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Phytoplankton successions and species distribution in prairie ponds of the Erickson-Elphinstone district, southwestern Manitoba.

by

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ABSTRACT

The phytoplankton of approximately 50 small prairie lakes in the Erickson-Elphinstone district of Southwestern Manitoba have been surveyed since 1972. During 1973 seasonal succession studies were conducted on 5 of the lakes (Nos. 885, 154, 882, 255, 103). These are described in detail in this report. The species list for the area includes species from a total of 46 lakes which were sampled during the years 1972-1974.

Le phytoplancton d'à peu près 50 petits lacs des Prairies dans le district d'Erickson-Elphinstone situés dans le sud-ouest du Manitoba a été examiné depuis 1972. Pendant 1973 on a effectué des études successives saisonnièes sur 5 des lacs (numéro 885, 154, 882, 255, 103). Ceux-ci sont décrits en détail dans ce rapport. La liste des espèces pour ce district inclut des espèces provenant de 46 lacs qui furent échantillonés durant les années 1972-1974.

INTRODUCTION

The phytoplankton of approximately 50 small lakes in the Erickson-Elphinstone region of S. W. Manitoba (Johnson, L. 1970, Sunde, *et al.* 1970) have been surveyed since 1972. During 1973 seasonal succession studies were conducted on 5 of the lakes. These are described in detail in this report. The species list for the area includes species from a total of 46 lakes which were sampled during the years 1972-1974.

The phytoplankton enumeration and sampling method has been described by Kling and Holmgren (1972). Physical and chemical characteristics of the area have been reported by Sunde and Barica, 1975 and Barica, 1975. Most of the lakes in this agricultural region are shallow (2-3 m) and do not stratify during summer months. The approximate areas of the lakes is 0.8-23.1 ha with the majority less than 10 ha. Some are highly eutrophic and support dense (100,000 mg/m^3) algal populations (usually *Aphanizomenon*) for a short period in July or August. Many Aphanizomenon blooms collapse in July or August. Less eutrophic lakes have more diverse phytoplankton assemblages and show less tendency to form blooms. Algal populations decrease in the fall and winter, in all lakes. In February or March algal biomass reaches a low of <1000 mg/m^3 wet weight in most lakes. During the winter months many of the lakes in the study area are completely anaerobic (Barica, 1974).

No previous algal studies in this immediate area have been done, and the object of this paper is to supply some information on the seasonal succession of phytoplankton in Erickson-Elphinstone prairie pothole lakes.

RESULTS

Lake 885 (Figure 1) Z_{max} = 3 m., A_o - 2.4 ha*

This lake has been studied since 1972. During 1973 an intensive study was begun. The lake is a typical summerkill lake (Barica, 1974). During each summer of observation the population of algae has been dominated by *Aphanizomenon flos aquae* which has collapsed, followed by O_2 depletion and fish kill. Figure 1 shows the seasonal succession pattern for 1973. During the year the biomass ranged from 500 mg/m^3 in winter to 96,000 mg/m^3 at the peak of the summer algal bloom. Maximum chlorophyll a values were 200 µg/l**. The lowest values for biomass occurred in March and April when snow cover reached its maximum and very little light penetrated the snow. A small population (300 to 500 mg/m^3 respectively) of Chlorophyta, Diatomeae and Cryptophyceae was able to survive in these conditions. Immediately after ice break-up in the spring (late April or May) there was an increase in the phytoplankton population. Chrysophyceae (Fig. 1), mainly of the genus *Chrysochromulina*, predominated. Shortly after this pulse the Cryptomonads, mainly *Cryptomonas marssonii*, *C. rostratiformis*, *C. ovata* and *Rhodomonas minuta* var. *nannoplanktica* increased. In mid June *Aph. flos-aquae* began to increase. It composed 99% of the total biomass during the time (June-August) of bloom conditions. The remainder of the biomass consisted of Chlorophyta: *Ankyra judayi* and *Ankyra sp. (Schroederia)* and *Rhodomonas minuta*. L. 885 had a maximum biomass of 96,000 mg/m^3 at the end of July, 1973 two weeks before the entire lake became O_2 depleted (August 10). At this time, live biomass in the lake was less than 100 mg/m^3. With the onset of autumn there was an increase in species of Chrysophyceae, Cryptophyceae, Chlorophyta, and Diatomeae, as is typical of autumn conditions in these lakes. These tended to remain on into the winter.

Lake 154 (Figure 2) Z_{max} = 4.9 m, A_o = 10.1 ha

L. 154 was also studied in a preliminary survey in 1972 and was sampled more intensively during 1973. It was also usually a summer kill lake dominated by *Aph. flos-aquae*, but the pattern of succession was somewhat different from that of L. 885.

The biomass ranged throughout the year from 500 mg/m^3 in winter to 60,000 mg/m^3 in late July. In January, 1973 the lake was dominated

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* Max. depth and surface area respectively.

** Average values for 0-2 m depth, approximating the euphotic zone.

by coccoid Cyanophyta (*Aphanocaposa* sp.) plus some Chlorophyta, Cryptophyceae and Diatomeae. In March and April under ice the Chlorophyta increased to 75-80% of the biomass (genera *Scenedesmus, Monoraphidium, Actinastrum Chlamydomonas* predominating) with Cryptophyceae (*Cryptomonas obovata, C. marssonii, Rhodomonas minuta*) composing the remainder. After ice out on 15 May there was a small diatom pulse in the population (*Synedra, Nitzschia* and *Cyclotella* spp.) followed in early June by a sharp increase to 58% of Cyanophyta (*Merismopedia* sp. and *Microcystis* sp). In June this population declined from 15000 mg/m^3 + 500 mg/m^3 and 58% Cryptophyceae (June 20) (*Cryptomonas marssonii, Rhodomonas minuta. Chroomonas* sp.). In July Cyanophyta (*Anabaena* spp., *Microcystis aeruginosa, Aphanizomenon flos-aquae*) dominated again, this time forming from 90 to 100% of the biomass, which increased from 300 mg/m^3 (July 15) to 60,000 mg/m^3 (July 25) in two weeks. Maximum chlorophyll at this time was 140 µg/1 (0-4 m). In late August the biomass again dropped to 2000 mg/m^3. Cyanophyta (mainly *Aphanizomenon* in healthy condition) still formed 90% of the total biomass. In the autumn the population returned to a relatively equal distribution of Cyanophyta, Chrysophyceae, Diatomeae and Cryptophyceae. These proportions persisted through the winter with a slight increase in Chlorophyta and decrease in Chysophyceae under the ice. In 1974, the *Aphanizomenon* population maintained itself with no collapses throughout the summer (June-September) and gradually declined during the fall (unpublished data).

Lake 882 (Figure 3) Z_{max} = 3.4 m, A_o = 5.7 ha

L. 882 is a mixed bloom lake during its mid summer peak. The range in biomass was from 100 mg/m^3 in winter to 30,000 mg/m^3 in late August. In January the phytoplankton 65% was composed of Chlorophyta (*Chlamydomonas* spp.) 25% Peridineae (*Gymonodinium* spp.) and 10% Chrysophyceae (*Ochromonas* sp. and *Chromulina* sp.). In March the population had approximately the same composition with an increase in biomass to 1400 mg/m^3. In late May the biomass increased to 1800 mg/m^3 due to a diatom pulse (*Cyclotella meneghiniana, Chaetocera mulleri, Amphiprora alata*); the Cyanophyta (*Merismopedia, Chroococcus*) had started to increase as well. In mid June diatoms declined and Cyanophyta increased to 68% (mainly *Anabaena, Meriamopedia, Aphanocapsa* species) and the biomass rose to 10,000 mg/m^3. Chlorophyll a was 60-70 µg/1 (0-2) at this time. In July, these populations declined with an increase in small Chlorophyta (*Monoraphidium, Dictyosphaerium, Oocystis* and *Chlorella* etc.), Diatomeae (*Cyclotella, Synedra, Nitzschia* and *Chaetocera* species) and Cryptophyceae (*Rhodomonas minuta, Cryptomonas erosa, Chroomonas* sp.). In late August there was a very marked increase in biomass to 30,000 mg/m^3 with a change in population to a dominance of Peridineae (*Ceratium hirundinella*) and Cyanophyta (*Aphanizomenon flos-aquae, Microcystis aeruginosa*). In September the population declined with another change in population to the more typical autumn forms of roughly equal (15-25% each) proportions of Diatomeae, Chrysophyceae, Chlorophyta, and Cyanophyta.

Lake 255 (Figure 4) Z_{max} = 2.7 m, A_o = ha

This lake is the least eutrophic of the lakes discussed. It had a minimum winter biomass of 500 mg/m^3 and a summer maximum of 10,000 mg/m^3, corresponding to 18-24 µg/l chlorophyll a (0-2 m). The winter plankton was composed mainly of Chlorophyta (*Chlamydomonas*) Chrysophyceae (*Ochromonas*, *Chromulina*, *Dinobryon*) and Cryptophyceae (*C. rostratiformis*, *C. obovata*, *Rhodomonas minuta*), with an increase in Chrysophyceae (*Kephyrion spirale*, *K. cupuliforme*, *Ochromonas*, *Chromulina* species) and Diatomeae (*Syneda*, *Nitzschia*, *Diatoma*, *Fragilaria*, *Taballaria* species) after the spring thaw in May. After the diatom pulse, the Cyanophyta (*Merismopdia*, *Microcystis* species) increased to form 90% of the total biomass of 2000 mg/m^3. This population declined in early August with a change in dominance to Peridinae (*Ceratium hirundenella*) which in late August composed 95% of the maximum biomass of 9000 mg/m^3. Once again with the onset of autumn the population changed to Chlorophyta (*Monoraphidum* spp.), Diatomeae (*C. meneghiniana*, *Synedra acus*), Cryptophyceae (*C. marssonii*, *Rhodomonas minuta*, *Katablepharis ovalis*), and Chrysophyceae (*Ochromonas*, *Chromulina*, *Bicoeca*, *Stenokalyx* species). This lake did not experience any algal bloom collapses in either 1972 or 1973. In 1974 the dinoflagelates did not predominate in August but rather the Cyanophyta remained throughout the entire summer (unpublished data).

Lake 102 (Figure 5) Z_{max} = 1.5, A_o = 10.1 ha

L. 103 has been sampled since 1972 but not as regularly as the others. The succession pattern, however, was very different from the preceding lakes in 1973, presumably due to the discharge from municipal sewage lagoons, supplying phosphorus at rates 10x higher than in other lakes (Barica, 1975). The winter low biomass was around 3000 mg/m^3 in January dominated by Cryptophyceae (*C. rostratiformis*, *C. erosa*). In March the population dominance changed to Euglenophyta (*Phacus sp.*) with a rise in biomass to 36,000 mg/m^3. In early May shortly after ice melt the biomass, dominated by Cryptophyceae (*C. rostratiformis*, *C. erosa*), Diatomeae (*Cyclotella meneghiniana*, *Nitzschia* spp.) and Chlorophyta (*Chlamydomonas* sp., *Chlorogonium* sp., *Coccomyxa* sp., *Lauterborniella* sp., *Chlorella* spp.), reached its yearly maximum values of 140,000 mg/m^3, corresponding to 169 µg/l of chlorophyll a. In late May some O_2 depletion and silicon depletion was noticed (Barica, 1975) but no phytoplankton samples were taken at this time other than a net sample indicating a predominance of Diatomeae and some small Chlorophyta. By July the biomass had declined to its yearly minimum values of 1000 mg/m^3 dominated by Chorophyta (*Chlamydomonas* sp., *Oocystis* spp., *Ankyra* spp.), Diatomeae (*Synedra* spp., *Cyclotella* spp., *Nitzschia* spp., *Gomphonema* spp.) and Cryptophyceae (*C. erosa*, *Katablepharis*, *Rhodomonas minuta*). In August the population began to increase again, rising to 6500 mg/m^3 dominated by 95% Cyanophyta (*Aphanizomenon*, *Microcystis*), Chlorophyll a was about 100 µg/l (0-1 m). In September the biomass was still increasing but the population dominance had changed from Cyanophyta to 65% Diatomeae (*Cyclotella meneghiniana*, *Cocconeis* sp., and *Surirella* sp.).

The remainder was Chlorophyta (*Monoraphidium* spp., *Gloeococcus* sp., *Dictyosphaerium* sp.). The biomass consisted of Chrysophyceae, Chlorophyta, Cyanophyta (*Merimopedia tenuissima, Aphanocapsa* sp., *Aphanothece* sp.) and Cryptophyceae (*C. obovata, Rhodomonas minuta*) as in the other lakes, when the population declined to 900 mg/m^3 under December ice.

DISCUSSION

Although no previous phytoplankton studies have been done in this immediate area relatively extensive work was done on Saskatchewan lakes as well as some Alberta lakes in which the chemical, physical, and biological characters are similar. Much of the work in Saskatchewan lakes was done by Kuehne (1941) and Rawson and Moore (1944) who reported on the phytoplankton in lakes of varying salinities and more recently Hammer (1964, 1969, 1970, 1973) who studied the successions of blue-green algal blooms of the lakes. Bozniak and Kennedy (1968) reported on the phytoplankton successions in an oligotrophic and eutrophic lake in Alberta and Lin (1972) also described seasonal succession patterns in some Alberta lakes.

A very detailed report on phytoplankton in Minnesota lakes by Brooks (1971) was concerned with phytoplankton from similar lakes as well as more oligotrophic lakes. He grouped the lakes according to their conductivities and discussed the various phytoplankton assemblages in each group.

Literature on phytoplankton biomass is limited for lakes similar to those of the Erickson-Elphinstone district. However, three studies reporting comparable biomass data have been done; Lake Winnipeg (Holmgren and Kling, 1973 MS and Brunskill, 1973) and Pelican Lake, Manitoba (Davidson, 1973 MS) and Severson Lake, North Dakota (Schindler and Comita, 1972).

Lake Winnipeg, though not completely on the prairie and a much larger lake than those of the Erickson-Elphinstone area, is influenced by prairie drainage and climate. At some stations Lake Winnipeg has high biomass values (10,000 mg/m^3) and predominance of Cyanophyta (*Aphanizomenon, Microcystis* and *Anabaena*) and Chlorophyta (Chlorococcal type). Pelican Lake, a southern Manitoba prairie lake studied in the summer of 1973, reached a maximum biomass value of 50,000 mg/m^3 predominated by Cyanophyta (*Lyngbya birgie* and *Microcystis flos-aquae*) (Davidson, 1973 MS). Severson Lake, North Dakota (Schindler and Comita, 1972) is not an annual winter-kill lake as are most of the Erickson-Elphinstone lakes, but it is definitely a eutrophic prairie lake with a biomass maximum of 60,000 mg/m^3 dominated by Cyanophyta. In 1965 it experienced winterkill conditions and its phytoplankton succession closely resembled lake 103 (figure 5) with maximum shortly after ice-out and a subsequent decrease into July and gradual recovery in August and September.

On the basis of Vollenweider's 1968 lake classification, Erickson lakes are definitely very eutrophic, all having midsummer maximum biomass values well above the 10,000 mg/m^3; the lower limit given for eutrophic lakes. Non-prairie eutrophic lakes have comparable biomass values, (Table II) but the phytoplankton dominating at the maxima are primarily Chlorophyta and Cyanophyta compared to mainly Cyanophyta in the prairie lakes. It has been found, however, that where sewage enters a lake, the dominating phytoplankton are Chlorophycean of the chloroccal type, i.e. *Scenedesmus* spp., *Monoraphidium* spp., *Ankistrodesmus falcatus, Oocystis lacustris, O. borgie, Pediastrum duplex, Chlamydomonas* spp., *Chlorella* spp., etc. (see species list). This occurs in prairie lakes (Hasler, 1947), Lake Winnipeg, south basin (Holmgren and Kling 1973 MS), sewage lagoons, Arctic lakes (Schindler *et al.*, 1974) and artificially eutrophied shield lakes (L. 227) (Schindler *et al.*, 1973). Chlorophycean communities of the type mentioned above have been found after a July collapse of a cyanophycean bloom (Lin, 1972) in Alberta lakes and in the Erickson Lake No. 587 in July, 1974, (unpublished data) and after treating an *Aphanizomenon* bloom in Lake 106, in early July 1973 with Cu SO_4. Probably numerous factors are also involved here, for if the bloom collapse occurred later in the season, normal autumn increases mentioned in earlier descriptions of seasonal successions followed. The actual causes of a bloom collapse are not known but may possibly be attributed to a population outgrowing its nutrient supply and then being present in much greater abundance than can be supported by the replenishment rate of the limiting nutrient (O'Brien, 1974).

Peridinae became dominant in a few Erickson lakes during certain years, although most of the time they are of very minor importance. When the group does dominate as in the case of Lake 255 and Lake 882 in August, 1973, (Figure 3 and 4) the only species present belonging to Peridineae is *Ceratium hirundinella*. In 1974 both lakes returned to cyanophycean dominance. A similar phenomenon was found in Lake Kinneret in Israel (Serruya *et al.*, 1974) where during a dry year and lower phosphorus loading, Peridineae dominated and in the wet year the Cyanophyta returned. On the other hand in arctic lakes, Char and Meretta (Kalff *et al.*, 1975 and Schindler *et al.*, 1974) artificial enrichment experiments with phosphorus resulted in increased growth in Peridineae rather than in Cyanophyta although Cyanophyta were present.

A total of 237 taxa have been identified in the Erickson-Elphinstone lakes from 1972-74, 264 were identified from Lake Winnipeg 1969, (Holmgren and Kling, 1973 MS), 297 from South Indian Lake 1972-1973 (Hecky *et al.*, 1974), and 89 from Pelican Lake 1973 (Davidson, 1973). It would appear that the more eutrophic a lake the fewer species present but care must be taken with this generalization because the number of species found increases with the time spent looking for them, the number of years spent on an area, the method of collection and the time of the year in which samples are taken. The spring and fall samples generally contain more species than do summer and winter samples.

It is difficult to compare lakes on the basis of plankton associations (Brooks, 1971) for a single lake could go through 3 or more associations during a single season or vary from year to year as the Lake 255 Peridineae-Cyanophyta dominance mentioned previously. The Erickson-Elphinstone lakes, however, could be generally classified according to the Hutchinson (1967) system used by Brook (1971) as having mesotrophic or eutrophic Dinoflagellate plankton, eutrophic chlorococcal plankton, and cyanophycean plankton. It would appeare more reliable to compare the lakes on the basis of their summer maximum biomass (Vollenweider, 1968) and the degree of predominance of the variou algal groups. The summer maximum biomass is the point of maximum development of the algal growth of the lake. In order to determine this value it is necessary to monitor the variations throughout the whole ice-free season.

Comparing lakes on this basis (Table I) shows an increased predominance of Cyanophyta or Chlorophyta as the lakes become more eutrophic (indicated by the areas which increased biomass). Those with low biomass values (1st four areas from the Arctic and Canadian Shield areas) and notably lower nutrients experience a predominance of the Chrysophyceae group. The change in biomass with increased nutrients can be seen by the last two lakes in Table I, L. 227 an experimentally eutrophied Shield Lake (Schindler *et al.*, 1973), and Meretta Lake, a polluted Arctic Lake (Schindler *et al.*, 1974) which have both experienced an increase in algal biomass and a distinct shift in the group predominance from Chrysophyceae to Cyanophyta and Chlorophyta. The Erickson-Elphinstone lakes fit in this classification at the highly eutrophic end of the scale with the highest summer maximum biomass values and the highest dominance of Cyanophyta.

Table 1. Phytoplankton average summer maximum biomass values and percent composition for lake areas in central and northern Canada.

Lake Area	Av. midsummer Max biomass values mg/m^3		Predominating groups at the time of maximum biomass						
			Cyano	Chloro	Euglen	Chryso	Diato	Crypto	Perid
Char Lake, Cornwallis Isl.	200		0	5	0	30	10	10	45
Mackenzie Delta, N.W.T.	300		0	3	0	80	5	10	2
Chitty Lake, YK, N.W.T.	800		14	4	0	55	6	9	15
Experimental Lakes, Ont.	1,000		7	3	0	55	15	12	8
Southern Indian Lake, Man.	2,000		30	4	0	6	50	6	4
Lake Winnipeg, Man.	3,000	North Basin	45	4	0	4	23	22	3
Lake Winnipeg, Man.	2,300	South Basin	64	7	0	0	13	10	6
Lake Winnipeg, Man.	300	Straits	14	44	0	31	3	8	0
Erickson Lakes, Man.	10,000		0	0	0	0	0	3	97
Erickson Lakes, Man.	100,000		96	0	0	0	2	2	0
Pelican Lake, Man.	5,000		90	3	0	0	5	0	1
Meretta Lake, Cornwallis Isl.	9,000		8	20	0	20	0	2	50
Lake 227, ELA, Ont.	3,000		30	40	5	10	5	10	0

TABLE II

LAKES SAMPLED

Lake	Time Sampled
100	May, Aug., 73
108	May, 73
106	May, 73
109	May, June, Aug., 73
104	May, 73
156	July, 73
103	Year, 73-74
154*	Year, 73-74
255*	Year, 73-74
300	June, 73
301	June, 73
302	Mar., 73
305	Aug., 73
303	July, 73
304	Aug., 73
318*	July, 73, June, 74
400*	June, July, 73, May, June, July, 74
402	Aug., 74
414	Aug., 74
413	Aug., 74
412	Aug., 74
507	May, June, July, Aug., 73
503	June, July, Aug., 73
522	July, Aug., 73
587*	June, July, 73 (May, June, July, 74)
504	Aug., 73
506	Aug., 73
675*	Aug., 74
615	May 15/74
701	May, July, 73
721	June, 73, May, June, July, 74
702	Aug., 73

* Lakes in the 1974 fish stocking program with B. Ayles and J. Barica.

Lake	Time Sampled
885*	year 73, 74
882*	year 73, 74
879	June, July, Aug., 73
810	July, 73
958	June, 73
Grayling L.	73-74 July, Aug.
Furby L.	July, 74
Dugout	Sept., 73
Moon L.	Aug., 73
L. Katherine	Aug., 74
Earl's L.	July, 74
Seeche L.	July 17
Woloski Lake	July, 74
Mervin Hunting Hawk L.	July, 74

SPECIES LIST

Cyanophyta

	Lakes					
	885	154	882	255	103	Others*
Microcystis aeruginosa Kützing	x	x	x	x	x	318,400,879,958,721,701,810, 503,109,402,414,413,Moon
Microcystis flos aquae (Wittrock) Kirchner	x					304,302,413,412,675
Aphanocapsa biformis A. Braun			x			675
Aphanocapsa elachista W. et G. S. West	x	x	x	x		304,156,109,302,400
Aphanocapsa elachista Var. planctonica G. M. Smith	x	x	x			412
Aphanocapsa delicatissima E. et G. S. West	x	x	x			156, 302, 315
Aphanothece clathrata W. et G. S. West	x	x	x	x		318,315,400,402,675,412, L. Kath.
Aphanothece clathrata var. brevis Bachmann			x			400, 675
Aphanothece gelatinosa (Hennings) Lemmermann			x			
Aphanothece nidulans P. Richt			x			
Pelogloea chlorina Lauterborn						L. Kath.
Chroococcus limneticus Lemmermann			x		x	318,958,400,412,587,675, Hunting Hawk.
Chroococcus dispersus (v. Keiss) Lemmermann						318, 400
Radiocystis geminata Skuja						Hunting Hawk.
Gomphosphaeria lacustris Chodat					x	587,402
Gomphosphaeria aponina Kutzing			x		x	675
Coelosphaerium Naegelianum Unger						Moon
Coelosphaerium minutissima Lemm.						302
Coelosphaerium Keutzingianum Naegeli						402,587
Merismopedia tenuissima Lemmermann		x	x	x	x	402,412,587,400,879,721, 503,318,156,304,Hunting Hawk
Merismopedia minima Beck		x			x	587

* Listed in Table II

SPECIES LIST CONT'D

			Lakes			
	885	154	882	255	103	Others
Marsoniella elegans Lemmermann						302,587,412,400,Woloski
Aphanizomenon flos-aquae (Linneaus) Ralfs	x	x	x			879,302,506,504,400,587,822, 303,305,721,318,507,615,318, 413,414,412, Earls,Grayling, (Sm. Aph.), Woloski
Anabaena flos-aquae (Lyngbye) Brebisson			x			402,879,302,701,810,587,400
Anabaena circinalis Rabenhorst						587,413,Seeche,400
Anabaena Solitaria fa. planctonica (Brunnthal) Komarek						Moon
Anabaena Wisconsiense Prescott						Grayling
Anabaena spiroides f. spiroides Klebahn						402, Moon
Anabaena spiroides var Crassa Lemmermann						414
Anabaena macrospora var robusta Lemmermann						414
Pseudoanabaena constricta (Szafer) Laut.	x	x				503,507,303, Grayling, Earl's
Pseudoanobaena articulata Skuja	x	x				109
Oscillatoria limnetica Lemm						587, Grayling, 517
Oscillatoria sp.					x	507, 109
Oscillatoria Agardhii Gomont					x	Grayling, Furby
Oscillatoria amphigranulata van Goor						Grayling
Lyngbya birgei Smith G. M.						107, Moon
Lyngbya endophytica Elenkin et Hollerback	x	x	x	x	x	
Lyngbya musicola Lemm.						414
Lyngbya limnetica Lemm.						109, Moon
Spirulina sp.						302, 879
Gloeotrichia echinulata (J.E. Smith) P. Richt						400

SPECIES LIST CONT'D

Chlorophyta

	Lakes					
	885	154	882	255	103	Others
Collodictyon triciliatum Carter	x		x			507,879,587,675
Scourfeldia sp.		x		x		615
Chlamydomonas sagittula Skuja		x		x		587
Chlamydomonas spp	x	x	x	x	x	318,302,503,587,721,958, 402,Grayling, L. Kath, Moon
Chlorogonium sp					x	507
Chlorogonium maximum Skuja					x	507
Carteria sp.				x		318, L. Kath
Phacotus lenticularis (Ehr) Stein						Grayling, Earl
Gonium pectorale Müller					5	587
Gonium sociale (Dujardin) Warming		x				
Pandorina morum (Müller) Bory						522
Pandorina charkoweinsis Korsh.						Sewage lagoons
Eudorina elegans Ehrenberg						587
Gloeocystis planctonica (W. et G. S. West) Lemm.		x	x			L. Kath
Gloeococcus schroeteri (Chodat) Lemm.		x	x	x		675,879,810,400,503,109, Seeche
Sphaerobotrys fluviatiles (Butch) Bourrelly			x			
Planctosphaeria gelatinosa G. M. Smith		x		x		109, 400
Tetraedron minimum (A. Br.) Hansg		x				318,109,675,721,506
Tetraedron caudatum var. longispinum Lemm.						675,412,
Tetraedron limeticum Borge						
Tetraedron trigonum (Naeg.) Hansg.						506

NOTE: Many of the Chorophyta of the Euchlorophyta were typical of post bloom collapse conditions or late fall and under ice conditions.

SPECIES LIST CONT'D

	Lakes					
	885	154	882	255	103	Others
Schroederia setigera Lemm.	x	x	x	x	x	400, 318
Ankyra judai (G. M. Smith) Fott.	x	x	x	x	x	318,507,303,107,879,302, 800,587,520,109,503
Ankyra sp.	x	x			x	400,810,701,958,302,879, 318
Pediastrum duplex Meyen		x	x			675,507,503,302
Pediastrum duplex var. clathratum (A. Br.) Lagerh.					x	400
Pediastrum boryanum (Turpin) Meneghini						318,303,304,522,400,958, 721
Pediastrum boryanum var. longicorne Racib.						402
Chlorella vulgaris Beyer					x	
Chlorella sp.	x		x		x	100, 522, 400
Oocystis submarina var. variablis Skuja	x	x		x		304, 675
Oocystis lacustris Chodat			x			318,503,522,587,675,400, Moon
Oocystis solitaria Wittrock				x		107
Oocystis borgei Snow						109,503,675,414,587
Oocystis crassa Wittr.						675, 400
Chodatella quadriseta Lemm. (Lagerheimia)		x				506,302
Trochiscia reticularis (Reinsch) Hansg	x					
Treubaria triappendiculata Bernard						507,109,318,587
Nephrocytium agardhianum Näg						
Nephrocytium limneticum (G. M. Smith) Skuja						
Kirchneriella obesa (West) Schmidle						587
Kirchneriella elongata G. M. Smith						302, 587
Kirchneriella lunaris (Kirchner) Moebius	x		x			302, 587

SPECIES LIST CONT'D

	Lakes					
	885	154	882	255	103	Others
Selenastrum bibraianum Reinsch		x	x	x		587,400,879,109,522,302
Ankistrodesmus gracilis (Reinsch) Kors		x	x	x		615
Monoraphidium contortum (Thuret in Breg) Komarkova		x	x	x	x	318,615,879,506,DO,400,587 503,304,180,302
Monoraphidium setiforme (Nyg.) Komarkova	x	x	x	x	x	400
Monoraphidium convolutum (Corda) Komarkova		x	x	x	x	318, 304, 675
Closteriopsis longissimum var. tenuissimum G. M. Smith			x			400
Coenocystis subcylindrica Korch.			x			106
Achantosphaeria Zacharias Lemm.						675, 400
Golenkenia radiata Chodat	x	x				507, 803
Dictyosphaerium Ehrenbergianum Näg			x			503,506,587,412
Dictyosphaerium pulchellum Wood		x			x	318,582,400
Dictyosphaerium simplex Skuja					x	
Dictyochlorella sp.			x			587
Coelastrum reticulatum (Sorg) Senn.						503
Coelastrum cambricum Archer						506
Coelastrum microporum Näg						318,503,506,675,400
Crucigenia rectangularis (Näg) Gay		x				400
Crucigenia quadrata Morren		x				304, 503, 400
Tetrastrum staurogeniaeforme (Schr) Lemm.		x				503
Scenedesmus balatonicus Hortob.						675
Scenedesmus arcuatus Lemm		x				302
Scenedesmus spinosa Chodat.		x				318,109,675
Scenedesmus armatus Chodat.		x				879
Scenedesmus ecornis (Ralfs) Chodat		x				
Scenedesmus acuminatus (Lagerheim) Chodat		x				506, 879

SPECIES LIST CONT'D

	Lakes					
	885	154	882	255	103	Others
Scenedesmus quadricauda (Turp.) Breb.		x				506, 302, 675
Scenedesmus denticulatus Lagerheim						675
Scenedesmus spp.			x		x	304,522,506,810,721,302, 675,400,318,Woloski, Furby
Tetradesmus wisconsiensis G. M. Smith					x	109
Lauterborniella elegantissima Sch.					x	
Actinastrum hantzschii Lagerheim		x				318, 507, 318, 400
Tetrallantos lagerheimii Teiling		x	x			
Coccomyxa spp.					x	507
Elakatothrix gelatinosa Wille			x			503, 315, 400, 318, 412
Quadrigula closteroides (Boulin) Printz						503, 107
Gloeotila contorta Chodat						302
Stichococcus minutissimus Skuja						587
Stichococcus sp.						507, 587
Planctonema lauterbornii Schmidle						675
Closterium aciculare West.						675,503,879,400,318
Staurastrum paradoxum Meyen				x		
Staurastrum sp.						302
Spondylosium planum (Wolle) W. et G. S. West						
Cosmarium depressum (Naeg) Lund			x			

SPECIES LIST CONT'D

Euglenophyta

	Lakes					
	885	154	882	255	103	Others
Euglena pisciformis Klebs						302, 106, 109
Euglena viridis (OFM) Ehrenberg						302, 675
Euglena spathirhyncha Skuja						302, 109
Euglena oblonga Schmitz						302
Euglena elastica Prescott						412
Euglena acus Ehr.	x		x	x		400
Euglena sp.		x		x	x	506,109,156,304,503,302, 675
Lepocindis sp.						109, 879
Lepocindis fusiformis (Carter) Lemm.						587
Astasia sp.						302, 587, 675
Peranema sp.						879
Phacus tortus (Lemm.) Skv.	x					302
Phacus pseudonorstedii Pachm						
Phacus caudatus Hubner		x				304, 522, 400
Phacus mirabiles Pachm						402
Phacus chloroplastes Prescott						Grayling
Phacus sp.	x	x			x	675
Trachelemonas volvocina Ehrenberg						302,587,318,109,522,400
Trachelemonas armata (E.) Stein					c	Grayling, 522
Trachelemonas intermedia Dang.						302, 587, Grayling
Trachelemonas superba var. spinosa Presc.						302, Grayling
Trachelemonas sp.						675

SPECIES LIST CONT'D

Chrysophyceae

	Lakes					
	885	154	882	255	103	Others
Chromulina cf minor Pasch.	x					
Chromulina erkensis Skuja	x	x	x	x	x	
Chromulina sp.						318,507,100,522,400,DO, 615,L. Kath.
Chrysococcus rufescens Klebs						100
Chrysococcus spp.						100
Kephyrion spirale (Lackey) Conrad						
Kephyrion cupuliforme Conr.				x		
Kephyrion petasatum Cons.				x		675
Stenokalyx monilifera (Gerloff) Schmid	x			x		675
Stenokalyx sp.						108
Mallomonas acaroides Iwanoff						879, 400
Mallomonas tonsurata Teiling						587
Mallomonas producta Lemmerman						675
Mallomonas pumilo Harris and Bradley						109
Mallomonas elongata Reverdin						675
Mallomonas globosa Schill.	x					
Mallomonas sp.			x			109, 958
Erkenia subaequiciliata Skuja	x		x			701,675,109,701,582,Moon Hunting Hawk, L. Kath.
Dinobryon sertularia Ehrenberg						109, 958, 675
Dinobryon acuminatum Ruttner		x		x		
Dinobryon divergens Imhof.						402, Seeche
Ochromonas cf Vallesiaca Chod	x					400, 582
Ochromonas verrucosa Skuja	x					587, 400
Ochromonas sp.	x	x	x	x	x	318,507,701,304,109,402, 675,522,DO,587,615,400, Moon,L. Kath.
Heterochromonas sp.	x			x		701, 587

SPECIES LIST CONT'D

	Lakes					
	885	154	882	255	103	Others
Pseudokephyrion cf cylindricum						109
Pseudokephyrion cf ellipsoideum (Pasch.) Schmid.						109
Pseudokephyrion poculum Conr.						109,
Pseudokephyrion sp.						100
Chrysochromulina parva Lackey	x		x			701,675
Rhizochrysis sp.						587, 400, 675
Bicoeca ainikkiae Jarnefelt				x		587
Bicoeca sp.		x		x	x	587
Salpingoeca freguentissima (Zacharias) Lemmerman						587,400,318,675
Desmarella moniliformis						507
Desmarella phalanx Stein						587, 675
Lagenoeca sp.			x			
Botryococcus braunii K. G.	x			x		503,109,675,Hunting Hawk

SPECIES LIST CONT'D

Diatomeae

	Lakes					
	885	154	882	255	103	Others
Melosira distens (Ehr) Kreiger		x				879, 587
Melosira granulata Ehrenberg						302,Moon,Woloski ,506
Cyclotella meneghiniana Kg			x		x	318,675,400,318,503,587, 506,615
Cyclotella comta Ehrenberg			x			400,318,503,522,302,587
Cyclotella meneghiniana Kutz laevissima (VanGoor) Hustedt	x		x	x	x	
Cyclotella cf. glomerata Bachman						L. Kath.
Stephanodiscus astreae Grun		x				507,304,522,400,302,Moon
Stephanodiscus hantzschii var. pusilla Grun.	x					304, 507
Chaetocera Muelleri Lemmermann			x			507, 100, 587
Tabellaria fenestrata (Lyngbya) Kützing				x		503,721,304,507
Diatoma elongatum A. G.				x		587
Diatoma elongatum var. actinastroides Krieger				x		302
Fragilaria spp.			x	x		587,Furby,Hunting Hawk, Moon, Woloski
Synedra acus var. radians (Kützing) Hustedt		x	x	x		318,302,318,315,615,005, 675,587,721,506,522,502,303 156,109,106,100,108,701
Synedra cyclopum Brutschi						302
Synedra ulna (Nitzsch) Ehr.						507, 587
Synedra rumpens Kütz	x				x	
Asterienella formosa Hassall						109,107,Seeche,Furby
Asterienella formosa var. gracillima (Hantzsch) Hassall		x				400
Achnanthes sp.?				x		
Cocconeis sp.					x	
Navicula sp.				x	x	503, 721

SPECIES LIST CONT'D

	X Lakes					
	885	154	882	255	103	Others
Amphiprora cf. alata Kütz			x			587, 615, 400
Gomphonema sp.					x	315
Eunotia cf faba (Ehrbg.) Grunow		x				400
Nitzschia holsatica Hust.				x	x	
Nitzschia sp.		x	x		x	400,315,507,879,587,005, 675
Surirella cf ovata Kütz			x		x	304,302,582,675,400

SPECIES LIST CONT'D

Cryptophyceae

	Lakes					
	885	154	882	255	103	Others
Gonyostomen semens (Ehrenberg) Diesing	x					
Cryptomonas marssonii Skuja	x	x	x	x		958,318,400,615,315,D.O. L.Kath.,507,106,109
Cryptomonas erosa Ehrenberg	x	x			x	675,005,587,400,507,302, 701,106
Cryptomonas ovata Ehrenberg	x				x	109,587,Grayling,Moon,506
Cryptomonas rostratiformis Skuja				x	x	318,587,879,302,400,675 402,413,414
Cryptomonas obovata Skuja	x	x	x	x		587,156,522,879,413
Rhodomonas minuta Skuja	x	x	x	x	x	958,302,879,675,Moon, Grayling,L.Kath,414,412, 721,810,506,504,DO,400,587 303,318,507,100,108,106, 156
Rhodomonas minuta var. nannoplanctica Skuja	x			x		507,304,587,109
Rhodomonas cf lacustris Pasch. et Ruttner	x					522
Chroomonas cf breviciliata Nyg.	x	x	x	x	x	522, 587, 675
Chroomonas acuta Utermöhl	x					522, 675, 400
Katablepharis ovalis Skuja	x	x	x	x	x	879,109,318,587,615, Grayling,L. Kath.,507, 156,522,400
Cyathomonas truncata (Fres) Fisch.	x			x		503,318,156,107,879,504, 615

SPECIES LIST CONT'D

Peridineae

	Lakes					
	885	154	882	255	103	Others
Gymnodinium acidotum Nyg.						302
Gymnodinium spp.	x	x	x	x		109,302,615
Glenodinium edax Schilling	x					507,302,701,156
Glenodinium gymnodinium Penard	x	x				615,675
Peridinium inconspicuum Lemmermann						109, Grayling
Peridinium sp.	x					413
Ceratium hirundenella (Müller) Schrank			x	x		Seeche,Furby,675,615,107, 587,879,302,958,701,810, 100,156,304,318
Ceratium carolinianum (Bailey) Jörgensen						522, 502

REFERENCES

Barica, J. 1974. Some observations of internal recycling, regeneration and oscillation of dissolved nitrogen and phosphorus in shallow self-contained lakes. Arch. Hydrobiol. 73:334-360.

Barica, J. 1975. Geochemistry and nutrient regime of saline eutrophic lakes in the Erickson-Elphinstone district of southwestern Manitoba. Fish. Mar. Serv. Res. Dev. Tech. Rep. 511: 82 pp.

Bozniak, E. G. and L. L. Kennedy. 1968. Periodicity and ecology of the phytoplankton in an oligotrophic and eutrophic lake. Can. Jour. Bot. 46, 1259-1271.

Brooks, A. J. 1971. The phytoplankton of Minnesota lakes - a preliminary survey. Univ. of Minnesota, WRRC Bull. No. 36, 12 p. Minneapolis.

Brunskill, G. J. 1973. Rate of supply of nitrogen and phosphorus to Lake Winnipeg, Manitoba, Canada. Verh. Internat. Verein, Limnol. 18:1755-1759.

Davidson, C. 1973. Pelican Lake report. Botanical Sec. U. of M. MS. rept.

Hammer, U. T. 1964. The succession of bloom species of blue-green algae and some casual factors. Verh. Intern. Verein. Limnol. 15:829-836.

Hammer, U. T. 1969. Blue-green algal blooms in Saskatchewan lakes. Verh. Internat. Verein. Limnol. 17:116-125.

Hammer, U. T. 1970. An ecological study of bloom species of blue-green algae in lakes of the Qu'Appele River System, Saskatchewan. Saskatchewan Research Council, Saskatoon, Sask., 188 p.

Hammer, U. T. 1973. Eutrophication and its alleviation in the upper Qu'Appelle River system, in Saskatchewan. Procedding of the Symposium on the lakes of western Canada. pp 352-369. University of Alberta Water Resources Centre, Edmonton.

Hasler, A. D. 1947. Eutrophication of lakes by domestic drainage. Ecology. 28:383-395.

Hecky, R., R. Harper and H. Kling. 1974. Phytoplankton and primary production in Southern Indian Lake. MS prepared for the Lake Winnipeg, Churchill and Nelson Rivers Study Board.

Holmgren, S. K. and H. Kling. 1973. Phytoplankton of Lake Winnipeg. Fish. Res. Board. MS. rep. Unpubl.

Johnson, L. 1970. Management of winterkill lakes. Proceed. Symp. Management Midwest winterkill lakes, Spec. publ. N. Cen. Div. Am. Fish. Soc. 73-75.

Kalff, J., S. K. Holmgren, H. Kling and H. E. Welch. 1975. Phytoplankton Biomass cycles in a unpolluted and in a polluted polar lake. Verh. Internat. Verein. Limnol. 19 (in press).

Kling, H., and S. K. Holmgren. 1972. Species composition and seasonal distribution of phytoplankton in the Experimental Lakes Area, northwestern Ontario. FRB Tech. Rep. No. 337: 56 pp.

Kling, H. 1972. Species distribution and abundance in Char and Meretta Lakes, Cornwallis Island. University of Toronto, Department of Zoology, Annual report on Char Lake Project, IBP, pp 23-26.

Kuehne, P. E. 1941. The phytoplankton of southern and central Saskatchewan (Part I & II). Can. J. Research C. 19:292-322.

Lin, C. K. 1972. Phytoplankton succession in a eutrophic lake with special reference to blue-green algal bloom. Hydrobiologia. 39:321-334.

O'Brien, W. J. 1974. The dynamics of nutrient limitation of phytoplankton algae: a model reconsidered. Ecology. 55:135-141.

Rawson, D. S., and J. E. Moore. 1944. The saline lakes of Saskatchewan. Can. J. Res. D. 22:141-201.

Schindler, D. W. and C. W. Comita. 1972. The dependance of primary production upon physical and chemical factors in a small, senescing lake, including the effect of complete winter oxygen depletion. Arch. Hydrobiol. 69:413-451.

Schindler, D. W., H. Kling, R. V. Schmidt, J. Prokopowich, V. E. Frst, R. A. Reid, and M. Capel. 1973. Eutrophication of lake 227; Experimental Lakes Area, northwestern Ontario by addition of phosphate and nitrate: the second, third, and fourth years of enrichment, 1970, 1971, and 1972. J. Fish. Res. Board Can. 30:1415-1440.

Schindler, D. W., J. Kalff, H. E. Welch, G. J. Brunskill, H. Kling, and N. Kritsch. 1974. Eutrophication in the high Arctic-Meretta Lake, Cornwallis Island (75°W lat.). J. Fish. Res. Board Can. 31:647-662.

Serruya, C., M. Edelstein, U. Pollingher and S. Serruya. 1974. Lake Kinneret sediments: nutrient composition of the pore water and mud water exchanges. Limnol. Oceanogr. 19: 489-508.

Sunde, L. A., J. Whitaker and G. H. Lawler. 1970. Rainbow trout production in winterkill lakes. Proceed. Symp. Managt. Midwest Winterkill lakes. Spec. Publ. N. Cen. Div. Am. Fish. Soc. 57-63.

Sunde, L. A., and J. Barica. Geography and morphometry of the aquaculture study area in the Erickson-Elphinstone district of southwestern Manitoba. Fish. Mar. Serv. Res. Dev. Tech. Rep. 510: 35 pp.

Vollenweider, R. A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors of eutrophication. OECD Report DAS/SSI. 68. 27:159 p.

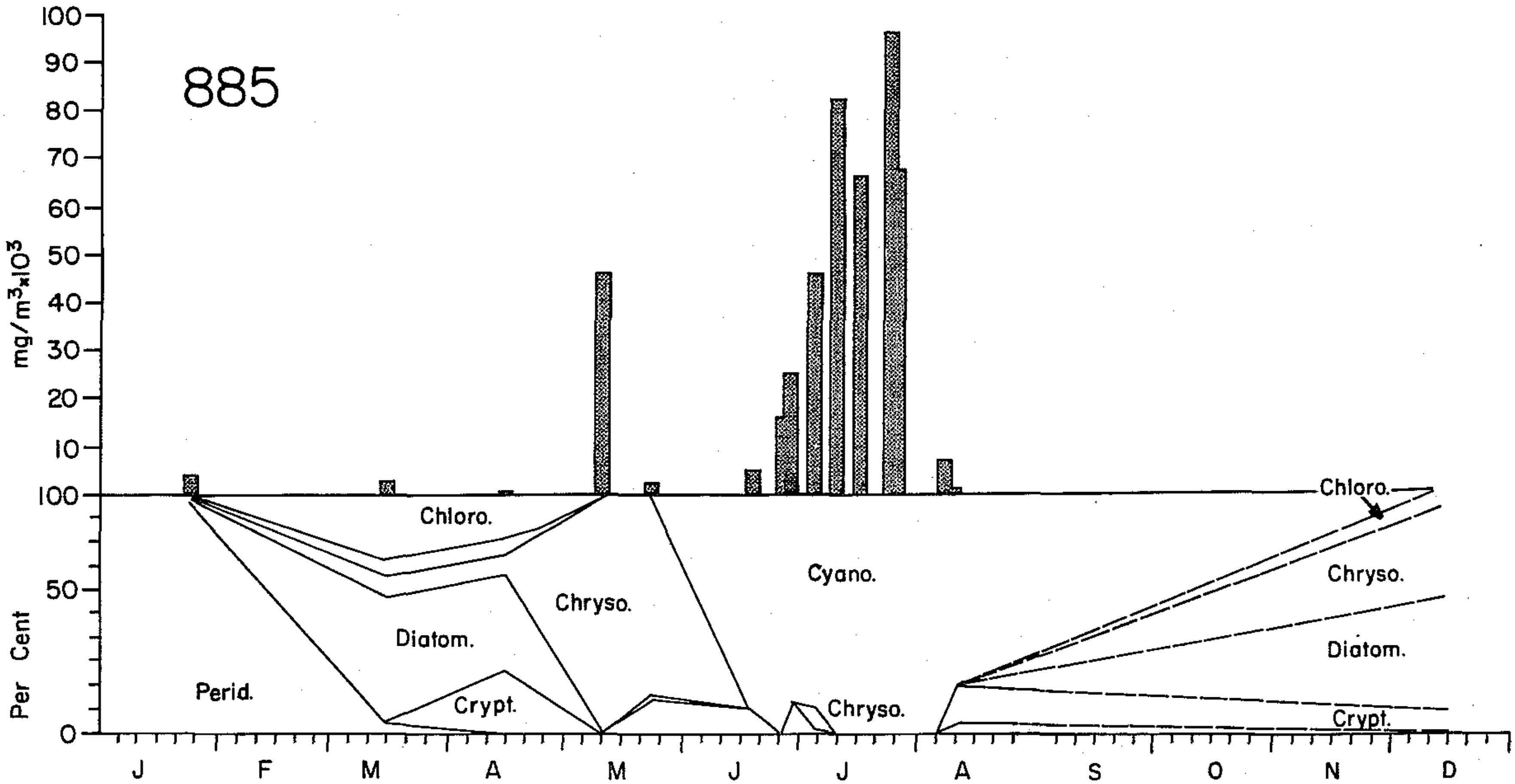

Figure 1. The phytoplankton volume in Lake 885 in 1973 and accumulative percent composition.

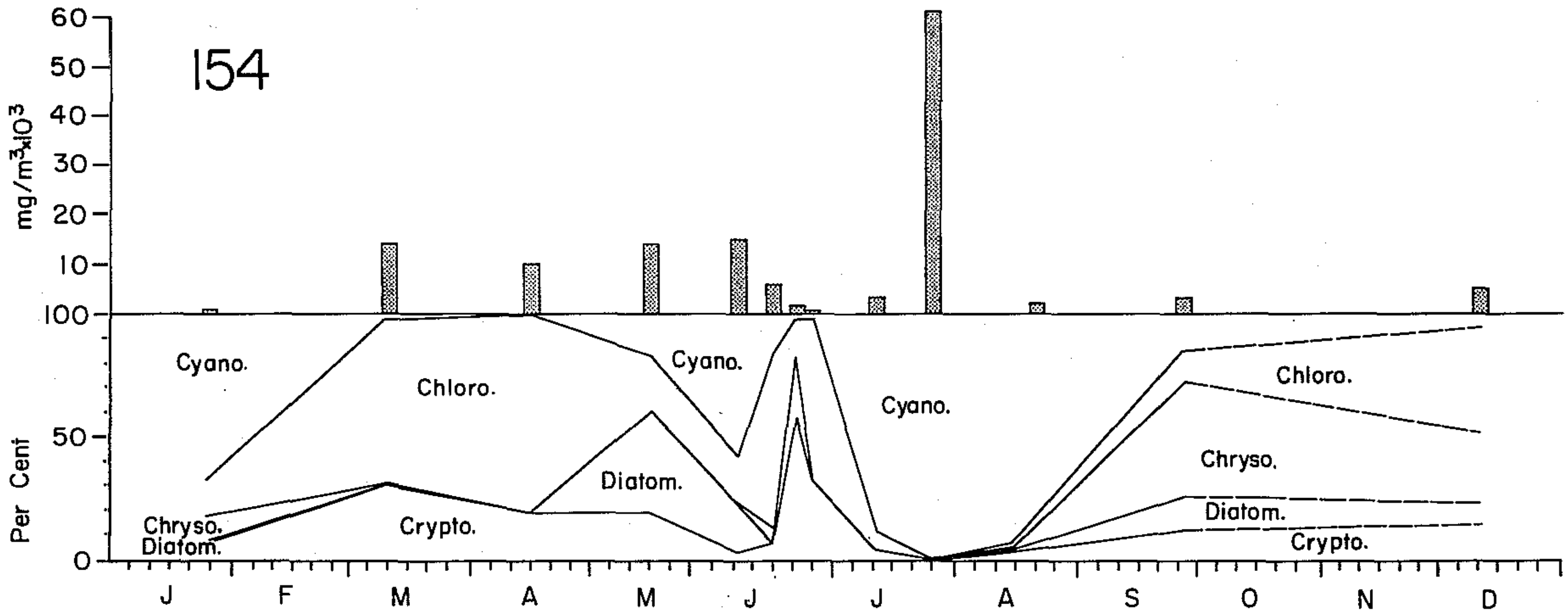

Figure 2. The phytoplankton volume in Lake 154 in 1973 and accumulative percent composition.

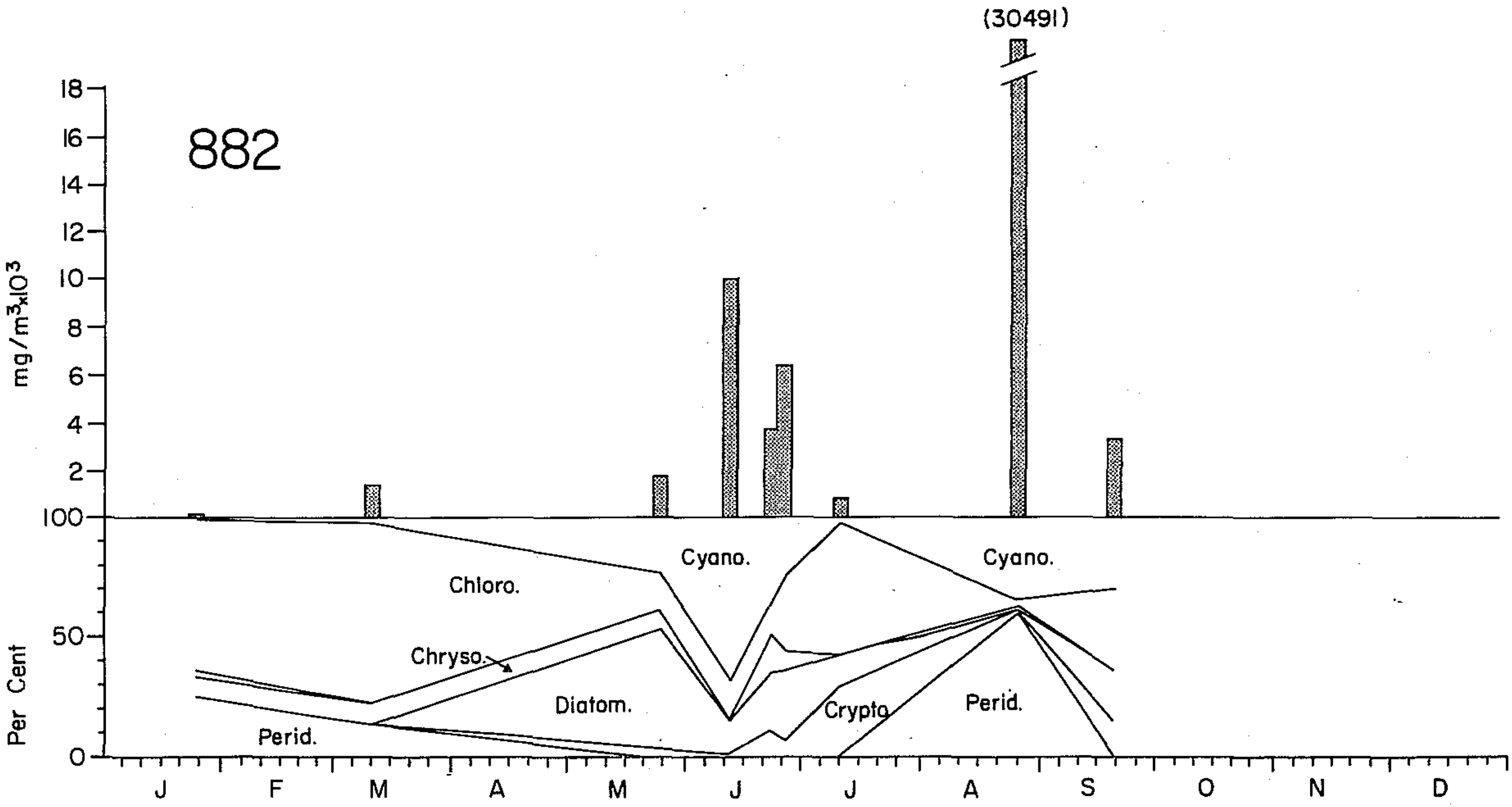

Figure 3. The phytoplankton volume in Lake 882 in 1973 and accumulative percent composition.

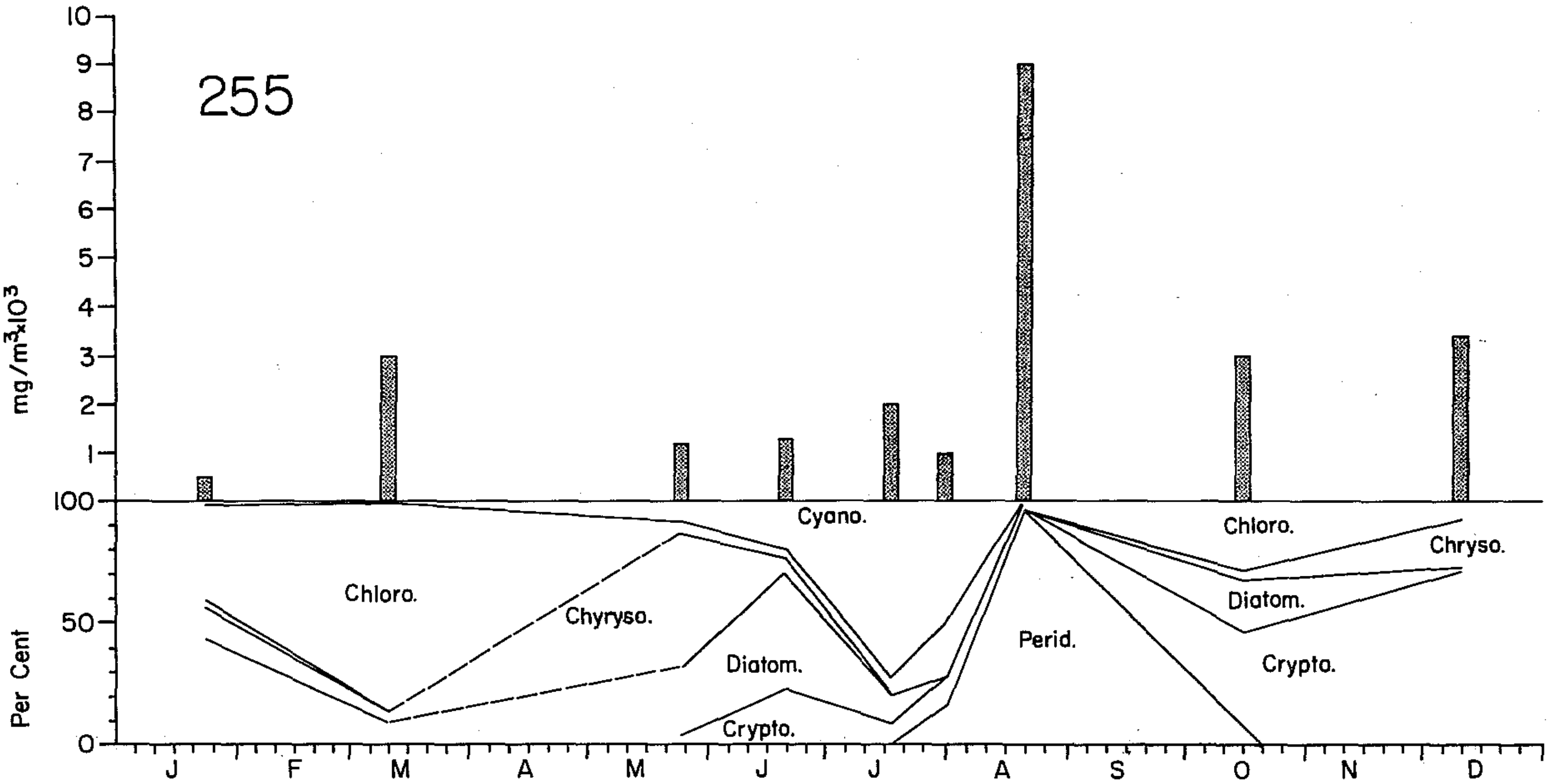

Figure 4. The phytoplankton volume in Lake 255 in 1973 and accumulative percent composition.

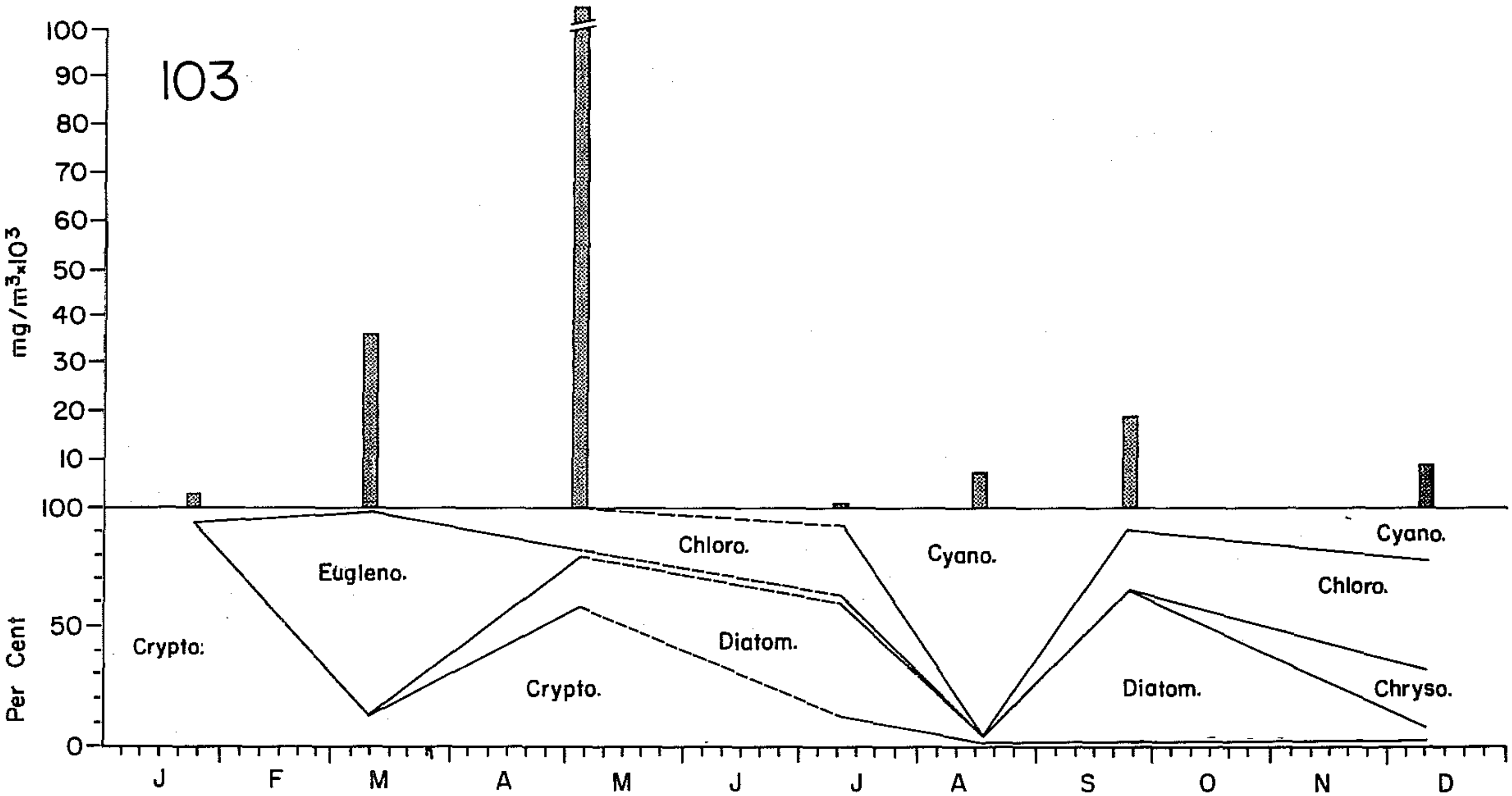

Figure 5. The phytoplankton volume in Lake 103 in 1973 and accumulative percent composition.