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EXPERIMENTAL CROPPING OF LAKES. 3. PHYTOPLANKTON AND ZOOPLANKTON

by

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ABSTRACT

Samples of phytoplankton were collected by a van Dorn sampler in 1972 and samples of zooplankton by a Wisconsin style net in 1971 and 1972 from Alexie, Baptiste, Chitty and Drygeese lakes near Yellowknife, Northwest Territories. Seventy-nine major taxa of phytoplankton were identified, Chitty Lake having the most taxa (56) and Alexie Lake the fewest (28). Chrysophyceae dominated the phytoplankton in all four lakes while Cyanophyceae or Cryptophyceae were second in importance. Seasonal changes in numbers and biomass were not consistent among the lakes. Average summer biomass was higher in Chitty Lake (742 mg/m^3), and lowest in Baptiste Lake (346 mg/m^3) well within the range for oligotrophic lakes (< 1000 mg/m^3). Sixteen species of crustacean zooplankton were identified from the lakes, Chitty having the most species (13) and Drygeese the fewest (9). Limnocalanus macrurus was the most abundant of three large copepod species identified. Diaptomus spp. was the most abundant copepod group while Bosmina longirostris was the most abundant cladoceran. Crustacean zooplankton were most abundant in Alexie and Chitty lakes (33-95 individuals/l) and least abundant in Baptiste and Drygeese lakes (15-37 individuals/l). Most differences in plankton populations observed among the lakes reflected the fact that they are located on two separate sub drainages of the Yellowknife River system.

RÉSUMÉ

On a recueilli en 1972, des échantillons de phytoplancton au moyen de l'échantillonneur van Dorn et en 1971 et en 1972, des échantillons de zooplancton avec un filet de type Wisconsin, dans les lacs Alexie, Baptiste, Chitty et Drygeese près de Yellowknife (Territoires du Nord-Ouest). On a identifié soixante-dix-neuf groupes principaux de phytoplancton, le lac Chitty en ayant 56, soit le plus grand nombre, et le lac Alexie venant au dernier rang avec 28. L'espèce de phytoplancton la plus abondante dans les quatre lacs était Chrysophyceae, suivie de Cyanophyceae ou de Cryptophyceae. Les changements saisonniers dans le nombre et la biomasse n'étaient pas constants d'un lac à l'autre. C'est dans le lac Chitty que la biomasse moyenne en été était la plus élevée (742 mg/m^3), tandis que c'est dans le lac Baptiste qu'elle était la plus basse (346 mg/m^3), bien en decà de la concentration maximale des lacs oligotrophes (1000 mg/m^3). On a identifié 16 espèces de crustacés zooplanctoniques dans les lacs, le lac Chitty venant en tête avec 13 et le lac Drygeese, en dernière place, avec 9. Le Limnocalanus macrurus était le plus abondant copépode des trois grandes espèces identifiées. Diaptomus sp. était le groupe des copépodes le plus abondant tandis que Bosmina longirostris dominait chez les cladocères. Les crustacés zooplanctoniques étaient le plus abondant dans les lacs Alexie et Chitty (33-95 individus/l) tandis que c'est dans les lacs Baptiste et Drygeese qu'on en trouvait le moins (15-37 individus/l). La plupart des différences observées dans les populations de plancton des divers lacs viennent de ce que ces derniers sont situés dans deux bassins tributaires distincts du système hydrographique de la rivière Yellowknife.

INTRODUCTION

This is the third in a series of reports describing physical and biological parameters of four lakes (Alexie, Baptiste, Chitty, Drygeese) near Yellowknife in the Northwest Territories. The lakes are being used in an experiment to determine the response of lake whitefish (Coregonus clupeaformis) to exploitation (Healey 1973). Water chemistry and morphometry are described in a previous report (Healey and Woodall 1973). The purpose of this report is to present information collected in 1971 and 1972 on phytoplankton and zooplankton populations in the lakes.

METHODS

Samples of phytoplankton were collected during the open water season of 1972. Zooplankton were collected during both 1971 and 1972.

Phytoplankton were collected by means of a van Doran water sampler at the deepest point in each lake (Station I for each lake, Fig. 1). Samples were taken from the surface, 1, 3, 5, 7, 10 and 15 m depths. About 100 ml of water was collected in a vial and the phytoplankton preserved with 1 ml of Lugols. Samples were taken at approximately monthly intervals in late May, June, July, August and September. Many of the vials used were of poor quality glass and fractured during storage so that the samples were lost. The data presented here are, therefore, incomplete.

Zooplankton were collected by means of a Wisconsin style net with a 25 cm diameter mouth and fitted with a net of no. 20 bolting cloth (Nytex, 73μ mesh). Samples were taken at two or three stations in each lake (Fig. 1) twice in 1971 (early July and late August) and three times in 1972 (late May, late July and late September). Samples were taken by hauling the net vertically from the bottom to the surface at a speed of about 2 ft (60 cm) per second. The samples were preserved in 10% formalin for later examination.

Phytoplankton identifications were made by H. Kling while crustacean zooplankton were initially identified by Dr. K. Patalas of the Freshwater Institute and then counted by us on the routine basis.

Phytoplankton samples were shaken to redistribute the cells and a 10 ml subsample withdrawn from the vial. The subsample was allowed to settle for 12-16 hours in an Utermohl chamber. Large cells were counted in 1/2 the chamber surface at 100 × magnification and small cells counted in a diagonal strip at 400 × using an inverted microscope. Estimates of cells per litre were converted to estimates of biomass by measuring cell diameters, converting these to volume on the basis of cell shape and assuming a density of 1.

Zooplankton samples were reduced to 100 ml total volume and a 1 ml subsample was removed while the sample was being stirred with a magnetic stirrer. The 1 ml subsample was placed in a Sedgwick Rafter cell and the plankton counted under 45 × magnification. Larger copepods and cladocerans were identified to species and counted. Diaptomids and Cyclopoids were identified merely as Diaptomus spp. and Cyclops spp. in the counts. Cladocera and all copepodid stages were counted for the whole cell. The numbers of nauplii and rotifers were counted in three microscope fields at the edge and three at the centre of the counting cell. Routine counts of nauplii and rotifers were not begun until 1972. Counts in the six microscope fields were divided by the proportion of the cell covered by the six fields to give an estimate of the total number of nauplii and rotifers in the 1 ml subsample.

Initially three 1 ml subsamples were counted from each sample. Variability between subsamples was generally small, so this was later reduced to two per sample. Subsample counts were averaged and multiplied by 100 to give the number of organisms in the whole sample. These values were converted to estimates of numbers per unit volume of lake by dividing by the volume swept by the net and assuming a 25% efficiency for the net.

The settled volume of zooplankton in the samples was measured by allowing the samples to settle in tall calibrated vials.

RESULTS: PHYTOPLANKTON

Species composition

A total of 79 major taxa of phytoplankton were identified from the four lakes. Chitty Lake had the most taxa (56) and Alexie the fewest (28). Sixteen of the taxa occurred in all four lakes, nine occurred in three of the four lakes, 17 in only two of the lakes and 38 were present in only one of the lakes (Table 1). Values of similarity of major species composition (numbers of species two lakes have in common/total number of species in the two lakes) for the six possible paired comparisons of the four lakes indicated that the greatest similarity was between Alexie and Drygeese lakes (52) and least between Baptiste and Chitty (36) (Table 2).

There were few species of Euglenophyta and Chlorophyta in any of the lakes, although major Chlorophyta species were relatively more abundant in Drygeese than in the other lakes. Similar numbers of species of Cyanophyta, Chrysophyceae, Diatomeae, Cryptophyceae and Peridineae occurred in Alexie. Chrysophyceae dominated in numbers of species in Baptiste, Chitty and Drygeese. Peridineae were second in number of species in Baptiste, Peridineae and Diatomeae were second in Chitty and Diatomeae were second in Drygeese (Table 1).

Abundance and biomass

Chrysophyceae dominated both in number of cells and in biomass in all four lakes at all sampling dates. Cyanophyceae and Cryptophyceae were generally second and third in abundance although Chlorophyta were important in Alexie and Chitty lakes and Diatomeae in Drygeese Lake. In Alexie Lake Peridineae were second in biomass followed by Cryptophyceae. In Chitty Lake

Cyanophyta and Cryptophyceae were second and third in biomass. In Drygeese Lake Diatomeae and Cryptophyceae were second and third in biomass (Tables 3 and 4).

Seasonal changes in numbers and biomass were not consistent among the lakes. In Alexie Lake numbers and biomass doubled between July and August. In Baptiste Lake numbers and biomass were high in late May, dropped to almost 1/3 the May value in July, then increased slightly in August. In Chitty Lake numbers and biomass were low in June and August and high in July. In Drygeese Lake numbers and biomass declined throughout the summer. Average numbers of cells and biomass were comparable in Alexie, Baptiste and Chitty lakes but were twice as great in Drygeese Lake (Table 5).

The original sampling program was designed to provide seasonal data on depth distribution. Because so many samples were lost, very little interpretation may be made of the data on depth distribution. In general, the surface waters appear well mixed at the times of sampling and there was no indication of unequal depth distribution of the phytoplankton above the thermocline (Table 6). Samples from below the thermocline were available only for Chitty and Drygeese lakes in July when the 10 and 15 m samples were from below the thermocline. Numbers and biomass in these samples were not markedly lower than those in samples from above the thermocline.

The biomass of phytoplankton was well within the range considered by Vollenweider (1968) to characterize lakes as ultra oligotrophic (<1000 mg/m^3). Summer biomass averaged 348 mg/m^3 in Alexie, 346 in Baptiste, 742 in Chitty and 581 in Drygeese lakes.

RESULTS: ZOOPLANKTON

Species composition

A total of 16 species of crustacean zooplankton were identified from the four lakes (Table 7). Chitty Lake had the most species (13) and Drygeese the fewest (9). Five species occurred in all four lakes, four species in three of the lakes, five species in two of the lakes and two species in only one lake. Calculation of similarity of species composition indicated that Alexie and Chitty lakes were very similar (64) as were Baptiste and Drygeese lakes (67) (Tables 8).

Abundance and settled volume

Three species of large copepods were found in Alexie and Chitty lakes (*Limnolalanus macrurus*, *Senecella calanoides*, *Epischura lacustris*, Table 7). *L. macrurus* was most abundant (about 2.0 individuals/l), *S. calanoides* less abundant (0.8 individuals/l) and *E. lacustris* rate (0.1 individuals/l) in Alexie Lake. The large copepods were generally less abundant in Chitty Lake. *L. macrurus* was again most abundant (0.8 individuals/ 1), *S. calanoides* second in abundance (0.4 indivuals/l) and *E. lacustris* rare

(0.1 individuals/l). In Baptiste and Drygeese lakes, only L. macrurus and E. lacustris were found. L. macrurus was most abundant (2.5 individuals/l in Drygeese, 2.2 individuals/l in Baptiste). E. lacustris was about half as abundant (1.3 individuals/l Drygeese, 0.8 individuals/l Baptiste) (Tables 9, 10). Although one fewer species was present, the larger copepods were more abundant in Baptiste and Drygeese (3.0 and 3.8 individuals/l) than in Alexie and Chitty (2.9 and 1.3 individuals/l).

Diaptomids were generally more abundant than cyclopoids. Both were relatively abundant in Alexie and Chitty lakes (6 individuals/l to 44 individuals/l) and less abundant in Baptiste and Drygeese lakes (2 individuals/l to 7 individuals/l) (Tables 9, 10), the opposite situation to that of the large copepods.

Limnocalanus was most abundant in July samples from the lakes and less abundant in both spring and fall samples. E. lacustris was also most abundant in summer samples except in Chitty Lake where numbers declined from spring to fall. Diaptomids were generally least abundant in spring samples and abundant in both summer and fall samples. Cyclopoids showed no consistent seasonal pattern of abundance. Nauplii were most abundant in mid-summer samples except in Drygeese where they were most abundant in spring samples (Tables 9, 10).

Bosmina longirostris was the most abundant cladoceran in samples from all but Chitty Lake. Average abundance was highest in Baptiste Lake (12.5 individuals/l) and lowest in Drygeese Lake (2.1 individuals/l). Daphnia longiremis was the second most abundant cladoceran, being more abundant than B. longirostris in Chitty (16 individuals/l) but less abundant in Alexie (0.9 individuals/l) and Baptiste (1.2 individuals/l) and rare in Drygeese (0.01 individuals/l). Daphnia retrocurva was absent from Chitty Lake and was less abundant than D. longiremis in Alexie and Baptiste lakes. It was, however, the second most abundant cladoceran in Drygeese Lake (0.45 individuals/l) (Tables 9, 11). Other cladoceran species were rare in the samples averaging 0.1 individuals/l or less.

B. longirostris was most abundant in mid-summer samples, and less abundant in spring and fall samples except in Chitty Lake where it was also abundant in fall. D. longiremis was also most abundant in mid-summer in Alexie and Chitty lakes, while in Baptiste Lake it was rare in the samples until autumn. D. retrocurva was absent from spring samples. It was present in summer samples from Alexie, Baptiste and Drygeese lakes. It was again absent from autumn samples in Alexie Lake but was present in increased numbers in samples from Baptiste and Drygeese lakes (Table 10).

Copepods greatly outnumbered cladocera in samples from Alexie and Drygeese lakes but these groups were more similar in abundance in Baptiste and Chitty lakes.

Overall, crustacean zooplankton (excluding nauplii) were most abundant in samples from Chitty and Alexie lakes (open water season averages for 1971 and 1972: 33-95 individuals/l) and much less abundant in Baptiste and Drygeese lakes (open water season averages: 15-37 individuals/l). This difference was mainly due to the much higher numbers of Diaptomids and Cyclopoids in Chitty and Alexie lakes, although there were marked differences in the abundance of all the taxa between lakes (Table 11). Crustacean zooplankton were also, on average, most abundant in midsummer samples, although, as noted, different taxa had different seasonal patterns of abundance (Table 10). Crustacean zooplankton were about twice as abundant in the 1971 samples as in the 1972 samples but because the lakes were not sampled at the same time it is difficult to interpret this difference.

Rotifers were most abundant in the samples from Chitty Lake, averaging 287 individuals/l during the open water season. They were much less abundant in Alexie (97 individuals/l) and Baptiste (150 individuals/l) and relatively rare in Drygeese (38 individuals/l). In Alexie and Chitty lakes rotifers were most abundant in summer samples, and much less abundant throughout the open water season (Tables 10, 11).

Settled volumes of zooplankton follow the same general pattern as abundances, being greater in Alexie and Chitty lakes than in Baptiste and Drygeese lakes and greater in 1971 than in 1972 (Table 12). The magnitude of the difference between lakes and years was considerably smaller however. The greater similarity between lakes in settled volumes of zooplankton probably reflects the fact that numerical differences in abundance occurred mainly among the small forms, which have a relatively small effect on total volume. The absence of a substantial difference between years is less obviously related to numerical differences among zooplankton. Both large and small forms varied in abundance between years, although small forms did tend to vary more. Settled volumes, of course, include many organisms not counted in the estimates of numerical abundance so that any comparison may be futile. The results do suggest, however, that total volume of net plankton among the lakes is more similar than was indicated by the estimates of numerical abundance of some species.

DISCUSSION

One of our criteria for selecting lakes for the study of whitefish population dynamics was that they should appear to be quite similar. The lakes were originally selected on the basis of preliminary data on fish species composition and abundance. Information on physical and chemical parameters (Healey and Woodall 1973) indicated that the lakes were indeed similar and "typical" of shield and shield margin lakes in general. Our information on plankton composition and abundance further emphasizes the similarity between the lakes. Many of the differences among the lakes reflect the fact that they lie on two separate sub drains, Alexie and Chitty lakes being part of one sub-drainage and Baptiste and Drygeese lakes part of another (Healey and Woodall 1973). The zooplankton information in particular indicates that Baptiste and Drygeese are more similar to each other than to Alexie and Chitty lakes which in turn are more similar to each other than to Baptiste and Drygeese lakes. Of the four lakes, Drygeese appears to be the least like the others, having the most different assemblage of phytoplankton and a high standing crop of phytoplankton in comparison to the other three lakes, yet a poor assemblage of zooplankton and a low standing stock of zooplankton.

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Table 1. Phytoplankton species composition in the four lakes. Only taxa of major significance to the biomass are listed.

Taxon	Lake Alexie	Lake Baptiste	Lake Chitty	Lake Drygeese
Cyanophyta				
Aphanocapsa elachista W. et G.S. West	+	+	+	+
Aphanocapsa delicatissima W. et G.S. West	+	+	+	+
Aphanothece clathrata W. et G.S. West	-	+	+	-
Oscillatoria limnetica Lemm.	-	-	+	-
Oscillatoria tenius Lemm.	-	-	+	-
Lyngbya sp.	-	-	+	-
Aphanezomenn flos aquae (Linneaus) Ralfs.	+	-	+	+
Anabaena circinalis Rabinhorst	-	+	-	-
Anabaena flos aquae (Lyngbya) Brébisson	-	-	+	-
Anabaena spiroides L. Spiroides Klebahn	+	-	-	+
Anabaena sp.	-	-	+	-
Chlorophyta				
Oocystis gigas (var. incrassata)	-	-	+	-
Trochisca sp.	-	+	-	-
Closterium sp.	-	-	-	+
Scenedesmus spp.	+	+	+	+
Tetraedron trigonum	-	-	+	-
Tetraedron sp.	-	-	-	+
Pyramidomonas tetrarhychnes Schenaida	-	-	+	-
Small chlorophyta, Elakatothrix, Chlorella, Ankistrodesmus spp.	-	-	-	+
Euglenophyta				
Trachelomonas volvocina Ehrenberg	-	-	+	+
Trachelomonas sp.	-	-	+	+
Phacus sp.	-	-	+	-
Euglena sp.	+	-	+	-
Chrysophyta				
Chrysophyceae				
Erkenia subequiciliata Skuja	-	+	-	+
Pseudokephryrion attenatum Hilliard	-	-	+	-
Dinobryon sociale Ehrenberg	-	+	-	-
Dinobryon sociale (var. americanum) (Brunnthaler) Bachmann	+	+	+	+
Dinobryon sociale (var. stipitatum) (Stein) Lemm.	-	-	+	-
Dinobryon bavaricum Imhof.	-	+	-	-
Dinobryon cylindricum Imhof.	-	+	-	+
Dinobryon crenulatum W. et G.S. West	-	+	-	-

Table 1. (cont'd)

Taxon	Lake: Alexie	Baptiste	Chitty	Drygeese
Chrysophyta				
Chrysophyceae				
Mallomonas elongata Reverdin	+	-	+	+
Mallomonas caudata Iwanoff.	-	-	+	-
Mallomonas acaroides Perty	-	+	-	-
Bitrichia chodatii (Reverdin) Chodat	+	-	+	+
Chrysoikos skujai (Nauwerk) Willen	-	-	+	+
Gloeobotrys limneticus (G.M. Smith) Pascher	-	+	-	+
Botryococcus brannii Kützing	+	+	+	+
Kephyrion spp.	-	+	+	+
Large Chrysophyceae, Ochromonas, Gloeobotrys spp.	+	+	+	+
Small Chrysophyceae, Chromulina, Chrysococcus spp.	-	+	+	+
Diatomeae				
Tabellaria fenestrata (Lyngbye) Kützing	+	+	+	+
Tabellaria floculosa (Rothest) Kützing	-	-	-	+
Asterionella formosa (var. gracilima) (Hantzsch) Hassal	+	-	+	+
Synedra acus Kutzing	+	+	+	+
(var. angustissima) Grunow				
(var. radians) (Kützing) Hastedt	+	-	+	-
Synedra nana Meister	+	-	+	+
Cyclotella comta Ehrenberg	+	+	+	+
Cyclotella stelligera Cleve	-	-	-	+
Cyclotella comensis Grunow	+	+	+	+
Melosira italica subarctica O. Müller	-	-	-	+
Meridion circulare Agardh	-	-	+	-
Caloneis sp.	-	-	+	-
Rhizosolenia erience A.L. Smith	-	-	+	-
Pyrophyta				
Cryptophyceae				
Cryptomonas marssonii Skuja	+	+	+	+
Cryptomonas obovata Skuja	+	+	+	+
Cryptomonas ovata Ehrenberg	-	+	+	-
Cryptomonas rostratiformis Skuja	-	-	+	-
Cryptomonas pusilla Backmann	-	-	+	+
Cryptomonas boreale Skuja	-	+	+	-
Rhodomonas minuta Skuja	+	+	+	+
Katablepharis ovalis Skuja	-	+	-	+

Table 1. (cont'd)

Taxon	Lake Alexie	Baptiste	Chitty	Drygeese
Peridiniaeae				
Peridinium aciculiferum Lemm.	-	-	+	-
Peridinium inconspicum Lemm.	+	+	+	+
Peridinium willei Huitfeldt-Kaas	-	-	+	-
Peridinium pusillum (Penard) Lemm.	-	-	+	-
Peridinium goslaviense Woloszynska	-	+	-	+
Glenodinium sp.	+	+	-	-
Gymnodinium mirabile Penard	-	+	+	+
Gymnodinium (c.f.) uberrimum (Allman) Kotoid et Swezy	+	+	-	+
Gymnodinium acidotum Nyg.	+	-	-	-
Gymnodinium (c.f.) lacustris Schiller	+	+	+	+
Gymnodinium helviticum Penard	-	+	+	-
Ceratium hirundinella (Müller) Schrank	+	+	+	+
Amphidinium sp.	-	-	+	-
Amphidinium luteum Skuja	-	-	-	+

Table 2. Taxa common to the lakes in paired comparisons and percent similarity.

	Paired comparisons					
Lake 1 Lake 2	Alexie Baptiste	Alexie Chitty	Alexie Drygeese	Baptiste Chitty	Baptiste Drygeese	Chitty Drygeese
Species only in lake 1 (A)	9	4	4	13	11	23
Species only in lake 2 (B)	18	28	17	28	15	12
Species common to both lakes (C)	18	23	23	23	25	28
Percent similarity 100 C/(A+B+C)	40	42	52	36	49	44

Table 3. Abundance and biomass of phytoplankton in the four lakes.

	Abundance millions of cells/m² surface				Biomass grams/m² surface			
	Alexie	Baptiste	Chitty	Drygeese	Alexie	Baptiste	Chitty	Drygeese
May 30-June 6								
Cyanophyta	-	6,422	2,170	2,033	-	1.927	0.644	0.492
Chlorophyta	-	526	719	2,099	-	0.054	0.115	0.315
Euglenophyta	-	<1	0	0	-	0.002	0.000	0.000
Chrysophyceae	-	14,250	9,692	40,825	-	2.688	2.429	9.227
Diatomeae	-	261	627	2,714	-	0.055	0.175	1.307
Cryptophyceae	-	3,198	965	4,515	-	0.914	0.351	1.255
Peridineae		62	50	160	-	0.495	0.304	0.841
July 24-31								
Cyanophyta	1,017	733	8,624	3,156	0.199	0.668	2.257	0.532
Chlorophyta	902	316	2,256	1,498	0.135	0.048	0.226	0.234
Euglenophyta	<1	0	5	0	0.001	0.000	0.023	0.000
Chrysophyceae	7,887	6,243	11,836	23,594	1.748	1.414	3.251	4.766
Diatomeae	600	90	1,576	1,509	0.301	0.054	0.302	0.585
Cryptophyceae	570	1,017	3,064	3,715	0.110	0.172	1.040	0.642
Peridineae	26	40	121	107	0.427	0.161	0.647	0.492
August 30-31								
Cyanophyta	1,068	328	3,394	793	0.209	0.673	0.689	0.193
Chlorophyta	999	602	1,962	597	0.157	0.091	0.294	0.087
Euglenophyta	3	0	4	<1	0.003	0.000	0.012	0.0005
Chrysophyceae	14,690	7,953	5,062	13,608	3.215	1.797	1.689	3.053
Diatomeae	466	283	373	604	0.160	0.255	0.221	0.469
Cryptophyceae	3,620	552	710	1,904	0.663	0.158	0.291	0.335
Peridineae	202	103	693	87	0.828	0.522	0.991	0.363

Table 4. Percent composition of phytoplankters calculated from biomass.

Lake	Alexie		Baptiste		
Date	27 July	30 Aug	30 May	28 July	30 Aug
Taxon					
Cyanophyta	6.80	3.99	31.41	26.54	19.24
Chlorophyta	4.63	3.00	0.87	1.89	2.60
Euglenophyta	0.04	0.06	0.04	0.00	0.00
Chrysophyceae	59.81	61.42	43.82	56.17	51.39
Datomeae	10.28	3.05	0.90	2.16	7.29
Cryptophyceae	3.78	12.66	14.90	6.83	4.53
Peridineae	14.67	15.82	8.07	6.42	14.94

Lake	Chitty			Drygeese		
Date	3 June	24 July	30 Aug	3 June	31 July	30 Aug
Taxon						
Cyanophyta	16.12	29.14	19.19	3.66	7.33	4.29
Chlorophyta	2.86	2.91	8.20	2.34	3.23	1.99
Euglenophyta	0.00	0.29	0.34	0.00	0.00	0.01
Chrysophyceae	60.36	41.97	30.36	68.67	65.73	67.78
Diatomeae	4.36	3.90	6.15	9.73	8.07	10.42
Cryptophyceae	8.73	13.42	8.12	9.34	8.85	7.45
Peridineae	7.57	8.35	27.63	6.26	6.79	8.06

Table 5. Abundance (millions of cells/m^2 surface) and biomass (g/m^3 surface) of all groups at each sampling date.

		Alexie	Baptiste	Chitty	Drygeese
Cells -	May 30-June 3		24,720	14,233	52,346
	July 24-31	11,003	8,481	27,482	33,580
	Aug. 30	21,049	9,821	12,198	17,593
	Mean	16,026	14,341	17,968	34,506
Biomass -	May 30-June 3		6.135	4.023	13.437
	July 24-31	2.923	2.517	7.746	7.251
	Aug. 30	5.234	3.496	3.588	4.594
	Mean	4.078	4.049	5.119	8.427

Table 6. Depth distribution of taxa for each lake and sampling date in micrograms/1.

	Depth (m)						
	0	1	3	5	7	10	15
Alexie 27 July							
Cyanophyta	45.4	35.5	29.4		17.3		
Chlorophyta	16.2	19.4	22.6		15.1		
Euglenophyta	0	0	0.4		0		
Chrysophycae	163.6	148.9	340.8		210.1		
Diatomeae	21.3	24.5	28.6		83.7		
Cryptophyceae	6.3	15.5	15.8		18.3		
Peridineae	68.8	81.3	33.6		85.7		
Σ	321.6	325.1	471.2		430.2		
Alexie 30 Aug.							
Cyanophyta	18.3	5.4	20.9	9.9	20.9	51.9	
Chlorophyta	17.2	10.8	20.5	19.4	13.8	11.9	
Euglenophyta	0.2	0	0	0	0	2.1	
Chrypsophycae	226.7	290.2	219.2	362.1	434.3	278.5	
Diatomeae	10.5	8.8	8.4	20.0	19.0	24.7	
Cryptophyceae	48.7	69.6	52.3	54.4	89.2	64.9	
Peridineae	38.4	92.9	115.9	74.0	85.1	51.3	
Σ	360.0	477.7	437.2	539.8	662.3	485.3	
Baptiste 30 May							
Cyanphyta	92.7		75.4	122.8			172.4
Chlorophyta	2.3		12.2	0.7			3.1
Euglenophyta	1.5		0	0			0
Chrysophycae	169.4		83.3	234.9			163.3
Diatomeae	1.7		3.6	0			8.8
Cryptophyceae	29.4		17.0	69.9			81.6
Peridineae	9.5		53.2	29.4			34.2
Σ	306.5		244.7	457.7			463.4
Baptiste 28 July							
Cyanophyta		26.2	320.2	1.4			
Chlorophyta		14.2	5.4	22.6			
Euglenophyta		0	0	0			
Chrysophycae		293.0	396.3	328.3			
Diatomeae		6.3	5.6	36.9			
Cryptophyceae		30.4	59.4	22.6			
Peridineae		30.8	31.5	67.6			
Σ		400.9	818.4	479.4			
Baptiste 30 Aug.							
Cyanophyta	11.9		105.2	154.9	82.2		
Chlorophyta	12.1		17.2	9.0	11.9		
Euglenophyta	0		0	0	0		
Chrysophycae	296.3		237.4	242.2	274.5		
Diatomeae	26.5		17.7	36.9	97.1		
Cryptophyceae	27.6		18.9	16.1	37.6		
Peridineae	55.1		40.3	146.7	45.5		
Σ	429.5		436.7	605.8	548.8		

Table 6. (cont'd)

	Depth (m)						
	0	1	3	5	7	10	15
Chitty 3 June							
Cyanophyta	39.5			157.1	0		
Chlorophyta	24.5			10.8	16.2		
Euglenophyta	0			0	0		
Chrysophycae	431.0			275.9	385.3		
Diatomeae	33.6			19.6	22.9		
Cryptophyceae	30.2			50.3	99.9		
Peridineae	23.9			65.5	15.2		
Σ	582.7			579.2	539.5		
Chitty 24 July							
Cyanophyta	147.3	128.8	182.1				119.3
Chlorophyta	12.5	10.8	22.3				7.9
Euglenophyta	0	0	0				3.8
Chrysophycae	341.5	237.1	265.8				144.0
Diatomeae	5.3	5.9	19.3				26.0
Cryptophyceae	13.0	22.8	22.3				140.5
Peridineae	61.9	46.5	34.4				50.9
Σ	581.5	451.9	546.2				492.4
Chitty 30 Aug.							
Cyanophyta		45.3		21.6		200.4	
Chlorophyta		70.9		18.3		28.0	
Euglenophyta		0		0.6		3.8	
Chrysophycae		40.2		106.7		211.6	
Diatomeae		39.3		19.4		21.8	
Cryptophyceae		21.7		14.9		72.4	
Peridineae		63.8		140.2		93.1	
Σ		281.2		321.7		631.1	
Drygeese 3 June							
Cyanophyta		15.8	20.8	66.2		24.4	32.3
Chlorophyta		19.4	36.8	17.2		25.9	12.9
Euglenophyta		0	0	0		0	0
Chrysophycae		783.4	527.3	536.0		801.3	600.9
Diatomeae		83.0	108.5	85.2		93.6	96.3
Cryptophyceae		84.0	90.2	165.9		44.9	74.0
Peridineae		42.5	41.6	35.3		65.7	105.1
Σ		1033.1	825.2	905.8		1055.8	921.5

Table 6. (cont'd)

	Depth (m)						
	0	1	3	5	7	10	15
Drygeese 31 July							
Cyanophyta	26.6		49.0		28.7	48.0	11.0
Chlorophyta	22.6		15.1		19.4	6.5	21.6
Euglenophyta	0		0		0	0	0
Chrysophycae	363.4		221.2		441.6	311.9	261.5
Diatomeae	61.3		41.2		39.0	40.7	19.8
Cryptophyceae	66.3		36.0		48.0	33.2	46.1
Peridineae	33.4		38.9		26.2	40.7	20.7
Σ	573.6		401.4		602.9	481.0	379.7
Drygeese 30 Aug.							
Cyanophyta	24.7		9.8	19.5	32.3	7.9	
Chlorophyta	12.9		6.6	10.8	12.9	0	
Euglenophyta	0		0.2	0	0	0	
Chrysophycae	278.1		153.9	343.3	307.6	530.2	
Diatomeae	42.4		44.1	25.1	36.1	103.5	
Cryptophyceae	29.2		19.3	41.6	47.5	27.5	
Peridineae	38.8		32.7	47.1	39.4	36.9	
Σ	426.1		266.6	487.4	465.9	706.0	

Table 7. Species of crustacean zooplankton found in the four lakes.

	Alexie	Baptiste	Chitty	Drygeese
Limnocalanus macrurus Sars	+	+	+	+
Senecella calanoides Juday	+	-	+	-
Epischura lacustris S.A. Borbes	+	+	+	+
Diaptomus sicilis S.A. Forbes	-	+	+	+
Diaptomus minutus Lilljeborg	-	+	-	-
Diaptomus ashlandi Marsh	+	-	+	-
Cyclops bicuspidatus Thomasi S.A. Forbes	+	-	+	-
Cyclops vernalis Fischer	-	+	+	+
Eurytemora composita Keiser 1929	-	-	+	-
Daphnia retrocurva Forbes	+	+	-	+
Daphnia longiremis Sars	+	+	+	+
Ceriodaphnia lacustris Birge	-	+	+	-
Bosmina longirostris (O.F.Müller)	+	+	+	+
Holopedium gibberum Zaddau	+	-	+	+
Diaphanosoma leuchtenbergianum Fischer	-	+	-	+
Leptodora kindtii (Focke)	+	+	+	+

Table 8. Species common to the lakes in paired comparisons and % similarity between lakes.

Lake 1 Lake 2		Paired comparison Alexie Baptiste	 Alexie Chitty	 Alexie Drygeese	 Baptiste Chitty	 Baptiste Drygeese	 Chitty Drygeese
Species only in lake 1	(A)	4	1	4	3	3	6
Species only in lake 2	(B)	5	4	3	5	1	2
Species common to both lakes	(C)	6	9	6	8	8	7
Percent similarity 100 C/(A+B+C)		40	64	46	50	67	47

Table 9. Numbers per l of zooplankton taxa in the four lakes at different dates and sampling locations.

Date	Limnocalanus macrurus	Epischura lacustris	Senecella calanoides	Diaptomus spp.	Cyclops spp.	Daphnia retrocurva	Daphnia longiremis	Bosmina longirostris	Holopedium gibberum	Leptodora kindtii	Diaphanosoma leuchtenbergianum	Ceriodaphnia lacustris	Eurytemora composita	Copepoda nauplii	Rotifers
<u>Alexie Station I 32 m</u>															
5/7/71	9.3	0.03	-	13.8	6.3	1.1	0.09	2.3	0.38	-	-	-	-	81.4	?
2/61/72	0.89	-	-	0.99	14.8	-	0.05	0.24	0.09	-	-	-	-	50.9	57.1
27/7/72	2.5	-	1.4	9.2	4.7	0.75	3.7	2.1	0.52	-	-	-	-	140	95.0
4/10/72	0.68	-	0.96	9.6	1.5	-	0.23	0.62	-	-	-	-	-	36.7	38.0
<u>Alexie Station II 18 m</u>															
6/7/71	1.6	-	-	42.2	20.4	1.0	0.11	8.1	-	-	-	-	-	1.5	?
30/5/72	0.45	-	0.45	1.0	9.1	-	-	-	-	-	-	-	-	53.6	39.3
27/7/72	6.0	-	3.9	19.6	21.2	-	8.4	7.4	0.15	-	-	-	-	248	196
<u>Alexie Station III 18 m</u>															
6/7/71	1.0	0.06	-	49.2	42.6	3.6	0.3	14.2	2.1	0.111	-	-	-	-	?
25/8/71	0.10	-	-	21.2	4.8	0.4	0.63	5.0	-	-	-	-	-	2.8	?
2/6/72	0.52	-	-	1.5	16.2	-	0.10	0.21	-	-	-	-	-	85.8	72.3
27/7/72	0.16	-	1.2	24.4	16.6	-	3.1	34.4	-	0.081	-	-	-	466	284
<u>Alexie Station IV 18 m</u>															
25/8/71	0.45	1.4	-	93.9	27.5	1.4	0.75	10.4	-	-	-	-	-	5.4	250
2/6/72	0.74	-	0.22	1.3	21.3	-	-	0.22	-	-	-	-	-	59.9	52.7
27/7/72	0.35	-	0.92	53.5	13.6	0.07	9.2	20.4	0.14	0.07	-	-	-	273.0	200
4/10/72	2.1	-	1.6	12.2	4.3	-	2.8	5.5	-	-	-	-	-	67	47.3

Table 9. (cont'd)

Date	Limnocalanus macrurus	Epischura lacustris	Senecella calanoides	Diaptomus spp.	Cyclops spp.	Daphnia retrocurva	Daphnia longiremis	Bosmina longirostris	Holopedium gibberum	Leptodora kindtii	Diaphanosoma leuchtenbergianum	Cerioclaphnia lacustris	Eurytemora composita	Copepoda nauplii	Rotifers
Baptiste Station I 30 m															
2/7/71	7.4	0.60	-	5.3	1.4	0.44	0.03	4.2	-	-	-	-	-	5.4	?
18/8/71	5.3	0.44	-	11.4	1.0	1.8	-	10.1	-	-	-	-	-	245	?
31/5/72	0.85	0.50	-	0.56	0.28	-	-	0.07	-	-	-	-	-	11.0	63.8
28/7/72	3.7	2.7	-	6.1	0.59	0.7	1.4	9.1	-	-	-	-	-	14.8	109
2/10/72	0.95	0.45	-	5.6	3.2	0.38	2.2	1.7	-	-	-	-	-	1.5	156
Baptiste Station II 12 m															
2/7/71	0.39	0.55	-	1.1	5.6	0.08	0.16	39.4	-	-	-	-	-	21.2	161
18/8/71	-	0.94	-	5.8	1.4	0.63	0.47	43.5	-	-	-	-	-	10.1	92
1/6/72	1.3	0.56	-	0.70	-	-	-	0.14	-	-	-	-	-	6.8	95
28/7/72	-	3.0	-	13.1	6.4	0.56	2.3	14.8	-	0.13	-	-	-	64	129
2/10/72	-	-	-	6.2	4.0	1.2	5.3	4.2	-	-	-	-	-	6.2	358.0
Baptiste Station III 20 m															
2/7/71	5.8	0.13	-	5.3	2.6	0.17	0.09	10.2	-	-	0.09	-	-	6.3	?
18/8/71	0.86	0.45	-	12.0	4.1	1.5	0.66	31.9	-	-	-	-	-	6.0	?
31/5/72	0.28	0.09	-	0.28	0.48	-	-	0.09	-	-	-	-	-	6.0	92.8
28/7/72	3.6	1.0	-	3.3	1.1	-	0.47	13.4	-	-	-	-	-	7.3	138
2/10/72	2.2	0.19	-	5.8	4.5	0.49	7.9	4.0	-	-	-	-	-	5.5	181

Table 9. (cont'd)

Date	Limnocalanus macrurus	Epischura lacustris	Senecella calanoides	Diaptomus spp.	Cyclops spp.	Daphnia retrocurva	Daphnia longiremis	Bosmina longirostris	Holopedium gibberum	Leptodora kindtii	Diaphanosoma leuchtenbergianum	Cerioclaphnia lacustris	Eurytemora composita	Copepoda nauplii	Rotifers
Chitty Station I 20 m															
7/7/71	2.9	0.06	-	39.5	2.2	-	15.4	0.47	0.09	-	-	-	-	?	?
23/8/71	1.2	-	-	53.3	2.9	-	4.1	16.1	0.07	-	-	-	-	3.8	?
30/5/72	0.11	0.89	0.07	0.59	23.6	-	0.89	0.48	0.07	-	-	0.07	0.11	128	54.5
24/7/72	1.9	-	2.7	17.9	2.4	-	7.4	0.11	-	-	-	-	0.11	87.6	106.0
5/10/72	0.60	-	0.88	24.6	4.2	-	0.82	5.4	-	-	-	-	-	58.9	57
Chitty Station II 15 m															
7/7/71	2.4	0.29	-	18.6	7.9	-	47.1	30.7	-	-	-	-	-	?	?
23/8/71	0.29	-	-	62.7	11.8	-	41.9	16.3	0.17	0.13	-	-	-	5.5	?
29/5/72	-	-	-	0.30	16.1	-	3.0	0.30	-	-	-	-	0.19	92.0	155
24/7/72	1.6	-	0.20	1.4	14.0	-	17.6	14.4	0.40	0.20	-	-	-	171	555
5/10/72	-	-	0.20	9.0	5.0	-	7.1	11.9	-	-	-	-	-	63	75.2
Chitty Station III 7 m															
30/5/72	-	-	-	-	36.8	-	-	3.4	-	-	-	-	-	80.5	485
24/7/72	-	0.20	0.81	1.4	4.4	-	1.0	7.9	-	-	-	-	-	119	975
5/10/72	-	-	0.2	13.3	8.5	-	10.5	18.1	-	-	-	-	-	136	119

Table 9. (cont'd)

Date	Limnocalanus macrurus	Epischura lacustris	Senecella calanoides	Diaptomus spp.	Cyclops spp.	Daphnia retrocurva	Daphnia longiremis	Bosmina longirostris	Holopedium gibberum	Leptodora kindtii	Diaphanosoma leuchtenbergianum	Ceriodaphnia lacustris	Eurytemora composita	Copepoda nauplii	Rotifers
<u>Drygeese Station I 33m</u>															
14/7/71	5.7	2.4	-	7.0	0.91	0.02	-	6.9	0.09	-	0.04	-	-	8.0	?
21/8/71	1.9	0.33	-	13.9	0.79	0.13	-	1.0	-	-	-	-	-	0.09	?
3/6/72	1.0	1.6	-	1.3	1.4	-	-	0.14	-	-	-	-	-	33.9	7.9
31/7/72	9.1	2.2	-	1.8	0.42	0.71	-	0.66	0.19	-	-	-	-	5.1	16.4
28/9/72	2.4	0.19	-	9.0	3.1	0.94	0.09	2.3	-	-	-	-	-	5.1	43.6
<u>Drygeese Station II 24 m</u>															
21/8/71	-	2.2	-	17.8	1.0	0.24	-	1.8	-	-	-	-	-	2.4	?
3/6/72	0.71	1.4	-	0.54	1.6	-	-	0.22	-	-	-	-	-	52.2	18.3
31/7/72	0.68	1.6	-	24.9	0.74	1.7	-	2.3	0.12	0.12	-	-	-	5.2	82.6
28/9/72	0.06	0.06	-	11.1	3.2	1.3	-	3.4	-	-	-	-	-	7.5	58.4

Table 10. Seasonal averages (No/l) for most abundant zooplankton.

Taxon	Lake	Spring (May-June)	Summer (July)	Autumn (Sept-Oct)
L. macrurus	Alexie	0.62	3.0	1.4
	Baptiste	0.81	3.1	1.0
	Chitty	0.04	1.8	0.2
	Drygeese	0.85	5.1	1.2
E. lacustris	Alexie	0.06	1.4	0
	Baptiste	0.40	1.3	0.23
	Chitty	0.30	0.11	0
	Drygeese	1.4	2.7	0.13
Diaptomus spp.	Alexie	1.1	27.0	10.8
	Baptiste	0.53	5.8	5.8
	Chitty	0.45	16.0	16.0
	Drygeese	0.90	11.2	10.1
Cyclops spp.	Alexie	15.2	18.0	2.9
	Baptiste	0.27	2.9	3.9
	Chitty	26.0	6.2	5.8
	Drygeese	1.5	0.70	3.1
D. retrocurva	Alexie	0	0.93	0
	Baptiste	0	0.32	0.68
	Chitty	0	0	0
	Drygeese	0	0.80	1.1
D. longiremis	Alexie	0.04	3.6	1.5
	Baptiste	0	0.57	5.0
	Chitty	1.3	17.7	6.1
	Drygeese	0	0	0
B. longirostris	Alexie	0.17	12.6	3.1
	Baptiste	0.10	15.2	3.3
	Chitty	1.6	10.7	11.8
	Drygeese	0.18	3.3	2.9
Copepoda nauplii	Alexie	63	187	52
	Baptiste	21	56	20
	Chitty	100	129	86
	Drygeese	43	6	6
Rotifers	Alexie	55	194	42
	Baptiste	84	134	232
	Chitty	231	545	84
	Drygeese	13	49	51

Table 11. Numbers/l for most abundant zooplankton in each lake and total abundance 1971, 1972.

Taxon	Lake			
	Alexie	Baptiste	Chitty	Drygeese
		1971		
L. macrurus	2.50	3.29	1.70	2.53
E. lacustris	0.298	0.518	0.088	1.64
Diaptomus spp.	44.06	6.82	43.52	12.90
Cyclops spp.	20.32	2.68	6.20	0.900
D. retrocurva	1.50	0.770	0.00	0.130
D. longiremis	0.376	0.235	27.13	0.000
B. longirostris	8.00	23.22	15.89	3.233
Subtotal	77.054	37.533	94.528	21.333
Nauplii	18.22	49.0	4.67	3.50
Rotifers	~250.0	126.5	~300.0	~40.0
Others	0.518	0.015	0.115	0.043
Total	345.792	213.048	399.313	64.876
		1972		
L. macrurus	1.44	1.43	0.468	2.33
E. lacustris	0.00	0.943	0.121	1.18
Diaptomus spp.	13.33	4.63	7.61	8.11
Cyclops spp.	12.33	2.28	12.78	1.74
D. retrocurva	0.082	0.370	0.00	0.775
D. longiremis	2.76	2.17	5.37	0.015
B. longirostris	7.11	5.28	6.89	1.50
Subtotal	37.052	17.103	33.239	15.650
Nauplii	148.0	13.7	104.0	18.17
Rotifers	108.0	147.0	287.0	37.87
Others	1.17	0.014	0.690	0.072
Total	294.222	177.817	424.929	71.762

Table 12. Settled volumes of zooplankton ml/m^3. Number in brackets after each station is station depth.

Lake	Date	1971 samples					Date	1972 samples				
		Station						Station				
Alexie		1(30)	2(18)	3(18)	4(18)	$\bar{x}$ all		1(30)	2(18)	3(18)	4(18)	$\bar{x}$ all
	6 July	1.04	1.28	1.56	-	1.29	2 June	0.29	0.42	0.43	0.38	0.38
	25 Aug.	-	-	0.56	0.56	0.56	27 July	0.74	1.10	1.08	1.27	1.05
	$\bar{x}$	1.04	1.28	1.06	0.56	0.92	4 Oct.	0.46	-	-	0.76	0.61
							$\bar{x}$	0.43	0.76	0.76	0.80	0.68
Baptiste		1(30)	2(12)	3(22)				1(30)	2(12)	3(22)		
	2 July	0.58	0.60	0.73		0.64	31 May	0.40	0.44	0.53		0.46
	18 Aug.	0.82	0.85	0.66		0.74	26 July	0.66	0.66	0.72		0.68
	$\bar{x}$	0.70	0.72	0.69		0.69	2 Oct.	0.49	0.72	0.65		0.62
							$\bar{x}$	0.52	0.61	0.63		0.59
Chitty		1(20)	2(15)	3(7)				1(20)	2(15)	3(7)		
	7 July	0.90	1.40	-		1.15	30 May	0.30	0.46	0.72		0.49
	23 Aug.	0.63	0.77	-		0.70	21 July	0.76	1.04	0.62		0.81
	$\bar{x}$	0.76	1.08	-		0.92	5 Oct.	0.65	0.62	1.35		0.87
							$\bar{x}$	0.57	0.71	0.89		0.72
Drygeese		1(34)	2(25)					1(34)	2(25)			
	14 July	0.53	-			0.53	3 June	0.22	0.25			0.24
	21 Aug.	0.28	0.35			0.31	31 July	0.84	0.54			0.69
	$\bar{x}$	0.40	0.35			0.42	28 Sept.	0.39	0.35			0.37
							$\bar{x}$	0.48	0.38			0.43

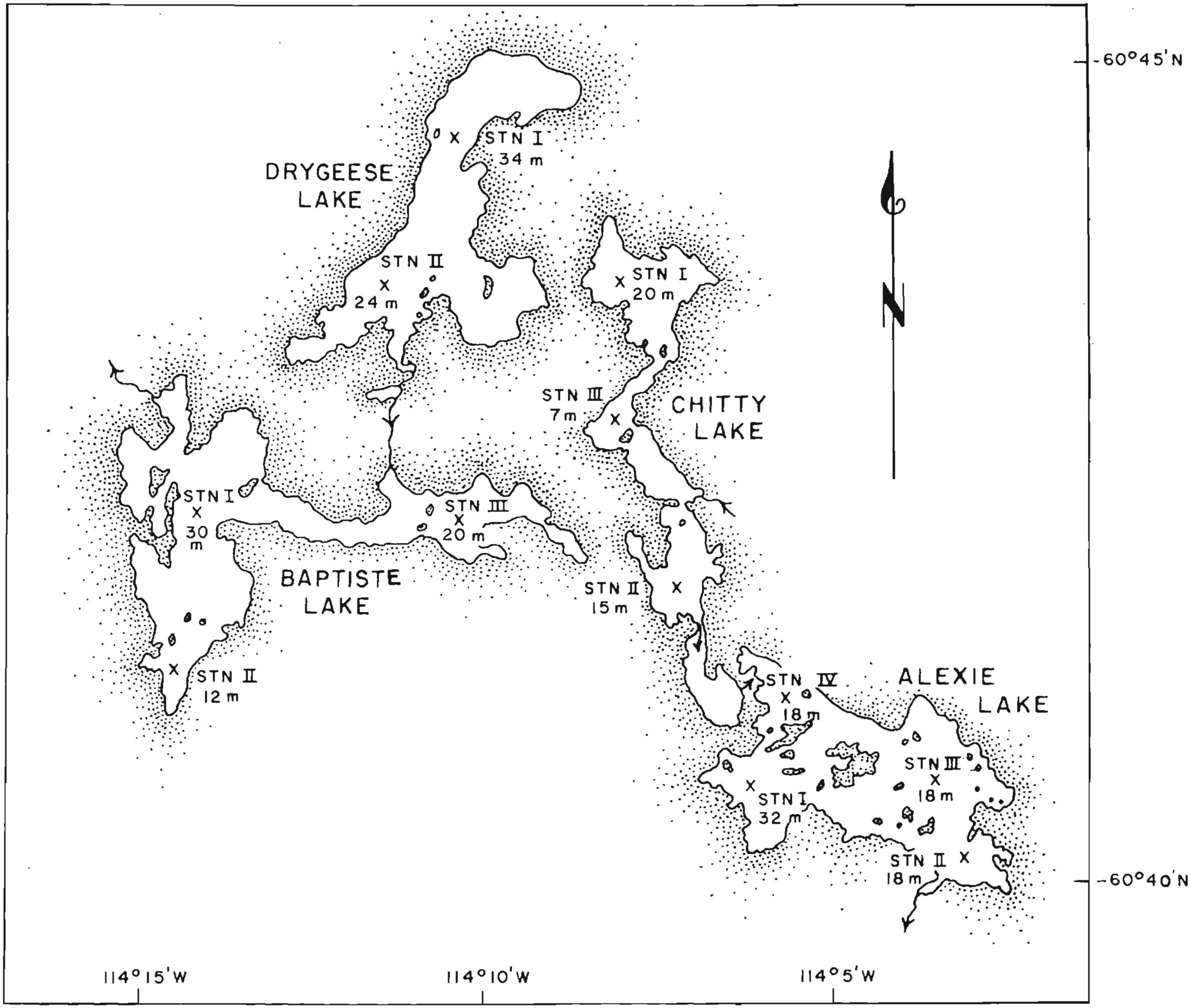

Fig. 1. Outline map of the study lakes and the location of sampling stations. Station I is at the deepest point in each lake.