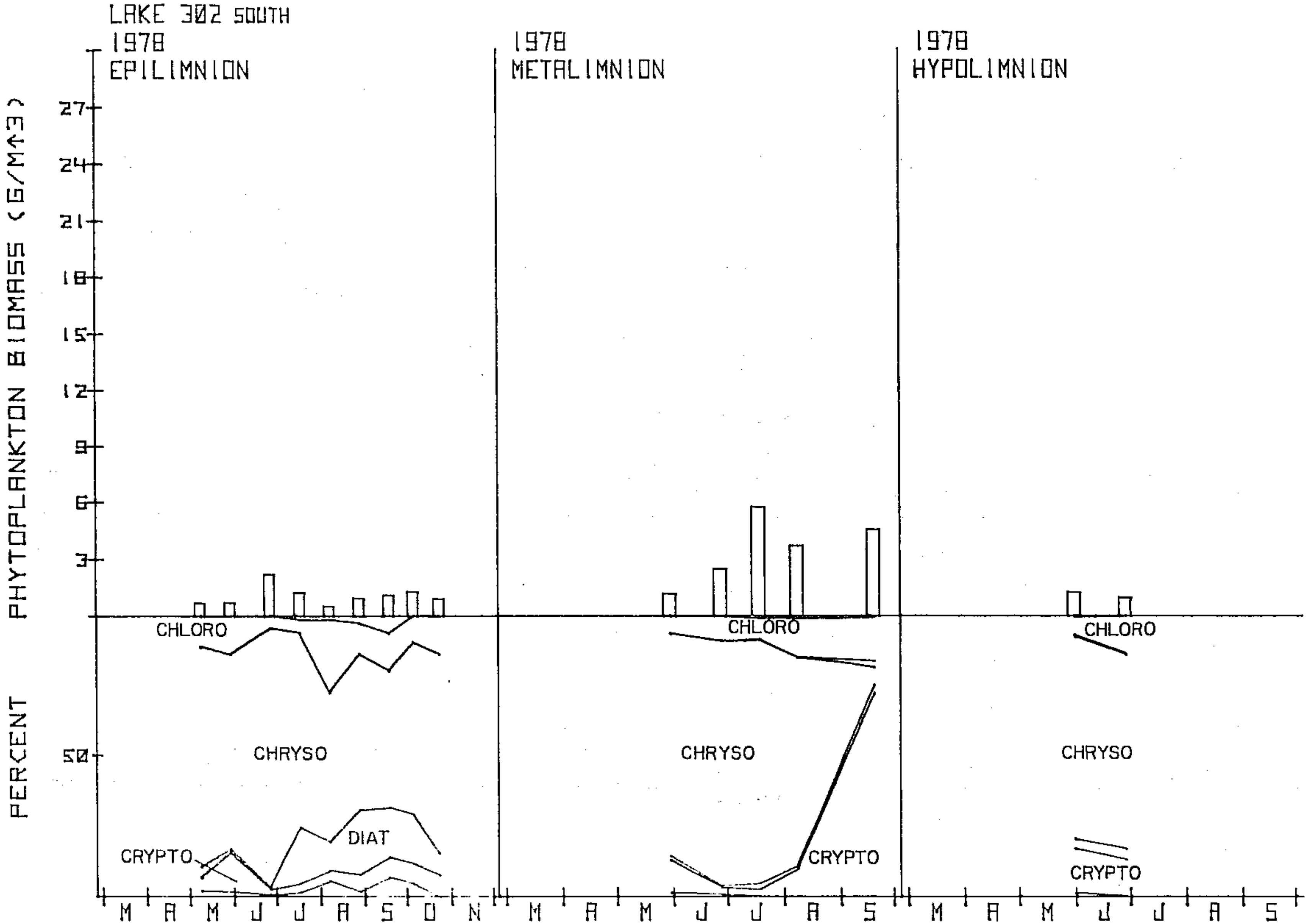

Fig. 13. Average phytoplankton volume in the epilimnion, metalimnion, and hypolimnion of Lake 302 south in 1978, and accumulative percent composition.

Table 14. Lake 302 south

Depth/Year	Date	Common Species: Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1978	May-Oct			*Chrysochromulina* spp *Chrysoccus* sp. *Salpingoeca frequentissima* Lemm. *Uroglena americana* Catkins *Stichogloea Doederleinii* Wille		
	Jun-Oct			*Dinobryon bavaricum* var. *Vanhoeffenii* Krieger		
	Aug-Oct		*Gloeococcus Schroeteri* Lemm.	*Chrysococcus* sp.	*Rhizosolenia eriensis* Smith	
	Sept			*Dinobryon bavaricum* Imhof		
	Oct				*Synedra acus* Kütz.	
Meta 1978	May-Sept			*Pseudokephyrion* sp. *Uroglena americana* Catkins *Chrysococcus* sp. *Chrysochromulina* spp		*Cryptomonas erosa* Ehr.
	Jun-Sept		*Chlamydomonas* sp. *Elaktothrix gelatinosa* Willen	*Stichogloea Doederleinii* Wille *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger		
	Jul-Aug		*Dictyosphaerium simplex* Skuja	*Mallomonas caudata* Iwanoff	*Asterionella formosa* Hassall	
	Aug-Sept		*Gloeococcus Schroeteri* Lemm. *Monoraphidium setiforme* Komar.	*Chromulina* sp.	*Tabellaria flocculosa* Kütz.	
	Sept					*Cryptomonas erosa* Ehr. *C. rostratiformis* Skuja
Hypo	May			*Pseudokephyrion* sp. *Chromulina* sp. *Chrysococcus* sp.		*Cryptomonas erosa* Ehr.
	Jun		*Dictyosphaerium simplex* Skuja	*Mallomonas caudata* Iwanoff *Stichogloea Doederleinii* Wille		

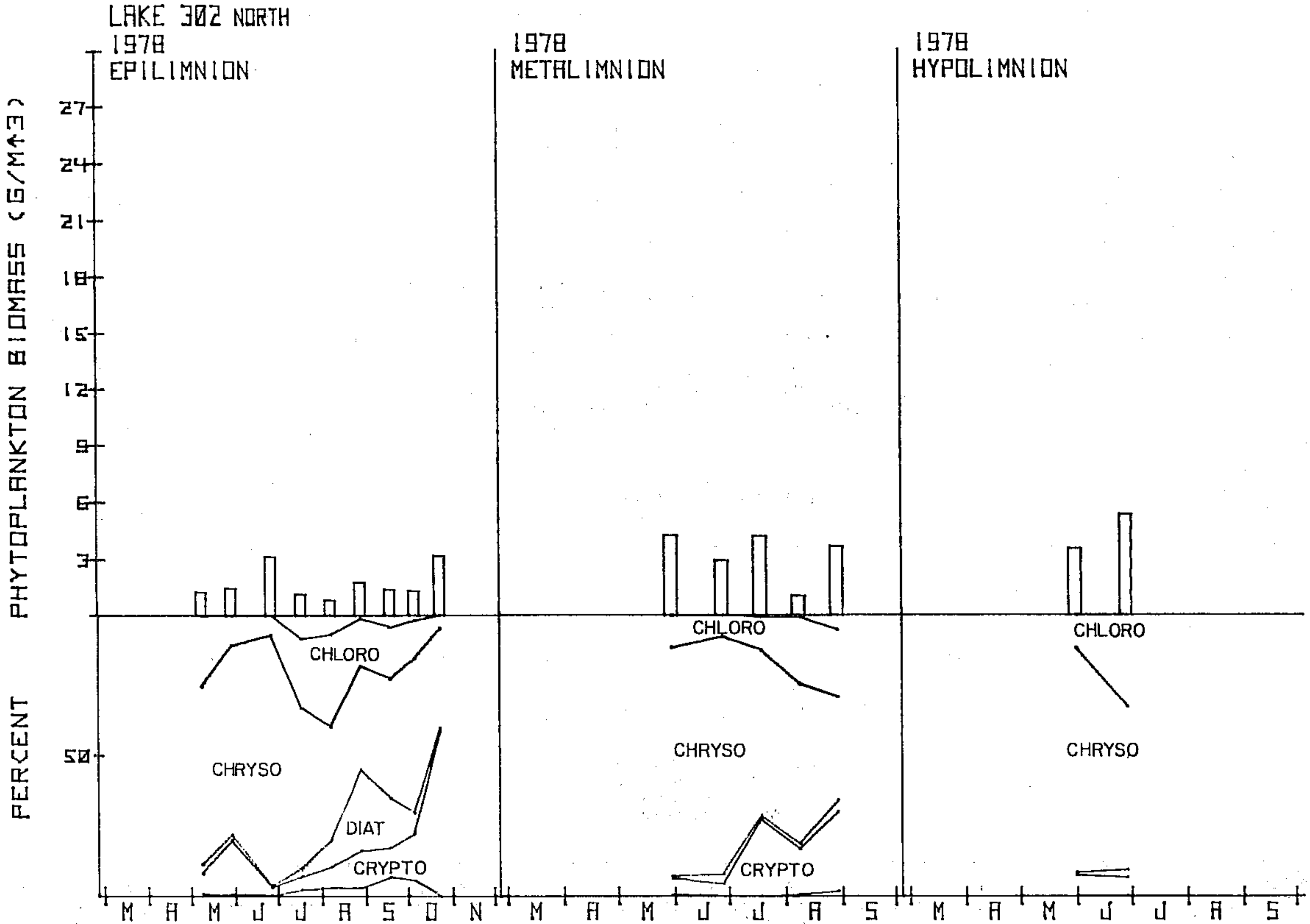

Fig. 14. Average phytoplankton volume in the epilimnion, metalimnion, and hypolimnion of Lake 302 north in 1978, and accumulative percent composition.

Table 15. Lake 302 north

Depth/Year	Date	Cyanophyceae	Common Species: Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1978	May-Oct		*Monoraphidium setiforme* Komar. *Chlamydomonas* sp.	*Chrysosphaerella longispina* Laut. *Salpingoeca frequentissima* Lemm. *Chromulina* sp. *Chrysococcus* sp.		*Cryptomonas erosa* Ehr.
	Jun-Oct		*Crucigeniella rectangularis* (Näg) Komar.	*Botryococcus Braunii* Kütz. *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger *Stichogloea Doederleinii* Wille *Mallomonas* sp.		
	Jul-Oct		*Gloeococcus Schroeteri* Lemm.			
	Aug-Oct				*Rhizosolenia eriensis* Smith	
	Oct			*Chrysochromulina* sp. *Dinobryon bavaricum* Imhof		*Cryptomonas ovata* Ehr. *C. rostratiformis* Skuja
Meta 1978	May		*Dictyosphaerium simplex* Skuja	*Chrysococcus* sp. *Dinobryon sociale* Ehr. *Chromulina* sp. *Uroglena americana* Catkins *Dinobryon bavaricum* var. *Vanhoeffenii* Krieger *Stichogloea Doederleinii* Wille *Mallomonas caudata* Iwanoff *Botryococcus Braunii* Kütz. *Dinobryon bavaricum* Imhof		*Cryptomonas erosa* Ehr.
			Gloeococcus Schroeteri Lemm. *Chlamydomonas* sp.			*Cryptomonas erosa* Ehr.
Hypo 1978	May		*Monoraphidium setiforme* Komar.	*Chrysococcus* sp.		*Katablepharis ovalis* Skuja
	Jun		*Chlamydomonas* sp. *Dictyosphaerium simplex* Skuja *Monoraphidium Contortum* (Thur.) Komárková-Legnerová	*Mallomonas caudata* Iwanoff *M.* sp. *Chromulina* sp. *Dinobryon bavaricum* Imhof	*Asterionella formosa* Hassall	*Cryptomonas erosa* Ehr.

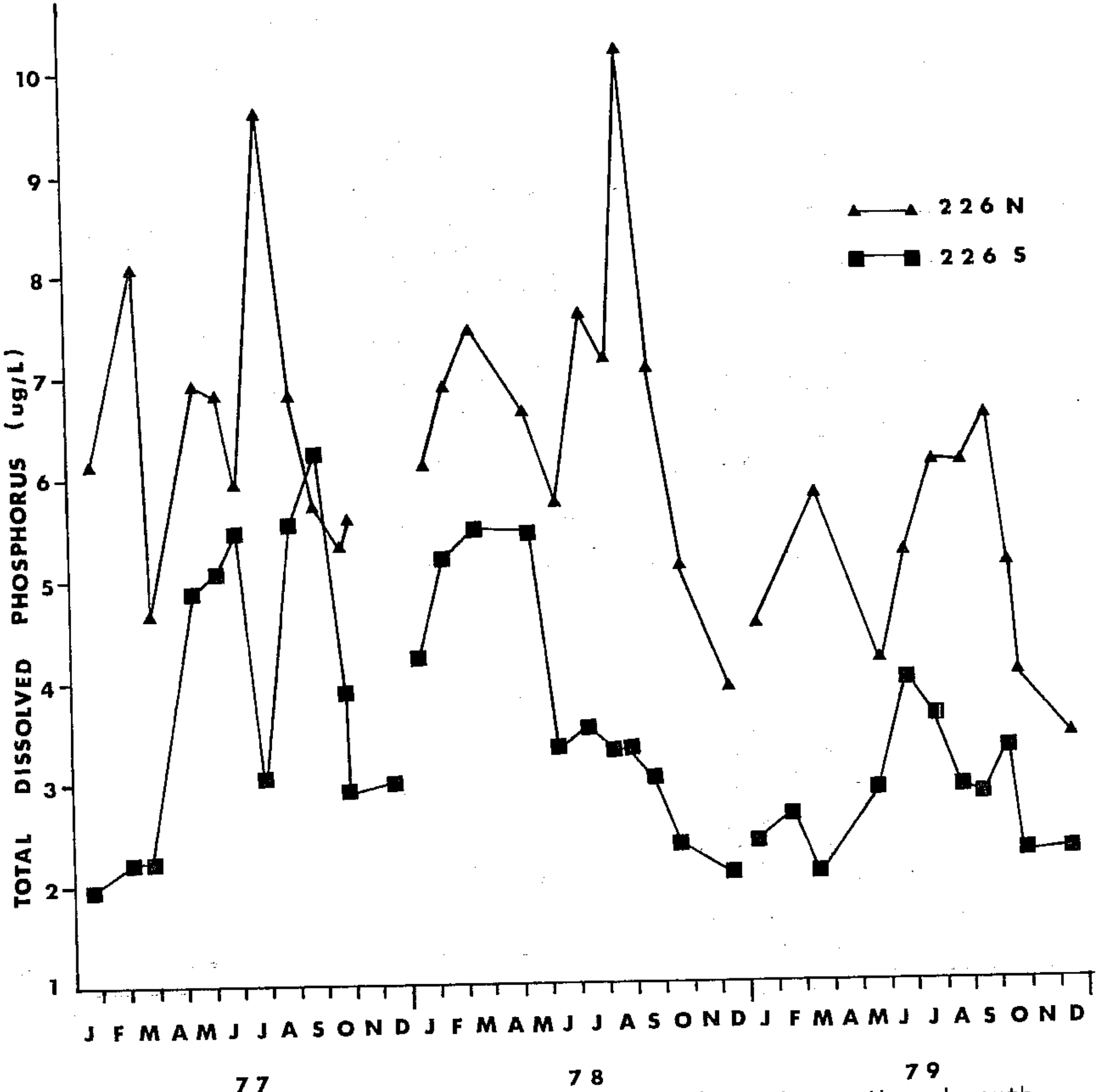

Fig. 15. Total dissolved phosphorus (μg/L) in the north and south basin of Lake 226.