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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

by

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TABLE OF CONTENTS

LIST OF FIGURES

	Page	Figu	<u>ire</u>	Page
ABSTRACT	iv	. 1	Average phytoplankton volume in the	
INTRODUCTION	1		epilimnion of Lake 227 in 1977-1979.	
BACKGROUND TO EXPERIMENTS	1	2	and accumulative percent composition .	12
Lake 227	1	_	Average phytoplankton volume in the metalimnion of Lake 227 in 1977-1979,	
Lake 226 north	1		and accumulative percent composition .	14
Lake 226 south	1	3	Average phytoplankton volume in	
Lake 302 north	i		the epilimnion of Lake 226 south in 1977-1979, and accumulative percent	
Lake 302 south	2		composition	16
Lake 304	2	4	Average phytoplankton volume in	•
Lake 227	2		the metalimnion of Lake 226 south in	
Lake 226 south	3		1977-1979, and accumulative percent composition	18
Lake 226 north	4	5	Average phytoplankton volume in	10
Lake 304	6 '		the hypolimnion of Lake 226 south in	
Lake 302 south	6 7		1977-1979; and accumulative percent composition	20
Lake 302 north	7	6	Average phytoplankton volume in	20
DISCUSSION	7		the epilimnion of Lake 226 north in	
ACKNOWLEDGMENTS	8 9		1977-1979, and accumulative percent	
	3	7	composition Average phytoplankton volume in	22
		•	the metalimnion of Lake 226 north in	
LIST OF TABLES			1977-1979, and accumulative percent	
LIST OF TABLES	•	8 .	Composition	24
<u>Table</u>	<u>Page</u>	ų ;	hypolimnion of Lake 226 north in 1977	
1 Mean biomass for ice-free season	11		and 1978, and accumulative percent composition	26
2 Common species found in the epilimnion	*.	. 9	Average phytoplankton volume in the	20
of Lake 227 in 1977-1979	13	*	epilimnion of Lake 304 in 1977 and	
3 Common species found in the metalimnion of Lake 227 in 1977-1979	15		1979, and accumulative percent	
4 Common species found in the epilimnion	10 .	10	Average phytoplankton volume in the	28
of Lake 226 south in 1977-1979	17	ia L	metalimnion of Lake 304 in 1977 and	
5 Common species found in the metalimnion of Lake 226 south in 1977-1979			1979, and accumulative percent	
6 Common species found in the hypolimnion	19	11	composition Average phytoplankton volume in	30
of Lake 226 south in 1977-1979	21		the epilimnion of Lake 261 in	
7 Common species found in the epilimnion		1	1977-1979, and accumulative percent	
of Lake 226 north in 1977-1979 8 Common species found in the metalimnion	23	· 19	composition	32
of Lake 226 north in 1977-1979	25	12	Average phytoplankton volume in the metalimnion of Lake 261 in 1977 and	
9 Common species found in the hypolimnion			1979, and accumulative percent	
of Lake 226 north in 1977-1979	27	4.0	composition	34
10 Common species found in the epilimnion of Lake 304 in 1977 and 1979	29	13	Average phytoplankton volume in	
11 Common species found in the metalimnion			the epilimnion, metalimnion, and hypolimnion of Lake 302 south in	
of Lake 304 in 1977 and 1979	31		1978, and accumulative percent	
12 Common species found in the epilimnion of Lake 261 in 1977 and 1979	22	1.8	composition	36
13 Common species found in the metalimnion	33 I	14	Average phytoplankton volume in the epilimnion, metalimnion, and	
of Lake 261 in 1977 and 1979	35		hypolimnion of Lake 302 north in	
14 Common species found in the epilimnion,			1978, and accumulative percent	
metalimnion and hypolimnion of Lake 302 south in 1978.	37	15	Composition	38
15 Common species found in the epilimnion.		13	Total dissolved phosphorus (µg/L) in the north and south basin of	
metalimnion and hypolimnion of Lake 302			Lake 226	40
north in 1978	39			

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-cles: 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} m³ 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/m²/yr	N g/m²/yr	p g/m²/yr	Artificial Nutrient Ratio (by wgt) C N P
1969-1974		7 (NaNO ₃)	0.50 (H ₃ PO ₄)	0:14: 1
1975-1979	$\frac{1}{2} \frac{1}{2} \frac{1}$	2.25 (NaNO ₃)	0.46 (H ₃ PO ₄)	0: 5: 1

LAKE 226 NORTH

Area 8.3 ha Volume 4.72 x 10⁵m³ 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/m²/yr	N g/m²/yr	P g/m²/yr	Artificial Nutrient Ratio (by wgt) C N P
1973-1979	3.69 (sucrose)	1.808 (NaNO ₃)	0.34 (H ₃ PO ₄)	10: 5: 1

LAKE 226 SOUTH

Area 7.8 ha Volume 4.885 x 10^{5} m³ 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/m²/yr	N g/m²/yr	P g/m²/yr	Artificial Nutrient Ratio (by wgt) C N P
1973-1979	3.69 (sucrose)	1.93 (NaNO ₃)	e 4	10: 5: 0

LAKE 261

Area 5.6 ha Volume 1.60 $\times 10^{5} \text{m}^{3}$ 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	N	p
	g/m²/yr	g/m²/yr	g/m²/yr
1973-1976	esserio di Transferio		0.246 (H ₃ PO ₄)

1977-1979 no additions

LAKE 302 NORTH

Area 12.8 ha Volume 7.32 x 10^{5} m³ 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 oc-cur 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 ₄ CL)	0.536 (H ₃ PO ₄)	7: 5: 1
1978	3.73 (sucrose)	2.79 (NH ₄ CL)	0.536 (H ₃ PO ₄)	7: 5: 1

LAKE 302 SOUTH

Area 10.9 ha Volume 5.54 x 10^{5} m³ 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 therm-

ocline.

1972-1976, 1978: No additions

LAKE 304

Area 3.6 ha Volume 1.15 x 10⁵m³ 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. to test the hypothesis that the deletion of phosphorus would 1973-1974:

reduce the eutrophying effects of enrichment.

1975-1976:

monitor the effects extremely high loading rates of nitrogen and phosphorous.

1977-1979: to study the recovery from

artificial enrichment.

	C g/m ² /yr	N g/m²/yr	Ρ g/m ² /yr	Artificial Nutrient Ratio (by wgt) C N P
1971-1972	5.5 (sucrose)	5.2 (NH4CL)	0.4 (H3PO4)	13.8:13: 1
1973-1974	5.5 (sucrose)	5.2 (NH4CL)	(H ₃ PO ₄)	
1975-1976		14.48 (NaNO ₃)	1.01 (H ₃ PO ₄)	0:14: 1

1977-1979 No additions - LAKE 227 1977

> Epilimnion (Fig. 1, Table 2): In early May, 1977, Lake 227 had an average epilimnetic biomass of 9,040 mg/m 3 . Chrysophyceae were 81% of the biomass and Cyanophyceae 14%. Fertilization began in mid May with weekly additions of NaNO3 and H3PO4 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 $\rm mg/m^3$ 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/m 3 and species composition had shifted to 32% chryso-phytes, 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 $27,400 \text{ mg/m}^3$. 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 $(34,234~\text{mg/m}^3)$. 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.

> $\frac{\text{Hypolimnion:}}{\text{was sampled}} \quad \text{In 1977, the hypolimnion in Lake} \\ \text{227} \quad \frac{\text{Was sampled}}{\text{was parted}} \quad \text{only once (18 May) because light}$ penetration was too low to allow photosynthesis in the hypolimnion for the rest of the summer. At this time the biomass was 4,430 ${\rm mg/m}^3$ and was 32% cryptophytes, 31% chlorophytes, 16% cyanophytes and 11% chrysophytes.

Epilimnion (Fig. 1, Table 2): In early May 1978, the standing crop of 3,300 mg/m³ was composed of 33% Cryptophyceae, 26% Cyanophyceae, 21% Chrysophyceae and 17% Chlorophyceae. Fertilization began in mid May with weekly additions of NaNO3 and H3PO4 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 $8.375~{\rm mg/m^3}$. Biomass declined to $4.210~{\rm mg/m^3}$ in mid July, then increased to 11,631 mg/m³ by the end of the month. Biomass declined throughout August and in mid September was 5,590 mg/m³. At that time, chlorophytes were 55% of the biomass and Cyanophyceae were 25%. In late September, biomass increased to 8,900 mg/m³ and composed of 40% chlorophytes, 31% cyanophytes and 20% chrysophytes. Biomass decreased to 5,580 mg/m³ in mid lotoper at which point sempling was discontinued 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/m³. 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/m³. In early August the maximum yearly biomass of 16,815 mg/m³ was recorded. By mid August, biomass had declined to 11,275 mg/m³ and species composition shifted to a co-dominance of chlorophytes and cryptophytes. Biomass continued to decline reaching 9,890 mg/m³ 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/m³. Artificial enrichment began in mid May with weekly additions of NaNO3 and H3PO4 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/m³ at this time. By mid July biomass had increased to 8,740 mg/m³ 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/m³ 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 $\,\mathrm{mg/m^3}$ 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 $\,\mathrm{mg/m^3}$ to 8,010 $\,\mathrm{mg/m^3}$.

Metalimnion (Fig. 2, Table 3): Sampling of the metalimnion began in late May, at which time the biomass was 1,360 mg/m³ 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/m³ 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/m³ in late July to 32,175 mg/m³ in late August when cyanophytes became dominant. Biomass then decreased through September averaging 20,660 mg/m³ 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/m³. Chrysophyceae were 57%. Artificial enrichment began in mid May with weekly additions of sucrose and NaNO3. By mid May dominance had shifted to Diatomeae (Rhizosolenia eriensis) and biomass increased to 4,740 mg/m³. Diatomeae dominated throughout June and early July, at times representing as much as 63% of the standing crop. Biomass increased to 7,760 mg/m³ in early June then decreased. In late July, dominance shifted to Chlorophyceae (Spondylosium planum and Chlamydomonas sp). Biomass increased to 9,800 mg/m³ 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/m³ 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/m³ 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/m³) was dominated by Chrysophyceae (49%) and Cryptophyceae (43%). Fertilization began in mid May with weekly additions of sucrose and NaNO3, as in previous years. Chrysophyceae continued to dominate throughout June and was 77% of the total biomass of 3,920 mg/m³ 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/m³. 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/m³ in early spring to 5,695 mg/m³ 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/m³ in mid May to 10,335 mg/m³ 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/m³) 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 NaNO3. 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 crypto-

phytes (Rhodomonas minuta, Cryptomonas erosa, Katablepharis ovalis) were present. Biomass ranged from 964 mg/m³ in early July to 2,150 mg/m³ in late July. Early in September Chlorophyceae became codominant 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/m³ 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/m³ to 2,175 mg/m³, averaging 1,780 mg/m³. In early October, Cryptophyceae became co-dominant with the existing chrysophycean population, each constituting 41% of the total biomass which was 1,415 mg/m³. Sampling ceased in early October due to deepening of the epilimnion.

<u>Hypolimnion</u> (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 ${\rm mg/m^3}$ standing crop. By mid May, biomass decreased to 1,825 ${\rm mg/m^3}$ of which chrysophytes were 66%. Fertilization began in mid May with weekly additions of sucrose, NaNO3 and H3PO4 being added at a N:P ratio of 5:1 by weight. Biomass increased to 4,870 mg/m³ 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/m³ 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/m³ 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/m³. 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/m³. Biomass ranged from 2,000 mg/m³ to 5,600 mg/m³ 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/m³. 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, NaNO₃ and H₃PO₄ being added at a N:P ratio of 5:1 by weight. Biomass increased steadily throughout June and early July reaching 5,840 mg/m³ 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/m³ 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/m³ in early September. Throughout the remainder of September cyanophytes decreased to 65% of the standing crop and biomass decreased to 6,500 mg/m³. Biomass continued to decrease and by mid October was 3,450 mg/m³. 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/m³ 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/m³, a metalimnetic yearly maximum. Chrysophyceae were 60% of the biomass and Cyanophyceae represented 21%. In mid July, the biomass decreased to 2,515 mg/m³ 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/m³. 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/m³ was recorded. The standing crop was 63% Chrysophyceae, 21% Cryptophyceae and 9% Chlorophyceae. In early June the biomass was 4,320 mg/m³. 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/m³ of which 58% were Chrysophyceae, 27% Cryptophyceae, 8% Peridineae, and 7% Chlorophyceae. Fertilization began at this time with weekly additions of sucrose, NaNO3 and H3PO4. Biomass increased to 4,840 mg/m 3 by late Chrysophyceae continued to dominate the dune. standing crop until early July when dominance shif-ted 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/m³); Spondylosium planum was 46% of the total. Chlorophyceae continued to dominate throughout August with biomass excalating to 11,815 mg/m3 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/m³. 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 icefree season with populations of chlorophytes, cyanophytes and diatoms occurring. Biomass decreased to 4,980 ${\rm mg/m}^3$ 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/m³. 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/m³ 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/m³. Biomass decreased rapidly and by mid September was 3,620 mg/m³. 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 $2,185~\text{mg/m}^3$ and the phytoplankton community was dominated by Chrysophyceae (51%) with a large population of Cryptophyceae present (41%).

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/m³ was 37% cryptophytes, 33% chrysophytes and 22% chlorophytes. Biomass increased throughout May and reached 3,050 mg/m³ 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/m³. 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/m³ then declined throughout September and October to 2,745 mg/m³.

Metalimnion (Fig. 10, Table 11): The early spring biomass was 22,780 mg/m³. 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/m³). Cryptophytes were 89% of the standing crop. By early July, biomass began to slump and, in early August, a biomass of 1,085 mg/m³ was recorded. Species composition shifted to a dominance of Euglenophyceae. Biomass increased throughout August reaching 13,160 mg/m³. 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 $660~\text{mg/m}^3$ 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/m³ composed of 55% Chrysophyceae, 19% Cryptophyceae, and 17% Chlorophyceae. In early June, biomass decreased to 255 mg/m³ (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/m³ 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/m³. 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 H₃PO₄ was discontinued. Sampling was continued for three years to follow its recovery. Sampling began in mid May when a biomass of 3,315 mg/m³ was recorded. The phytoplankton population was represented by 51% chrysophytes, 29% chlorophytes and 17% cryptophytes. Biomass decreased to 1,800 mg/m³ 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/m³. 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/m³. Throughout September and October, Chrysophyceae dominated with small populations of cyanophytes, chlorophytes, cryptophytes and dinoflagellates occurring. Biomass fluctuated from 1,725 mg/m³ to 2,680 mg/m³ 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/m³. By early June, biomass doubled (6,708 mg/m³) 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/m³. 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/m³. 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 H₃PO₄.

In early spring the biomass was 1,695 mg/m³. Chrysophyceae were 73% of the biomass and Chlorophyceae an additional 16%. In mid June, biomass increased to 2,500 mg/m³ 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/m³ 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 $1,105 \text{ mg/m}^3$ and was dominated by Chrysophyceae (Dinobryon sertularia). By early June, biomass decreased to 500 mg/m^3 , then increased to 860 mg/m^3 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 (Chrococcus 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/m³ to 1,350 mg/m³ 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 decrea mg/m^3 to 850 mg/m^3 in late October. Biomass decreased from 1,670

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 periodi-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/m³ to a metalimentic maximum of 4,335 mg/m³ in early July. Samples stored in late September when the doubt of pling 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 $675~\text{mg/m}^3$. 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 $\mathrm{mg/m^3}$ 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/m³. 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/m³ was recorded. Chrysophyceae were 87% of the standing crop. Biomass decreased in early August to $3,665~\rm mg/m³$ and species composition shifted to 73% chrysophytes, 13% chlorophytes and 10% crypto-phytes. By mid Setpember Cryptophyceae (Cryptomonas rostratiformis and Cryptomononas erosa) were 72% of the total biomass of 4,525 mg/m³ 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/m3 to 1,210 mg/m³, respectively.

LAKE 302 NORTH

1978

Epilimnion (Fig. 14, Table 15): In early May

the standing crop of 1,250 mg/m³ was 63% Chrysophyceae and 26% Chlorophyceae. Fertilization began in mid May with weekly additions of sucrose, NH4Cl and H₃PO₄ being pumped below the thermocline (8 meters). Biomass increased throughout June reaching 3,130 mg/m³ with chrysophytes dominating, constituting 89% of the standing crop. Biomass decreased throughout July and in early August was recorded at 803 mg/m³ (40% chrysophytes and 32%) chlorophytes). In late August, biomass doubled to 1,750 mg/m³. This increase correlates with an increased in diatoms, mainly Rhizosolenia eriensis. Throughout September and early October biomass remained constant (1,315 mg/m³) 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

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/m³ to 4,200 mg/m³ from May until late July. In early August a decrease in biomass was recorded (1,031 mg/m³) but, by late August biomass increased to 3,690 mg/m³. Sampling was discontinued due to fall mixing of the epilim-

Hypolimnion (Fig. 14, Table 15): The hypolimnion was sampled twice in 1978. In late May the biomass was 3,526 mg/m³. Chrysophyceae dominated with several species contributing. In late June biomass was $5.343~\text{mg/m}^3$ 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 H₃PO₄. 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 <u>Anabaena</u> or <u>Aphanizomenon</u>. 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 H3PO4

Artificial enrichment of Lake 261 ceased in 1977. It has been monitored for 3 years (1977-1979) to study the recovery from $\rm H_3PO_4$ 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 $\rm H_3PO_4$ did accelerate eutrophication and that within 2 years after enrichment ceased the standing crop returned to its prefertilization status.

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REFERENCES

- FLETT, R. J. 1976. Nitrogen fixation in Canadian Precambrian Shield lakes. Ph.D. Thesis, Univ. of Manitoba, Winnipeg. 197 p.
- FINDLAY, D. L. 1978. Seasonal successions of phytoplankton in seven lake basins in the Experimental Lakes Area, northwestern Untario following artificial eutrophication. Data from 1974 to 1976. Can. Fish. Mar. Serv. MS Rep. 1466: iv + 41 p.
- FINDLAY, D. L., and H. J. KLING. 1975. Seasonal successions of phytoplankton in seven lake basins in the Experimental Lakes Area northwestern Ontario following artificial eutrophication. Can. Fish. Mar. Serv. Tech. Rep. 513: 53 p.
- FINDLAY, D. L., and H. J. KLING. 1979. A species list and pictorial reference to the phytoplankton of central and northern Canada. Part I, II. Can. Fish. Mar. Serv. MS Rep. 1503: iv + 619 p.
- KLING, H. J., and S. K. HOLMGREN. 1972. Species composition and seasonal distribution of phytoplankton in the Experimental Lakes Area, northwestern Ontario. Can. Fish. Mar. Serv. Tech. Rep. 337: 56 p.
- SCHINDLER, D. W. 1977. Evolution of phosphorous limitations in lakes. Science (Wash. D.C.) 195: 260-262.
- SCHINDLER, D. W., T. RUSZCZYNSKI, and E. J. FEE. 1980. Hypolimnion injection of nutrient effluents as a method of reducing eutrophication. Can. J. Fish. Aquat. Sci. 37: 320-327.

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 12811 4040 4553 3221 4435 4224 2997 3505 1085 17003 6627 4928 3620 2854 14332 4671 2008 2640 13885 6347 5034 5499 4519 3951 3146 4111 6374 7934 2869 3491 Mean Biomass mg/m³ Mean biomass for ice-free seasons. Strata Epi Meta Hypo 226 North 226 South 302 South 302 North Table 1. Lake

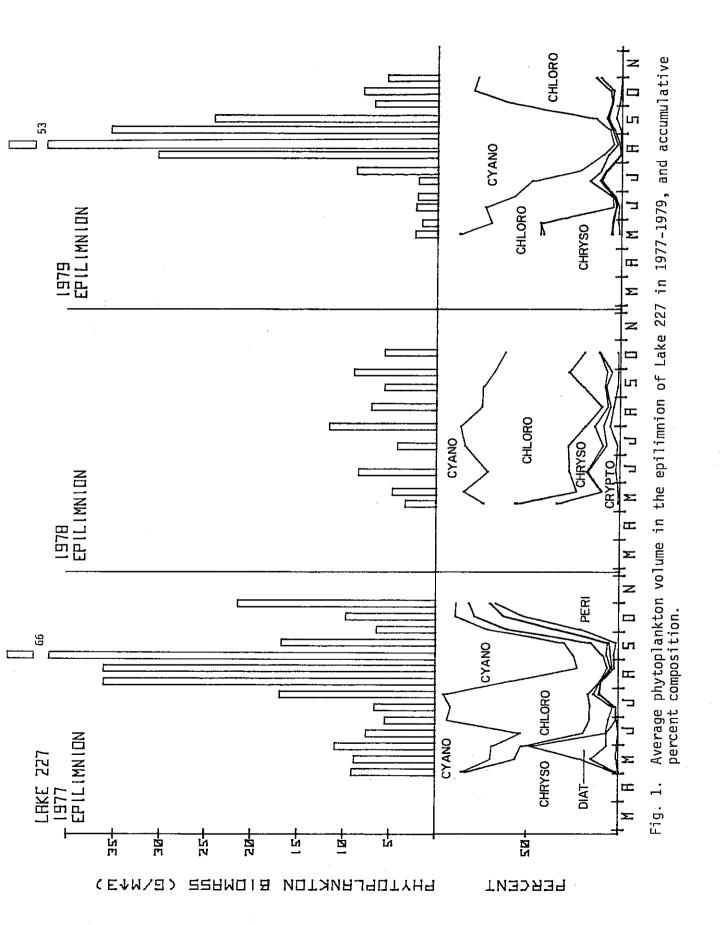


Table 2. Li	Lake 227		,	Common Species		
Depth/Year	Date	Суапорћусеае	СһТогорһусеае	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1977	Мау	Oncillatoria Redeket Van Goor	Dictycephaerium eimpiez Skuja Scenedamus denticulatus Lager. Monovophidium contartum (Thur.) Romárková-Legnsrová Spondilosium pionum Nest Scenedesmus quadricanda Brêb.	Dinobryon sertularia Ehr. D. sociale Ehr. Chrysochramilina parva Lackey	Cryptomonae eroea Ehr. C. roeiroiriformie Skuja Katablepharie ovalie Skuja	
	Jun-Oct	Jun-Oct <i>Geoillatoria Relekei</i> Van Goor	Spondylosium planum West Occystis submarina Var. variabilis Skuja	Gayaootromutina parva Lackey	Стуртотав егова Еhr.	
	Jul-Oct	Jul-Oct <i>Aphanisamenon floa-aquae</i> Ralfs Anabaena eolitaria f.a. planotomica (Brunnth.)Komar.	Diotyosphaerium simplex Skuja Staurustrum Bullardii Smith S. paradorum Neyen Soenedesmus quadrioauda Brêb.		Cryptomonae ovata Ehr.	Peridinium inaonspiaum Lemm. Aymnodinium Sp.
	Oct	Gamphoephaerium Lacuetrie Chodat				G. mirzbile Penard.
Ері 1978	May-Oct	May-Oct <i>Cacillatoria Redekei</i> Van Goor	Chlamydononas sp. Mongraphidium contortum (Thir. , Kamatradus-Legnerová Dictiosphaerium eimplar Skula Scenedesmus quadricauda Brêb.	Chrygootnomitina parva Lackey	Cryptononae obovata Skuja C. ovota Ehr. C. roetratiformie Skuja C. eroea Ehr.	
	Jun-Oct		Oocystia submarina var. variabilis Skuja			
	Jul-Oct	Арһаківателап дуасі їв Lemm.	Spordyłosium planım Mest Dictyosphaerium pulchelium Wood			Paridinium inconspicum Lemo.
	Aug-Oct	Anabaena, Solitaria f.a.). plantonica (Brunnth.) Komar.	Staurastrum sp.	* 4		
Ер† 1979	Мау-Лип	Oscillatoria Redeksi Van Goor	Chlamydomonaa sp. Chlorogontum maximum Skuja	Synura spp Salpingoesa frequentieeima Lemm. Chryesochromulina parva Lackey		
	ար-սոր 1	Oscillatoria limetica Lem.	Scenedasmuo danticulatuo Lager. S. quadricauda Bréb. Occyotia lacustria Chodat			
	Jul-Oct Oct	Anabasıa cylindrica Lemm. A. Solitaria f.a. planatonica (Brunnth.) Komar. Oscillatoria Radeksi Van Goor	Occystla submarina var. nord oblits			Peridinium inconopicum Lemm.
- ` _V			Scenedasmue denticulatus Lager. S. quadricauda Brêb. Occustis lacustris Chodat		Стурtотопав егова Ehr.	

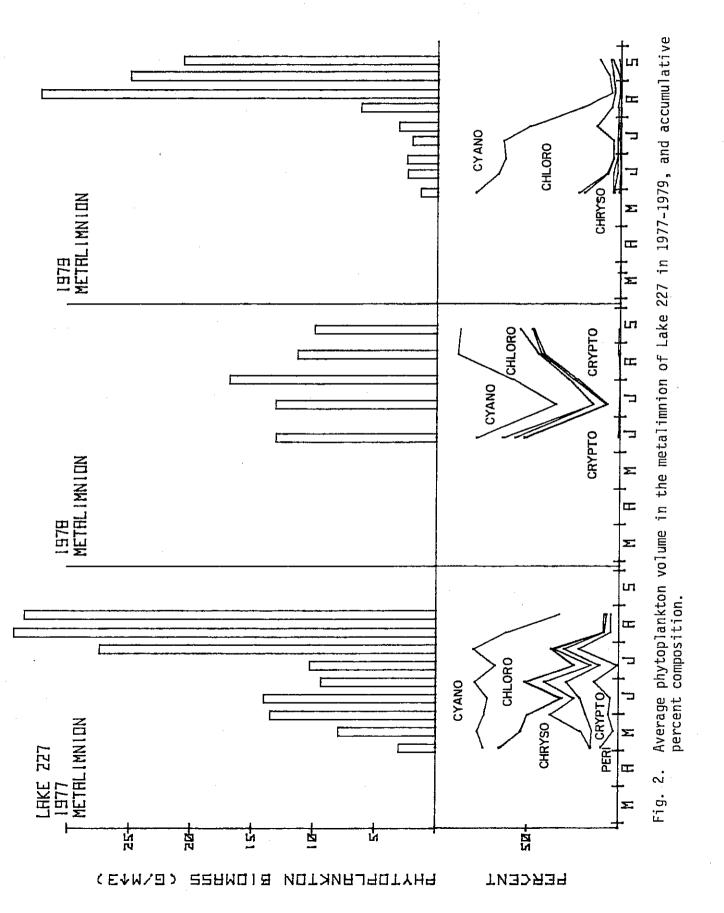
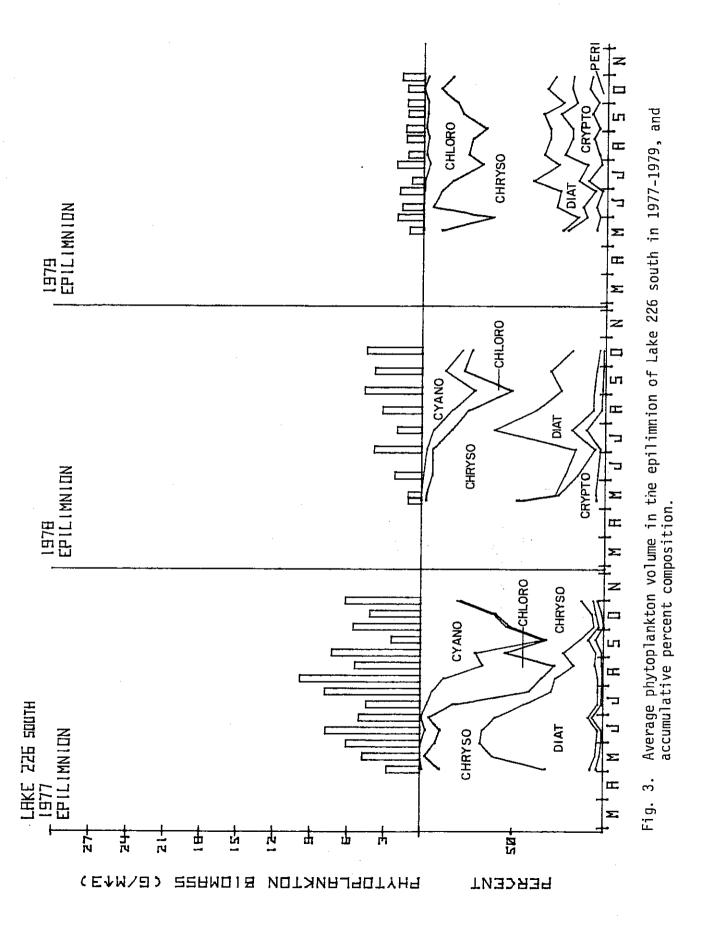
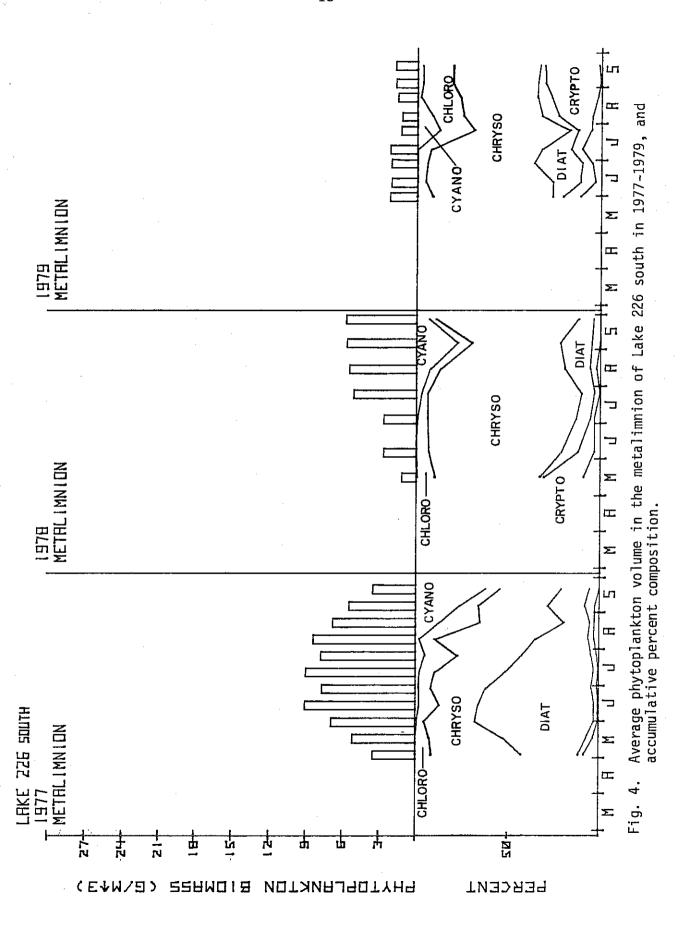


Table 3.	Lake 227			Common Species		
Depth/Year	11	Суапорһусеае	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Meta 1977	Мау	Osotllatoria Redekei Van Goor	Dictyosphaerium simplem Skuja Monorophidium Contortum (Thur.) Semedesmus quadricanda S. denticulatus Lager. S. brevispina Chodat	<i>Dinobryon sertularia</i> Ehr.	Cryptomonas erosa Ehr. Gryptomonas obovata Skuja C. erosa Ehr. C. rostratiformis Skuja	Gymrodinium sp.
	Jun-Aug Ju1-Aug Aug	Oscillatoria Redekei Van Goor Anabaena solitaria f.a. planstorica (Brunnth.) Komar.	Diotyospinaerium simplem Skuja Oocystis submarina var. variabilis Skuja Diotyospinaerium pulchellum Wood Staurastrum paradoxum Meyen Scenedesmus quadricauda Brêb. Spondylosium planum West	Сптувосітоти Гіла ратва Lackey	C. ovata Ehr. Gryptomonas erosa Ehr.	Gymrodinium sp.
Meta 1978	Jun-Sept Jul-Sept	Oacillatoria Redekei Van Goor	Chlorogonium maximum Skuja Dicipospinarium etmplex Skuja Chlamydomonas Spp. Scenedesmus breviepina Chodat Occystis submarina Ver.	Сінтувосінготийна рата Lackey	Cryptomonas obovata Skuja	
	Aug-Sept	Apianisomenon gracile Leum.	variabilis SKLja Diotyosphaerium pulchellum Wood Staurastrum SP.			Peridinium inconspicum Lemm.
Meta 1979	May-Jul	Oeaillatoria Redekei Van Goor	Chloroge Aium maximum Skuja Scenedesmus breviepina Chodat Biotyosphaerium pulchellum Wood Scenedesmus denticulatus Lager. S. quadricanda Brêb.	Chrysochromiina parva Lackey		
	Jui-Sept	. Oscillatoria limmetica Lemm. O. Redekei Van Goor Anabaena of. oylindrica Lemm.	Oocyatis lacustris Bréb. Chlamydomonas Sp.			
	Aug-Sept	: A. ef. Levandert Lemm.	:			



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Aug-Oct Costilatoria Radakat Van Goor Sept-Oct Anabasara solitaria Radakat Van Goor Sept Archaenta and Start Radakat Van Goor Sept Archaenta solitaria Radakat Van Goor Sept Archaenta Radakat Van Goor Sept Archaenta Solitaria Parchaenta Radakat Radaka	Aun-Oct Oppilizatoria Redekei Van Goor Aug-Oct Oppilizatoria Inmusica Lemn. Principal Sapi-Oct Oppilizatoria Stulja Aug-Oct Oppilizatoria Inmusica Lemn. Principal Sapi-Oct Oppilizatoria Stulja Aug-Oct Oppilizatoria Inmusica Lemn. Principal Sapi-Oct Oppilizatoria Stulja Aug-Oct Oppilizatoria Brun. Aug Oppilizatoria Redekei Van Goor Aug Oppilizatoria Redekei Van Goor Sept-Oct Oppilizatoria Redekei Van Goor Aug Oppilizatoria Redekei Van Goor Sept Arabanca opilizatia Aug Oppilizatoria Redekei Van Goor Aug Oppilizatoria Aug Oppilizatoria Aug Oppilizatoria Aug Oppilizatoria Aug O	And—Oct Oncillatoria Redakef Wan Goor Jun-Oct Oncillatoria Redakef Wan Goor Jun-Oct Oncillatoria Redakef Wan Goor And—Oct Andborn Contillatoria Redakef Wan Goor And—Oct Andborn Contillatoria Redakef Wan Goor And—Oct Andborn Contillatoria Redakef Wan Goor F.a. Planetaria Brun. And—Oct Andborn Contillatoria Redakef Wan Goor F.a. Planetaria Redakef Wan Goor And Oct Andborn Contillatoria Redakef Wan Goor And Oct Andborn Colland Sapt Andborn Colland And Oct Andborn Colland Andborn Co
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Aug-Oct Anabasna solitaria lemm. Sepi-Oct Anabasna solitaria Failsolina Bour- Oct Anabasna solitaria Hay Hay Sepi-Oct Anabasna solitaria Jul Aug Osarillatoria Radakoi Van Goor Sepi Arabasna solitaria Sepi Arabasna solitaria Failsolina Mest Fire plantina para lemm. Sepi Arabasna solitaria Failsolina Mest Chrysosphasvalia longiphra Laut. Biothyposphasvalia forgina mericanum Back. Aug Osarillatoria limmatica Lemm. Girlina Mood Girlina moodia Girlina Gi	Aug-Oct (activitation lemm. Partiagnia granulate (Roy et F.a. pianatonica Brun. Feliagnia granulate (Roy et Bour-F.a. pianatonica Brun. Ge Bour-F.a. pianatonica Brun. Ge Bour-Binobryon sarkularia Ehr. Brinobryon sarkularia Back. Arabasan solitaria Back. Gilangodomana Ehripophamaria Back. Gilangdomana Ehripophamaria Back. Brinobryon sarkularia Indiger Gilangdomana Sp. Brinobryon sarkularia Indiger Gilangdomana Sp. Brinobryon sarkularia Binobryon sarkularia Binobryon sarkularia Sp. Gilangdoma Sp. Gilangdoma Sp. Brinobryon sarkularia Binobryon Sp. Brinobryon Sp.	Aug-Oct Anabacan acittaria Brun. Teilingia premidata (Roy et 1819) Brunca Spinara Spin
Got Spinars sp	f.a. planetonida Brun. Oct Hay Hay Hay Hay Hay Ghryaconeus Brannii Kütz. Jul Aug Oseillatoria Radekei Van Goor Sept Arabana solitaria f.a. planetonica Sept Arabana solitaria F.a. planetonica Situngianna Planim West F.a. planetonica Trilingia parallata (Roy & Square anaricana Catkins Trilingia parallata (Roy & Square anaricana Back. Biss) Bourr. Hay-Sept Champianna sp. Champianna previsita Chuque Champianna sp.	Fia. Fianctonica Brun. Oct Hay Hay Hay Hay Ghryacochusmitha parva Lackey Aug Oncillatoria Radakei Van Goor Sept Arabaana solitaaria Fia. Planetonia Back. Fia. Planetonia Lemm. Bay Ghryacochusmitha parva Lackey Ghryacochusmitha Longiqua Laut. Finobryon aerthiaria Var. Biss) Bourr. Finobryon aerthiaria Var. Biss) Bourr. Ghryacochusmitha parva Lackey Ghryacochusmitha parva Lackey Ghryacochusmitha parva Lackey Ghryacochusmitha parva Lackey Finobryon aerthiaria Var. Ghronidema servicam Inhof Ghryacochusmitha parva Lackey Finobryon bavaricam Inhof Ghryacochusmitha parva Lackey Finobryon bavaricam Inhof Ghryacochusmitha parva Lackey Finobryon bavaricam Inhof Ghryacochusmitha parva Finobryon bavaricam Inhof
Hay Chrysochromithus parva Lackey Jun Sept Arabana solitaria Radakei Van Goor Sept Arabana solitaria Radakei Van Laut. Sept Arabana solitaria Van Coor Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Van Coor Sept Arabana solitaria Van Coor Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Van Coor Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Radakei Van Coor Sept Arabana solitaria Sept Arabana solitaria Sept Arabana Sept	Hay Jul Aug Osatilatoria Radakei Van Goor Sept Arabasa ositiarta T. Arabasa ositiarta Sept Arabasa ositiarta T. Arabasa ositia	Hay Sign Jul Aug Glargacohromitha para Lackey Birabayan sartutarfa Ehr. Dinabayan sartutarfa Ehr. Panioaffanta Kateger Brogiena amaricana Catkins Pinabayan sartutarfa Ehr. Panioaffanta Kateger Brogiena amaricana Catkins Pinabayan sartutarfa Ehr. Panioaffanta Kateger Brogiena amaricana Catkins Brogiena amaricana Catkins Brogiena amaricana Catkins Brogiena amaricana Laur. Brogiena amaricana Catkins Brogiena amaricana Sp. Brogiena amaricana Catkins Brogiena amaricana Catkins Brogiena amaricana Catkins Brogiena amaricana Sp. Brogiena amaricana Catkins Brogiena amaricana Sp. Brogiena amaricana Catkins Brogiena amaricana Sp.
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Oscillatoria Radoket Van Goor Spondyloatum planum West Spondyloatum planum West Bictyloaphaarium pulchellum Wad Silamydomonas Sp. Trilingia granulata (Roy & Trilingia granulata (Roy & Oscillatoria limmitica Lemm.	Destilatoria Radokar Van Goor Arabasna solitaria Arabasna solitaria Arabasna solitaria F.a. planotonia Distryosphaerium planum West Tolitangamana sp. Dirobryon serbularia Ehr. Dirobryon pavariam Imhof.	Desilatoria Redokar Van Goor Arabaana oolitaria Arabaana oolitaria Arabaana oolitaria F.a. planotonia Spondyloaium planum West Ghryseosphasralia longispha Laut. Spondyloaium planum West Ghryseosphasralia longispha Laut. Sichemidana Sp. Tailingia granulata (Roy & Symura unella Biss) Bourr. Biss) Bourr. Sept Chiamydamanas Sp. Chiamydama amaricana Imhof Chiamydama amaricana Catkins Mallamonas Sp. Chiamonas Sp. Chiamydama amaricana Catkins Antilamonas Sp.
Dacillatoria Rodokei Van Goor Spondyloaium planum West Arabasana aclitarta f.a. planotoniaa Dictyoophaerium pulchellum Wood Guyecophaerella longiopha Laut. Chlandamonaa Sp. Torlingia granulata (Roy & Synura wella Biss) Bourt. Dishopyon eertularia Var.	t Arabasnia Radakai Van Goor Arabasnia solitaria Dictipophasitum planum West f.a. planatoriaa Dictipophasitum planum West Graysosphasivila longiaphasitum Laut. Tolitangiamum Sp. Tolitangiamum Sp. Biss) Bourr. Destilatoria limmatica Lemm. Chimmydomanas Sp. Chimmydomanas Sp. Graysosphasiaran Krieger Biss Bourr. Chimmydomanas Sp. Graysosphasiaran Reger Biss Bourr. Binobryon sertularia Ehr. Graysosphasiaran Inhof	Arabasıra solitaria Badakai Van Goor Spondyloatium West Arabasıra solitaria Diotyloatium pilanum West F.a. planatoniaa Diotyloatium pilanilarilum Wood Ginysoophasvalla longiapina Laut. Diotyloatium pilanilarilarilarilarilarilarilarilarilarilar
f.a. planotoniaa Diotyoophaarium pulohallum Mood Diamydomonaa sp. Tollingia granulata (Roy & Opoillatoria limnotiaa Lemm.	f.a. planeteniaa Dietyaaphaarium pulohallum Mod Glianydamonaa sp. Tallinga granulata (Roy & Biss) Bourr. Booillateria linnetica Lemm. Cilanydamonas sp. Scept Scendenma Ereriepina Chodat Cilangidamaa Ereriepina Chodat	f.a. planatomida Diatyoophaarium puleiallum Wood Gruyaoophaaralla longlophaa laut. Chicaptanana Sp. Toilingia gramidata (Roy & Synura unella Dinobryon earbilaria var. Biss) Bourr. Sept Chicaptanana Sp. Chicaptanana Sp. Gruyaoophaariaria Ehr. Signura unella Dinobryon earbilaria Ehr. Dinobryon earbilaria Ehr. Chicaptanana Sp. Gruyaoophaaria Var. Dinobryon earbilaria Ehr. Chicaptanana breviopina Chodat Scendianana breviopina Chodat Chicaptana amaricana Imhof Chicaptana amaricana Catkins Anticanona Sp.
	Chiamydananas sp. Scenadosmus breviopina Chodst Chioretla sp.	Chlamydamana Sp. Chlamydamana Sp. Chrysochromitina parva Lafkey Scenademua breviapina Chodat Chlorella Sp. Urogiana americana Catkins Attlanona Sp.
		Urogiana amaricana Catkins Atilomonas sp.
Chrysochromais Sp. Scenadaemus brevispina Chodat Chichella Sp. Uroglana amaricana (atkins Dictyoaplasrium aimplex Skuja Sammidiana naturiana (atkins Sammidiana naturiana (atkins)	Diotycephaerium eimples Skuja Snaminionium oimum West	



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E 22(Table 5. Lake 226 south	ъ		Common Species		
Date	E E	Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
å V	May-Sept	v	ीर्गकापुर्वकानावड sp.	Dinobryon sertularia Ehr. Chrysochramičina spp Dinobryon sociale Ehr. Chromičina sp.	Antsosolenia eriensia Smith Cyciotella comta Kiitz.	
			Scenedaamus denticulatua Lager.	Chrygococcus sp. Synuxa spp. Synuxa spp. Urogiena americana Catkins Dinobryon banaricum var. Vanhoeffenii Krieger	Cyclotella glomerata Back. Synedra acus Kütz.	Cryptomonae eroaa Ehr.
5	-Sept 6	Oscillatoria Redekei Van Goor	Jun-Sept <i>Oscillatoria Redekei</i> Van Goor <i>Soensdasmus brevispina</i> Chadat	B. divergens var. Schauinslandii (Lemm) Brunnth.		<i>Katablepharia ovalia</i> Skuja
洹	Jui-Sept		Spondylosium planum West Ankistrodesmus falcatus Ralfs			
5	Aug-Sept	Oscillatoria limpetica Lemm.	Gloeooocous Schroeteri Lemm. Teilingia granilaia (Roy & Biss) Bourr		Tabellaria flocoulosa Kütz.	
Sept		Anabaena of. Levonderi Leum. A. solitaria f.a. planotonica Brun.	Всепадватие sp.			
<u> 5</u>	May-Sept			Chrysochromilina sp. Chromilina sp.		Cryptomonas erosa Ehr.
<u> </u>	Jun-Sept		Saenedeemue breviepina Chodat	Dinobryon serbularia Ehr. Urog'sena americana Catkins Dinobryon bavaricam var. Yanbosffenii Krieger		÷
3	Jul-Sept			Chrysosphaerslla longispina Laut. Dinobryon barkatam Imhof	Cyolotella aomta Kütz. Tabellaria flocallosa Kütz. Cyclotella glomerata Back.	
퍐	Aug-Sept G	Gecillatoria Redekei Van Goor <i>Chilamydomona</i> e sp.	Chlamydomonas sp.	Dinobryon sertularia Ehr.		
Sept	ĺ	Anabaena of. Levanderi Lemm. Oscillatoria limmettoa Lemm.		Mallomana ривидосотопаta Prescott	Swedra acus Kütz.	
à	May-Jul		Scenedeвтив brevispina Chodat	Chrysochromitina sp. Dindiryon bararioum Imhof Dinetricaria var. Distribarana Krieger Chrysochromitina parva Lackey	Cyclotella glomerata Back.	Cryptomonas erosa Ehr. C. rostratiformis Skuja
5 5	Jun-Sept Jul-Sept			Uroglena americana Gatkins Synura spp Dinobryon Orrygochromilina parva Lackey Kephyrion boraele Skuja	Cyciotella glomerata Back.	
햜	-Sept Ø	Aug-Sept <i>Chroococous limmeticus</i> Lemm.	Spondyloaium planum West Scanadaamus danticulatua lager.	Chrysochromtina spp		Cryptomanas erosa Elir. C. coata Elir. C. rostottformis Skuis
닮	Sept-Oct		Scanedesmus breviopina Chodat	Ochromonas sphagnalis Conr.		

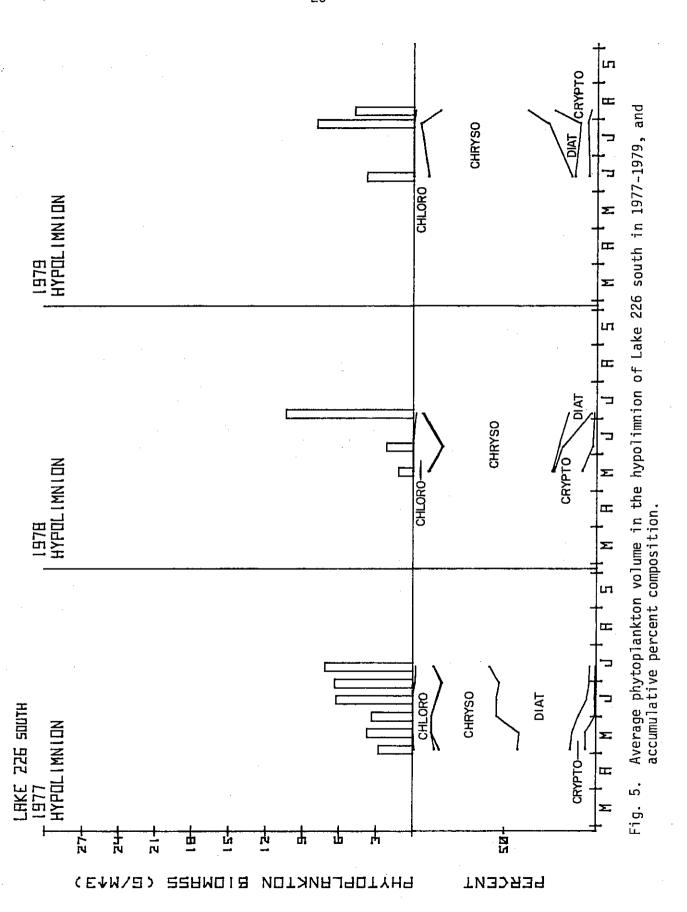
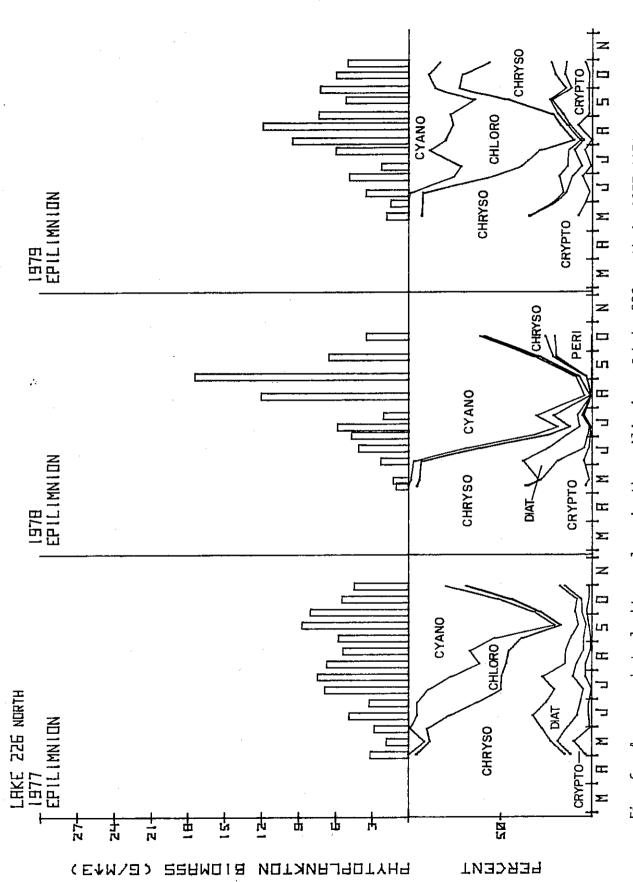


Table 6. Lake 226 south	ake 226 sc	outh		Common Species		
Depth/Year	Date	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae	Peridineae
Hypo 1977	May-Ju1	Cnlamydamonas sp.	Symura Spp Chromitina sp. Chrysococous Sp. Livejtena americana Catkins Dinobryon bavaricum var. Vanhoeffenti. Krieger D. sertularia Ehr.	Misosolenia eriensis Smith Gyolótella comta Kütz. Gyolotella glomerata Back.	Cryptomonas erosa Ehr.	Peridinum sp.
	մսո–մսT	Jun-Jul <i>Scenedesmus brevispina</i> Chodat <i>Mallomonas pseudocoronata</i> S. denticulatus Lager. Chrysolchromilina spp	Mallomonas pseudocoronata Prescutt Chrysolchromulina spp	Synedra acue Kütz.	Cryptomonas obovata Skuja	
Hypo 1978	May-Ju1		Chrysococus sp. Chromilina sp.		Cryptomonas erosa Ehr.	
	մսո–վս Մ	Jun-jul <i>Scenedesmis brevispira</i> Chodat				
	լու	•	Dinobryon sertularia Ehr.	Cyclotella comta Kütz.		
Нуро 1979	Jun	Soenedeamua brevieptna Chodat Chrysochromulina spp Chrysocoreus sp. Kaphyrion boreale Skuja Chrysochromulina pozva Lackey	Chrysochromulina spp Chrysococcus sp. Kephyrion borsale Skuja Chrysochromulina porva Lackey	Gyolotella glomerata Back.	Cryptomonae obovata Skuja Rhodomonae minuta Skuja Katablepharie ovalie Skuja	Peridinium aciculiferum Lemm.
is with	Aug ?	Scenedeвтив brevispina Chodat <i>Dinobryon ветилатіа</i> Ehr. Chrysochromulina parva	Dinobryon sertularia Ehr. Chrysochromulina parva	Cyclotella glomerata Back.	Gryptomonas erosa Ehr. C. rostratiformis Skuja C. ovata Ehr.	Peridinium aciculiferum Lemm.
÷.						



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

Table 7.	Table 7. Lake 226 north	orth		Common Species		
Depth/Year	r Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Ері 1977	Мау		Nonoraphidiun aotiforme Kamer.	Urogiena americana Catkins Symuro spp Ciriyacolromitina spp Dindryon serbicata Ehr. Cirywoolromitina parva Lackey Bindryon banaricum var. Varhooffanii Krieger	Ritaosotunta artenoto Smith Modenensa minuka Skuja	i Hiodomanau minuta Skuja
	Jun-Oct		Spondylosium planum West		Cyclotella glamarata Back.	
	Jul-Oct	Oooillatoria Redakci Van Goor	Scenedesmus dentioniatus Lager.		Synodra acus Kütz.	Спуртотонав втова Енг.
	Aug-Oct	Andwena sp. A. aclitaria f.a. plancionioa(Brunth) Komar			Tabetiania floceulosa Kütz.	
	Sept-Oct	t Gecillatoria Limetica Lemn.		Dinobeyon bavaricum Imhof		
i	Oct		Chlanydononaa sp.	D. sartularia Ehr.		
Ер1 1978	May	-		Сіпувосін'оті.Сіпа spp		Thodomonas minuta Skuja Cryptononas arosa Ehr.
	Jun			Uroglena americana Catkins Dirobryon sertularia Ehr. Mallomonas spp	Synsdra asus Kütz. Tabsīlaria floculosa Kütz.	
	Jun-Oct	Oscillatoria limnetica Lenn. Anabaena solitaria f.a. planotonica(Brunth.) Komar	Diatyosphaerium aimplex Skuja Chlamidomonas sp. r	Dinabryon sociale var. cmsricanum(Brunnth.) Bachm.	Attrovolenia erieneio Snith	
	Jul-Oct	Oscillatoria Redskei Van Goor				
	Sept-Oct	мидрайа сј. <u>Баугада</u> к, Цепп.		Chrynochromilina spp Chrynochromilina sp	Synedra acus Kütz.	Cryptomonae eroea Ehr. Katablepharis ovalis Skuja
Ept 1979	May-Jun			Chrysococus sp. Syntheryon sertidaria Ehr. Syntheryon sertidaria sp. Chrysochromitina sp. Brobryon bourtean imhof D. sertidaria var. protrubarana Krieger		<i>Cryptomonaa raatratiformia</i> Skuja
	Jun-Oct	Anabasna solitaria f.s. planatonica(Brunth.)Komar	Soenedemus brevispina Skuja Diotyoophasrium aimples Skuja Spondylostum planum Mest	<i>Urogiena america</i> na Catkins Salpingosca frequentionina Lemn.	Synedra azue Kütz.	
		4. of. oylindrica Lemn. Decillatoria linnetica Lemn.	Chlamydomanan sp.	Chrysochromulina spp	44	Cryptomonas erosa Ehr. Katablepharis ovalis Skuja
	:	Anabaena of. Levanderi Lemm.	Scenedesmus denticulatus Lager. Diatuonninamism Dilaisium Mood	Menhama andolo The	Cudatatta ameta Viita	
		Osaillatoria Redeksi Van Goor		D. benarican Inhof D. sextularia Ehr.	Ahibosolenia exiensis Smith	

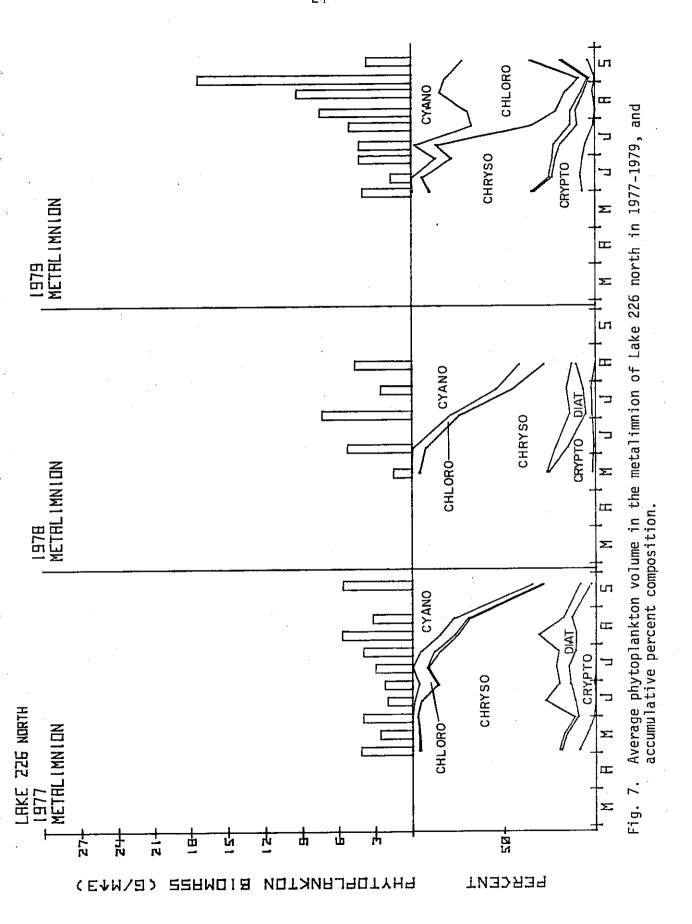
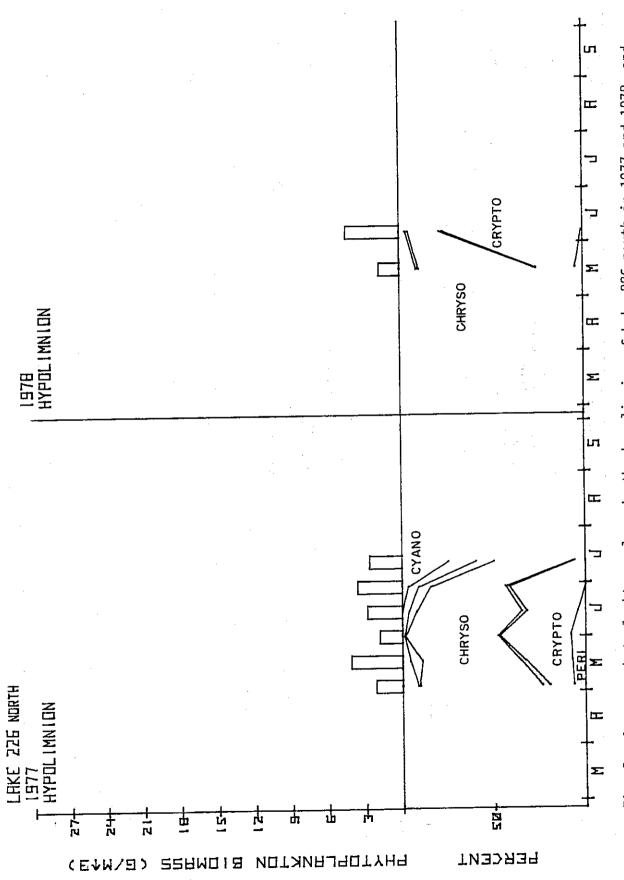
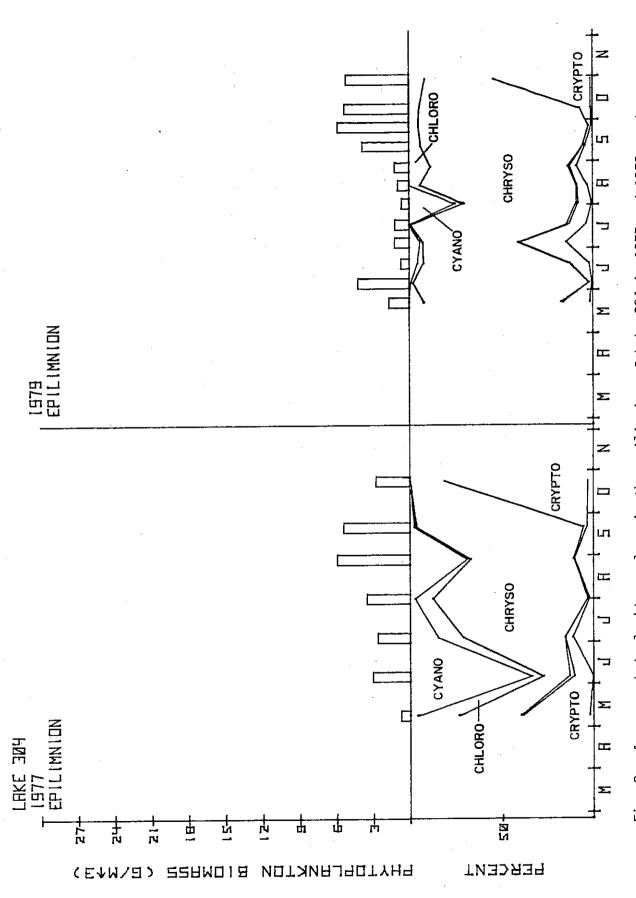


Table 8.	Lake 226 north	orth		Common Species		
Depth/Year	Date	Суапорһусеае	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Meta 1977	May-Sept	ų		Chryeochromitina sp. Dinobryon sertularia Ehr. Mailomonas pseudocoronata Prescott Uroglena americana Catkins Symra spp Dinobryon bavaricam var. Vanhoeffenii Krieger		Cryptomonze eroea Ehr. Hlodomonae minuta Skuja
, t _e t _e	Jun-Sept Jul-Sept	Oscilatoria Rodeket Van G	. Spondyloetum planum West oor	D. serbularia yar. protruberana Krieger Chrysococcue sp.	Ariaosolenia erienato Smith Sunedra acus Kitz.	Cryptomonaa roetratiformia Skuja
·	Aug-Sept Sept	t Anabaena Bolitaria Klebahn Geciliatoria Limietiaa Lemm.			Tabellaria floosulosa Kütz	
Meta 1978	Мау			Okrysochromulina spp Grysococous sp. Chromulina sp. Chrysochromulina porva Lackey		Стуртотов егова Енг.
	Jun		Dictyosphaerium pulchellum Waad	Uroglena amerioana Catkins Dinobryon serbularia Ehr.	Cyalotella glomerata Back.	Katablepharis ovalis Skuja
6 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	Ju] Aug	Oscillatoria Redekei Van Goor Anabosna solituria f.a. planotoniaa Brun. A. cf. Levanderi Lemm.	Chlamydonanau sp. Spondyloetum planum West	ទិរ្នារយៈធ spp	<i>Inbeliaria flocautosa</i> Kütz. <i>Ahisosolenia eriensis</i> Smith	Cryptononas ovata Ehr.
Meta 1979	May-Aug Jun-Aug Jul-Sept Aug-Sept	May-Aug Jun-Aug Anabaena of Lavanderi Lemm. Jul-Sept A. of cylindrica Lemm. Ovorllatoria Redeket Van Goor Anabaena of Levanderi Lemm. Aug-Sept Oscillatoria timmetica Lemm.	Spondylosium plænum West Sosnedesmus denticulatus Lager, Chlamydomonus sp.	Chrygococcus sp. Dinobryon serbularia var. protruberaja Krieger Broglena cmericana Calkins Salpingoeca frequentissima Lemm. Chrygocitromilina spp		Cryptomonaa roetratiformie Skuja C. erosa Ehr. Katabiepharis ovalis Skuja
	Sept			Chryaochromutina spp		Стуртотав вгова ЕНг.



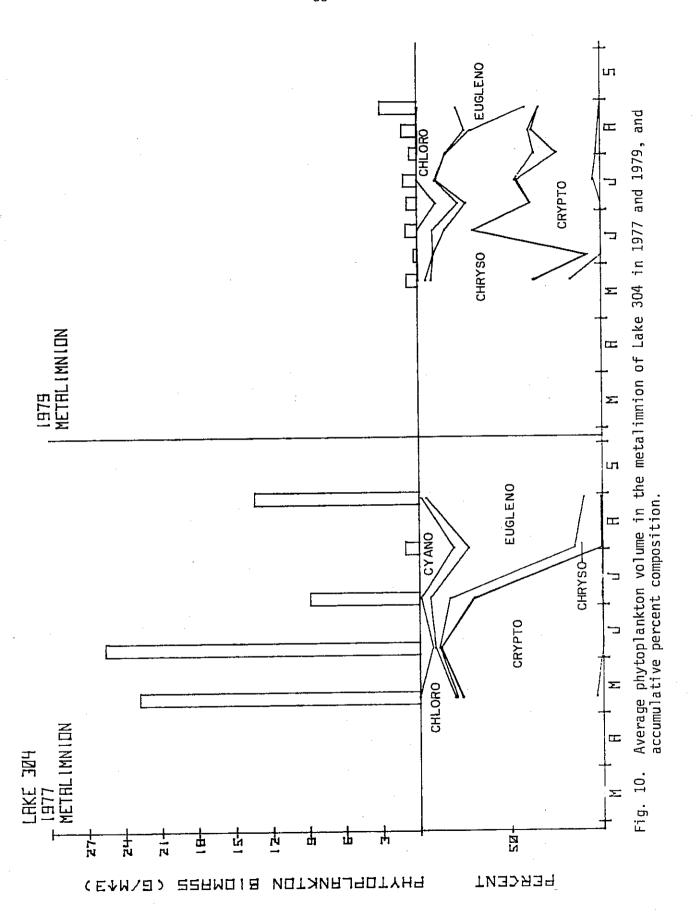
Average phytoplankton volume in the hypolimnion of Lake 226 north in 1977 and 1978, and accumulative percent composition. Fig. 8.

Table 9. Lake 226 north	Lake 226 m	orth		Common Species		
Depth/Year	Date	Cyanophyceae	Cinlorophyceae	Chrysophyceae	Cryptophyceae	Peridingae
Нуро 1977	May-Jul			Dinobryon borgei Lemm. Chrysceirromilina spp Dinobryon serbulara Ehr. Ochromonds sp.	Gryptomanae erova Ehr.	
	մսո–ժսմ	Oscillatoria Redekei Van Goor	Monoraphidium vetiforms Komar. Chlamydomonas sp.	Synuxa spp Korsch. Uroglena americana Catkins Mallomonas Pseudocoronata Prescott	Cryptomonas ovata Ehr. C. rostratiformis Skuja Katablepharis ovalis Skuja Cryptomonau Sp.	Peridinium sp. F. Willet HuitKass
	Jul	Synechacocaus aeruginosus Naeg.				
Hypo 1978	May-Jun		Chl umydomonaa sp.	Chryeochromulina sp. Chromulina sp. Chryeococcue sp.	Gryptamonaa eroua Ehr.	
	Jun			Symura spp Korsch. Uroglena americana Catkins	Cryptomonas oveta Ehr. C. rostretiformis Skuja Katablepharis ovelio Skuja	
Нуро 1979	Jun			Dinobryon serbularia var. protruberana Krieger Salpingoesa frequentieeima Lemm. Kephyrian boreale Skuja	Cryptomonas rostratiformis Skuja C. erosa Ehr. C. obovata Skuja Katablepharia ovalis Skuja	rci rci



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

Table 10.	Lake 304			Common Species		.
Depth/Year	Date	Суапорһусеае	Ch l orophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1977	May-Oct			Cáromulina sp. Dinobryon sertularia Ehr.	Стуртапопав егова Енг.	
	Jun-Oct	Jun-Oct Aphanizomenon flos-aquae Ralfs	Paulachulaia pasudovolvoz Skuja			
	Jul-Oct	Anabaena solitaria f.a. planetonica (Brunth) Komer.	Оговосссив Sahroeteri Leum.	Cirysochromalina spp Dinobryon divergens Imhof Chrysococcus sp.		Periodinium sp.
	Aug-Oct	Anabaena solitaria f.a. 17 meterio (Brinnth)	Staurabtrum paradomum Meyen		Cryptomonae ovata Ehr.	Gymnodinium sp.: Peridinium Willei Huit,-Kass
	Oct	Komar Komar			C. rostratiformis Skuja	
Epi 1979	May-Sept		Съ1 amy domonas sp.	Uroglena americana Catkins Сhryвососсив sp.	Cryptononae ovata Ehr.	
	Jun-Sept		e e e e e e e e e e e e e e e e e e e	ChrysochromLina spp	Cryptomonas erosa Ehr. C. rostratiformis Skuja	
	Jul-Aug	Jul-Aug Anabaena sp.		Dinobryon sertularia Ehr. D. divergens Inhof	Rhodomonas minuta Skuja Gymodintum sp.	Gymnodinium sp.
	e.	A. oircinalis Rabenh.	Dinobryon bavarioum Dinobryon bavarioum Gloeooccus Sohroeteri Lemm. D. serbularia Ehr. Monoraphidium setiforme Komark. Chrysochromulina spp Chlamydomonas sp. Salpingoeca frequenti	Dinobryon bavaricum Imhof D. serbularia Ehr. Chrysochromilina spp Salpingoeca frequentissima Lemn.	Cryptomonas eroea Ehr. C. ovata Ehr.	



	- and 304			מייינים להניים		
Depth/Year	Date	Суапорһусеае	Chlorophyceae	Euglenophyceae	Chrysophyceae	Cryptophyceae
Meta 1977	May-Sept		Chlamydananaa sp.	Buglena acue Ehr.	Dinobnyon sertularia Ehr.	Cryptomonae avata Ehr.
	Jun-Sept	Jun-Sept Aphantaomenon flos-aquae Ralfs	fs†			u. eroba ent.
	ปีน]-Sept		Gloecoccue Schroeteri Lemm.	Trachelomonas volvocina Ehr. Dinobryon sociale Ehr.	Dinobryon sociale Ehr.	
	Aug			Astasia sp.	D. divergens Imhof	
Meta	Mak					
1979	?				Dinobiyon sertularia Ehr. Cimesocoms en	Cryptomonas erosa Ehr.
	:				Mallomonas caudata Iwanoff	
	านก				מואל הפנינו תעפו הבתיון הם ראוווא	
	ž					Cryptomonas sp.
		Anabaena Solitaria f.a. Pianatonica (Brunnth.) Komar	Monoraphidium setiforme Komar.			C. erosa Ehr. C. rostratiformis Skuja
٠		•	Scourfieldia cordiformie Takeda Euglena acus Ehr.		Chryeochromulina spp Salpingoeca frequentiseima Lemm.	C. erosa Ehr. G. oboveto Skuis
٠	#				•	C. sp.
;	,					

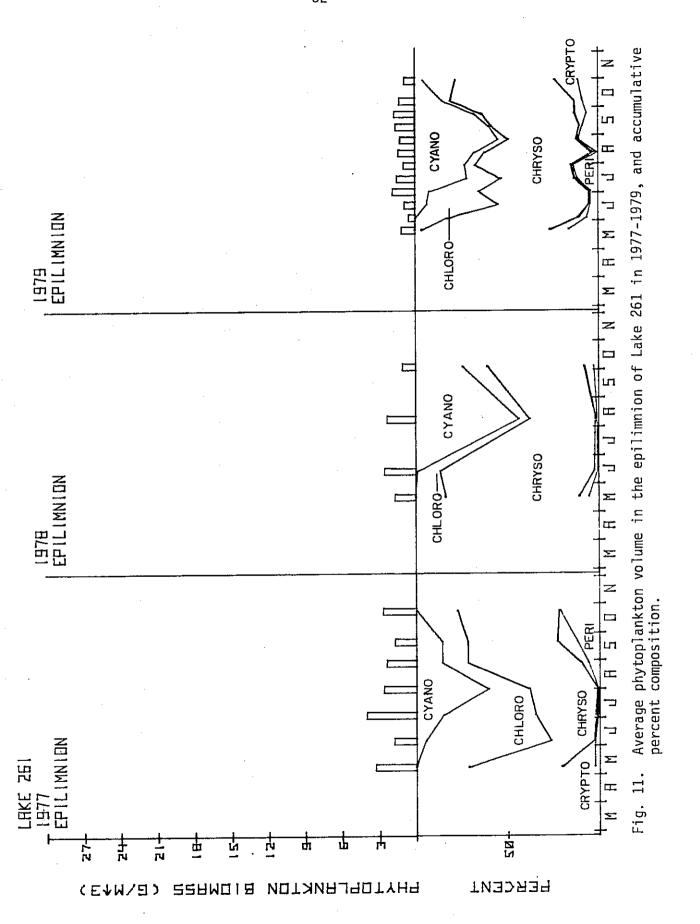
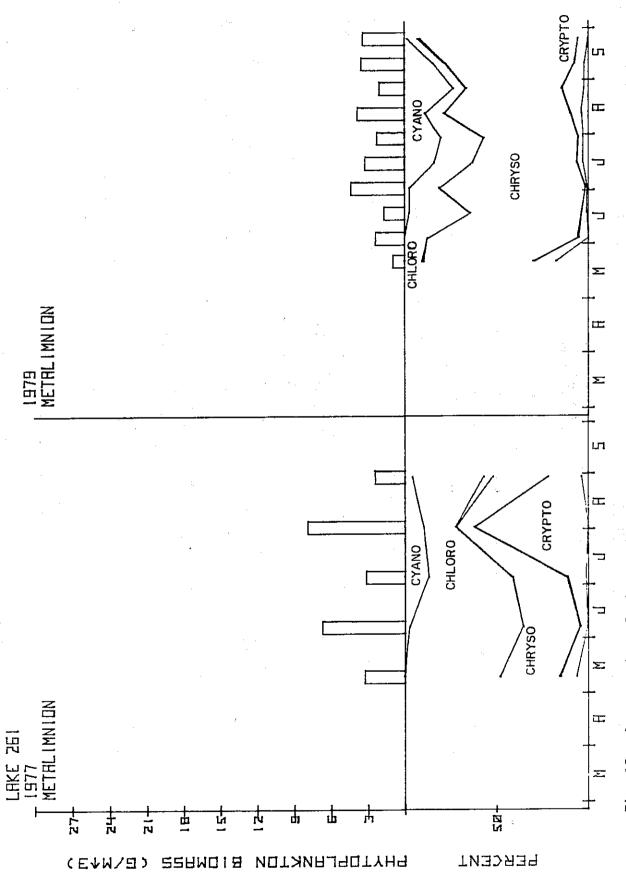
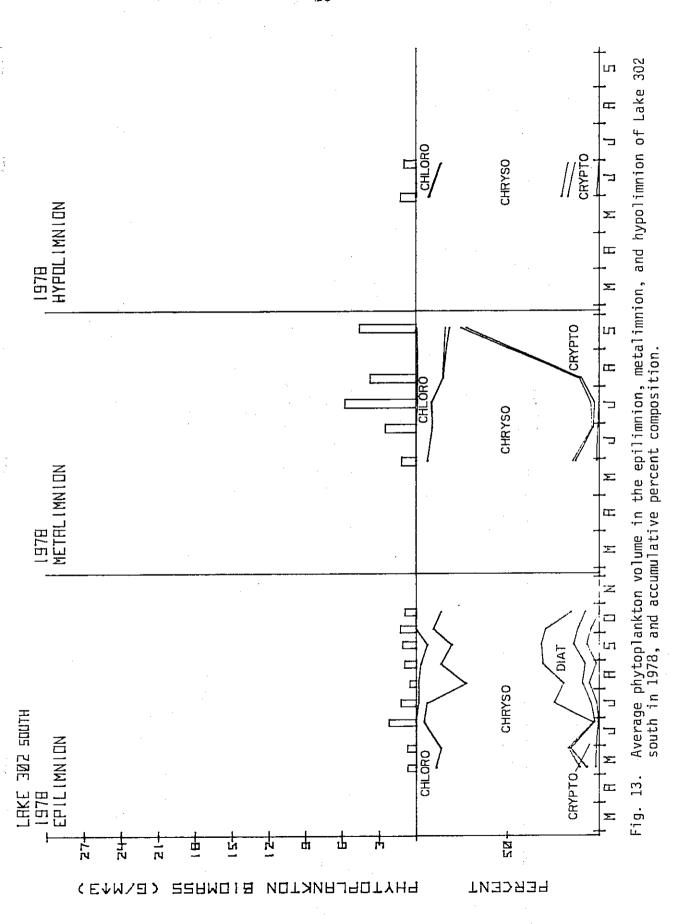


Table 12.	Lake 261			Common Species		
Depth/Year	Date	Суапорһусеае	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Ept 1977	Мау		Diotyosphaertum stmplez Skuja	Dinobryon sertularia Ehr. D. baparioum var. Vanboffenii Krieger Chryscoliromilina spp Chrysococus sp.	Gryptomonao eroea Ehr.	
	Jun∽Aug		Crucigenialla rectangularis (Nag) Komar Gloeccacus Schrosteri Lemm.	Botryococcus Bransis Kütz. Uroglena americana Catkins		
٠,	Ju?-Aug	Chroococas limeticus Lenn. Nertemopedia glawa Naeg.		Chrysococus sp Chromutina sp.		
	Aug	-	Vocystis Lacustrie Chodat	Dinobryon bavariaum var. Vanhoeffenii Krieger Chrysosphaerella longiapina Laut.		Gumodžniva sp.
	Sept	Chroococaa limeticu Lemi. Meriemopedia glawa Neeg.	Cocystis lacustris Chodat Glococystis planatorica Lemm. Dictyosphasrium similar Skuja Glocococous Schroeteri Lemm.	Botryococus Braunii Kütz. Symua spp Dinobryon sertularia Ehr.	Gonyoatomum aemen Dies.	<i>G</i> : sp.
0-7m 1978	May		Diotyosphaerium aimples Skuja	Dinobryon eociale var. etipitatum Lemm. Ghryeococum sp. Uroglena americana Catkins	Gryptonanae eroea Ehr.	Gymnodinium mirabile Penard
9 - 50 10 - 14	Jun		aloeococous Schroeteri Lemm.	Dinobryon sertularia Ehr. Girysosphaerella longispina Laut.		
	Aug-Oct	Chroococus limeticus Lem.		Botryococus Bramii Kütz.		
Epi 1979	May			Dinobryon sertularia Ehr.	<i>Cryptomon</i> aв <i>erosa</i> Ehr. C. <i>ovata</i> Ehr.	Peridinium aciculiferum Lemm.
e zašiniki	ไนก-ในไ	Chroseceus limmeticus Lemm.	Dictyosphaerium simplex Skuja Giosococcus Schrosteri Lemm.	Botryococcus Brannii Kütz. Chromilina sp. Chrysococcus sp. Botryococcus protruberans West		Gymnodintum sp.
٠		Chrosecous limeticus Lemm. Synechococcus Linearis		Chromilina sp. Botryococcus Braunii Kütz.		Gymnodintum sp.
ş ,·	t.	(Nag) komar-		Synura' spp Dinobryon sertularia var. protruberam Krieger	Стурѣстопав егова Ећг.	Peridinium Willei HultKass
		Chroococus limmeticus Lemm.	Dictyosplasvium simplex Skuja	Synura uvella Ehr. and Korsh. Dinbiryon sertularia var. proiruberans Krieger Botryocoacus Brainii Kütz. Salpingoeca frequentissima Lemm.	C, erosa Ehr.	P. Willei HuitKass Gymnodinium sp.

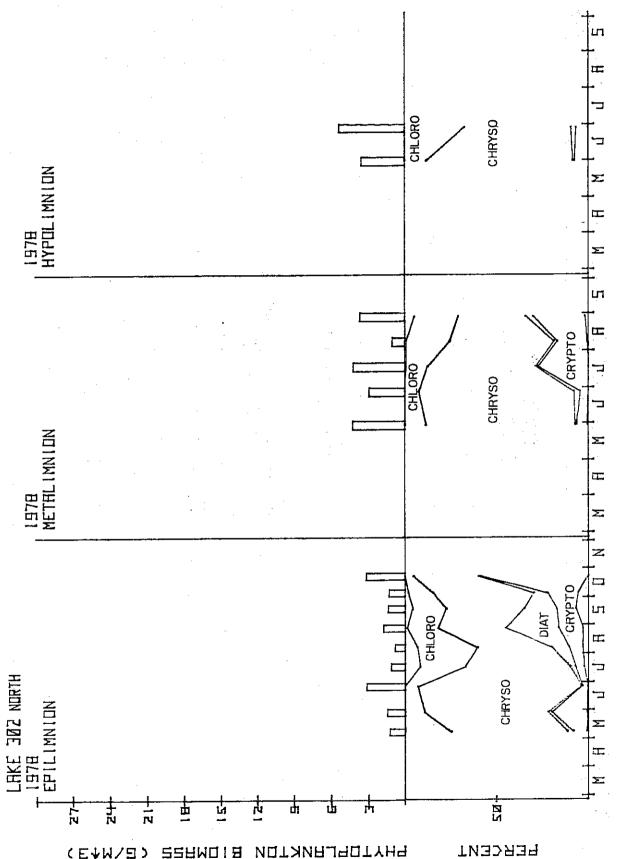


Average phytoplankton volume in the metalimnion of Lake 261 in 1977 and 1979, and accumulative percent composition. Fig. 12.

Table 13. Lake 261	Lake 261			Common Species		
Depth/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Meta 1977	Мау		Diotyosplasrium simplex Skuja Crucigentella rectongulorio (Nag) Komar. Diotyosplasrium simplex Skuja	Chrysococcus sp. Chromatina sp. Dinobyon serbularia Ehr. Chrysotkos Skajat Willen Droglena americana Catkins Dinobryon bavaricum Imhof	Gryptomonae eroea Ehr.	Pertäinium cotouliferum Lemm.
-	մս] - Aug	Meriemopedia glauca Naeg.	<i>Cocystic Lac</i> ustric Chodat	Chrysochronalina parva Lackey	Cryptomonas erosa Ehr.	
	Aug		Gloeococcus Schroeteri Lemm. Diotyosphaerium pulakelium Wood		Gonyostomun semen Dies.	
Meta 1979	Мау		Dict _{il} ospiusrium simples Skuja Giosococcus Schroeteri Lemn.	Chrygoococcus sp. Dinobryon sertilaria Ehr. Chrysococcus sp. Dinobryon barbariara Inhof D. sertularia Ehr. Rallomonas candata Iwanoff Chromilina sp. Iroglena amaricana Catkins Chrysosphaerella longispina Laut.	Gryptomonae roetratiformis Skuja	Peridintum acianliferum Lemm.
	Jul-Sept	Chroococaua Timmeticus Lemm.		Botryacoccus protruberans West Uroglena americana Calkins Chrysosphaerella longispina Laut. Symua Spp		
	Aug-Sept	Synachococous Tinacaria (Naj) Komar. <u>Mariamopadio glouco</u> Naeg. Chrocococus timeticus Lemm.			Cryptomonaв вхова Ehr.	



Depth/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1978	May-Oct			Chrysochromilina spp Grrysoccus sp. Salpingoeca frequentissina Lemm. Vroglena americaia Catkins Stichoglesa Doederleinii Wille		
	Jun-Oct			Pinobryon bavaricum var. Varkoeffenii Krieger		
	Aug-Oct	(350)	Gloeocccus Schroeteri Lemm.	Chrysococcus sp.	Hrisosolenia eriensis Smith	
	Sept			Dinobryon bavaricum Imhof		
	0ct				Synedra acus Kütz.	
Meta 1978	May-Sept			Paeudokephyrion sp. Uroglena americana Catkins Chrysococcus sp. Chrysochromilina spp		Счуртотопав егова Ehr.
	Jun-Sept	Cht. Eta	Chlamydomonas sp. Elaktothriz gelatinosa Willen	Stichogloea Doederleinii Wille Dinobryon bavaricum var. Varhoeffenii Krieger	· ••	
	Jul-Aug	Dia	Diotyosphaerium simplem Skuja	Mallomonas caudata Iwanoff	Asterionella formosa Hassall	
:	Aug-Sept	GLO: Moru	Gloeocoacus Schroeteri Lemm. Monoraphidium setiforme Komar.	Chromilina sp.	Tabellaria flocaulosa Kiitz.	
	Sept		·			Cryptomonas erosa Ehr. C. rostratiformis Skuja
Hypo	Мау			Pseudokephyrion sp. Chromulina sp. Chrysococcus sp.		Cryptomonas erosa Ehr.
	Jun	Die	Dictyosphaerium simplex Skuja	Mallomonas caudata Iwanoff Stichogloea Doederleinii Wille		



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

	Cryptophyceae	mosa Ehr.		vata Ehr. mrås Skuis	rosa Ehr. 88	ovalża Skuja oga Ehr.
	Crypto	Cryptomonae eroea Ehr.		Cryptomonae ovota Ehr. C. Postpotiformia Suis	Cryptomonae erosa Ehr.	Katablepharia ovalia Skuja Cryptomonaa erosa Ehr.
	Diatomeae			Ihinosolenia eriensis Snith		Abterionella formosa Hassall
,	Common Species Chrysophyceae	Giryaosphaerella longispina Laut. Salpingoeca frequentissina Lenm. Chromilina sp. Viryaococus sp.	Botzyococus Branti Kütz. Dinotzyon bararicum var. Yanboefferii Krieger Stiehogioec Doederleinii Wille Mallomonas sp.	Ciryeochromilina sp. Dinobryon bavaricum Imhof	Chrysocaceus sp. Dinobryon sociale Ehr. Chramitina sp. Droglena americana Catkins Drobryon bavaricum var. Vaniosffenit Krieger. Stichogloa Dosdarieinit Wille Mallomanas caudata Imanoff Botryococeus Brannit Kütz. Dinobryon bavaricum Imhof	Chrysococcus sp. Mallomonas caudata Iwanoff A. Chromitte
	Chlorophyceae	Monovaphidium settjorme Komar. Ohlamydomonas sp.	Crucigeniella rectangulario (Naÿ) Komar. Glosococus Salvoeteri Lemn.		Dictiosphaerium simplez Skuja Gloecoccas Schroeteri Lemm.	Monoraphidium setiforme Komar. C Chlamydonconas sp. Dictyosphastium simples Skula A
	Суапорћусеае			7		
Lake 302 north	. Date	May-Oct	Jun-Oct Jul-Oct	Aug-var Dat	Мау	Мау Јип
Table 15.	Depth/Year	Epi 1978			Meta 1978	Нуро 1978

