BASELINE ENVIRONMENTAL STUDIES OF RUTH LAKE AND POPLAR CREEK

ENVIRONMENTAL RESEARCH MONOGRAPH 1975-3
Published as a public service by:
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Through a comprehensive program of surveillance of the effects of our technology and careful application of that technology, we aim to prevent accidental damage to the environment. Total effects will be examined by professional ecologists and study results provided to public representatives.

FOREWORD

In preparation for the extraction of hydrocarbons from the tar sand of Lease No. 17, it will be necessary to divert Beaver Creek away from the mining area. A canal will carry Beaver Creek water into Ruth Lake and the overflow from the lake will pass *via* a second canal into Poplar Creek and thence to the Athabasca River. The ecology of Ruth Lake and Poplar Creek will therefore be altered, and the present study has been undertaken to assess "baseline" conditions, that is, the initial ecological conditions found in these two water bodies before the diversion is established. The information contained in the study will serve as a reference in monitoring changes introduced to Ruth Lake and Poplar Creek as a result of the diversion.

Although extensive mining is a necessary first step in the manufacture of synthetic crude oil from tar sand, with the support of environmental and biological science, ecological disruption can be kept to a minimum. It is even hoped that Lease No. 17, which at present consists of land of poor quality mainly because of bad drainage, will eventually be left in a condition biotically superior to that found before mining.

Syncrude Canada Ltd. recognizes that its environmental activities are of public interest and therefore published results from its ecological work in a form suitable to be read by interested parties outside the Company. All the data for this monograph were provided by Renewable Resources Consulting Services Ltd., Edmonton, Alberta, and publication in monograph form is sanctioned by them. The present monograph is one of a series reporting upon the ecology of Syncrude's lease holdings in the region of the Athabasca tar sands.

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ABSTRACT

Factors involved in the ecology of Ruth Lake and Poplar Creek are discussed. Ruth Lake is a small, littoral, moderately eutrophic lake. It has clear water, a muddy substrate, and is shallow (mean depth 1.5m). Winter stagnation occurred but the water was well oxygenated in summer.

Phytoplankton populations were moderate (3,000-6,000 cells/ml), relatively constant through the summer, and dominated by small and motile algae. Macrophytes were found at all points in the lake and *Nuphar variegatum* (lily pads) was very abundant where the water was 2 meters deep or more. Benthic invertebrates (3,000-9,000/m^2) were dominated by chironomidae larvae. Zooplankton were most abundant numerically in late May and averaged 20,000/m^3 over the summer. This community was typical of a moderately eutrophic pond. Probably because of low winter oxygen levels, brook sticklebacks and fathead minnows were the only fish found in the lake.

Poplar Creek is a small, brownwater tributary of the Athabasca River. Oxygen concentrations in the creek were always greater than 8 ppm, the stream pH was near 8.0, and the total dissolved solids and chloride levels were highest in winter. Tar sand is common in much of the substrate.

Benthic invertebrates were more diverse and abundant (about 250/2ft^2) on rubble substrates than in sand/silt bottoms (about 30/2 ft^2). Populations were lowest in May and highest in August-September, and dominated by clean water organisms (mayflies, stoneflies, caddisflies) in rubble substrates. The stream is slower, deeper, and wider with a sand/silt substrate below the proposed spillway. Above the spillway, a higher gradient occurs with more gravel/rubble riffles. A small resident, reproducing population of grayling in the upper section, and of suckers in both sections, is indicated.

1. INTRODUCTION

This study is a description of conditions existing in Ruth Lake and Poplar Creek, undertaken to provide baseline data before the Beaver Creek Diversion was established (Figure 1, page two). Information on the physical, chemical and biotic characteristics of the two water bodies has been assembled to provide a reference for measuring the effects of the diversion, and as an aid in making plans for maintaining environmental quality during and after mining and industrial operations. Specifically, the study aimed to meet the following objectives:

Ruth Lake

1. Determine the morphometry and substrate characteristics.
2. Measure temperature, dissolved oxygen concentrations, levels of selected chemical parameters, and water transparency.
3. Sample the biota to determine the composition, abundance, and fluctuations in pytoplankton, aquatic macrophytes, zooplankton, benthos, and fish fauna.

Poplar Creek

1. Determine the composition, abundance, and diversity of benthic macroinvertebrates in the stream.
2. Determine resident populations of fish and the physical characteristics of the stream as related to fish.

As regards organization of the report, in most cases the tables and figures containing the baseline data are printed on colored paper at the end of their respective sections, for easy reference.

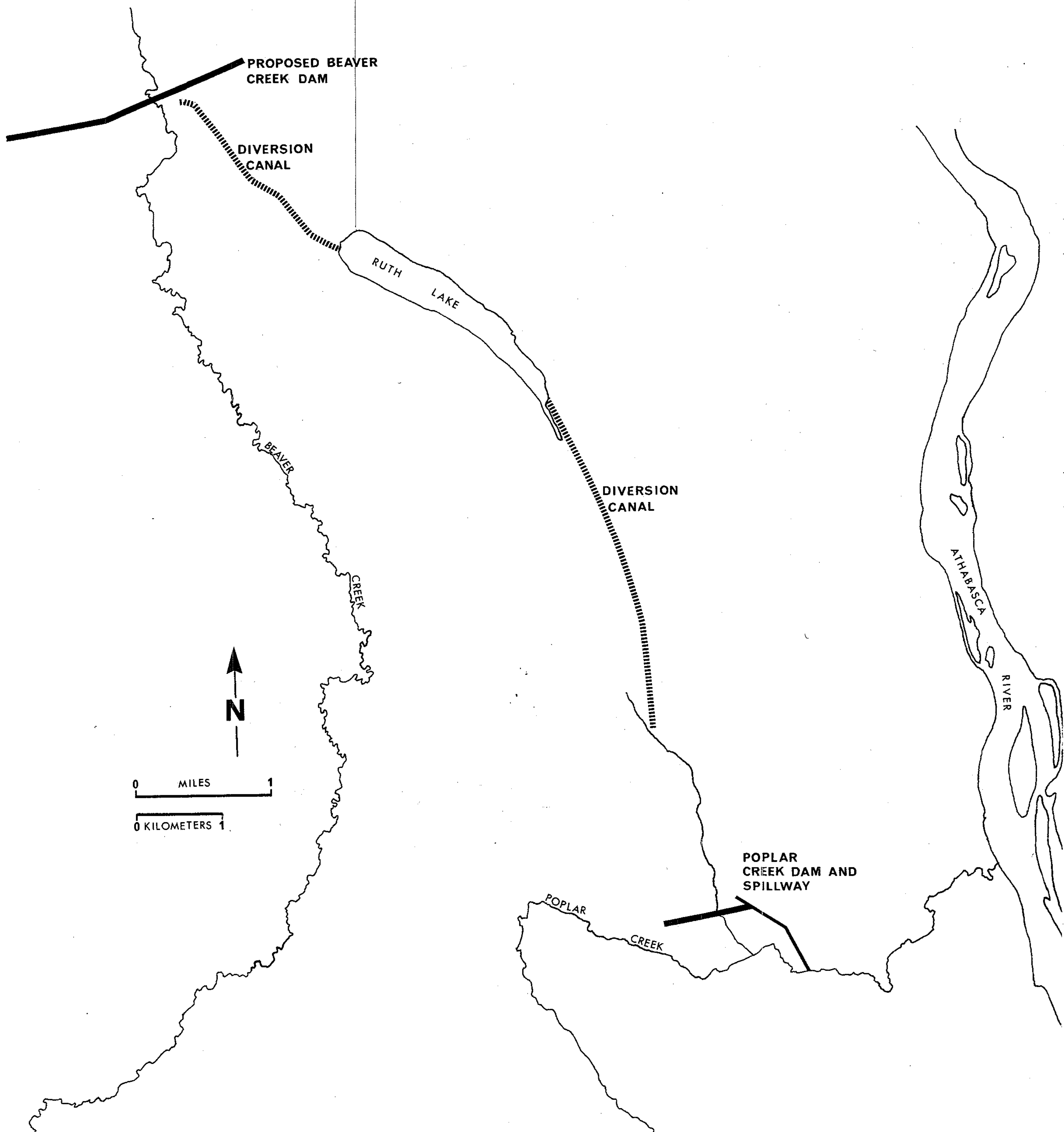

Figure 1. Ruth Lake area, Athabasca tar sands.

2. RUTH LAKE: METHODS

2.1 Sampling Program

Ruth Lake was sampled at three regular sampling stations: in late March, for physical factors and dissolved oxygen, and then every two weeks between May 29 and September 19 inclusive for phytoplankton, zooplankton, benthic macroinvertebrates, water temperature, dissolved oxygen, water chemical parameters, and water transparency. Additionally surveys and sampling were done for lake morphometry and substrate, aquatic macrophytes, and fish.

2.2 Methods

Morphometry

Water depth measurements were taken with a Secchi disc and calibrated line along 10 transects selected at approximately regular intervals throughout the length of the lake. The transects were aligned between prominant landmarks or along known compass directions to facilitate plotting on maps. Depth readings were taken along the transects at uniform intervals as determined by a constant 20 seconds of boat travel. The substrate conditions were noted at each sampling point. By drawing contour intervals derived from the depth measurements (Figure 2) it was possible to calculate the volume of the lake.

Physical and Chemical Factors

On the selected dates temperature, oxygen and Secchi disc visibility readings were taken at each regular sampling station. Temperatures were measured with a pocket thermometer or with a dissolved oxygen-temperature meter[1] (model #490-051, Int. Biophysics Corporation). Oxygen concentrations were measured with the same meter, or by the Winkler method (Azide modification)[2]. A standard 20 cm diameter, black and white Secchi disc was used to measure water transparency.

Water samples were collected and returned to the Syncrude Environmental Laboratory at the Syncrude site for the determination of pH, hardness, total organic carbon (TOC), alkalinity, phosphate (ortho- and total), nitrate, and turbidity. A sample composed of equal parts of water from about 50 cm under the surface and from about 40 cm above the bottom was collected at station 3 on each sampling date for this analysis. Starting on August 8, similar samples were collected from station 1, to provide a comparison between opposite ends of the lake.

Stations W1-W6 (Figure 2) were sampled on March 21, 1974, to determine snow and ice conditions, extreme winter oxygen concentrations, and the approximate water depth in the lake.

Phytoplankton

Unconcentrated water samples for phytoplankton analysis were collected from the top and bottom of the water column at each station and on each date. A Kemmerer water bottle was used for this such that the top sample came from approximately 0.5 m depth and the bottom sample came from about 0.4 m above the sediment. Samples were preserved immediately with acidic Lugol's iodine solution. Permanent, quantitative microscope slide preparations were made from the samples and examined for identification and enumeration of the algae. The keys in Smith (1950) and Prescott (1962) were used to identify algae.

1. An electronic meter permitting measurement of temperature and oxygen concentration, by means of a single temperature-compensated submersible probe.
2. The standard chemical method of measuring oxygen concentration in water. The azide modification prevents interference in the test from nitrate and ferrous iron.

For purposes of data presentation, the phytoplankton were placed into five major groups: Cyanophyta (blue-green algae), Chlorophyta (green algae), Bacillariophyta (diatoms), Flagellates (Crysophyceae, Cryptophyceae, Dinophyceae, Euglenophyta), and Ultraplankton (the small, unidentifiable plankters up to 5μ in one dimension).

Aquatic Macrophytes

A survey of aquatic submergent, floating-leafed and emergent plants was carried out in the field on August 6 and 7, 1974 - a time when standing crops of these plants were considered to have reached a maximum.

Sampling for submergent and floating-leafed plants was done on eleven transects (A to K) spaced at approximately regular intervals along the lake (Figure 5, p. 45). The transects were selected to cover the lake adequately, and were associated with landmarks and/or directions that could be easily recognized or plotted on maps or air photographs. Sampling was started at one end of each transect in 20 to 50 cm of water near shore, and was repeated at regular intervals (as measured by 20 seconds of boat travel) to the opposite shore. These sampling points and the direction of travel on the transects are indicated in Figure 5 (p. 45).

When needed for identification, plant samples were taken from the sampling points, bagged with 5% formalin, and examined in the laboratory. Fassett (1957), Gleason (1963), Moss (1959), and Meunscher (1944) were followed in identifying the plants. At each sampling point, the species present were determined, and the percentage of the substrate covered by each species estimated. Thus each point was described by the submergent macrophyte (or macrophytes) present and by the approximate percentage cover of the substrate by the more abundant species. These estimates were done visually: a simple garden rake was used to collect samples at most points but at the deeper points an Ekman dredge was employed. Where applicable the density of floating-leafed plants was noted at the submerged macrophyte sampling points.

Zones of the lake containing emergent aquatic plants were traversed by boat and observations made on species present, distribution, density and relative abundance of the plants. Where plants could not be identified immediately, samples were taken for subsequent inspection. The shoreline was divided into sections S1 to S12, plotted (Figure 6, page 46) on the basis of the dominant emergent plants (or plant associations) encountered. Dominance was decided from visual estimations, partly of the cover, but also taking into account the biomass contributed by individual plants from each species. For example, 10 plants of the relatively large *Typha latifolia* were judged to be dominant over 10 plants of *Saggitaria cuneata*.

Benthic Macroinvertebrates

One sample was taken at each of the three regular stations for benthic macroinvertebrates on each sampling date starting May 20, 1974, using a standard 6 inch square (232 cm^2) Ekman dredge. Samples were washed in the field with a screen-bottom bucket (aperture size 0.6 mm) and then bagged. These samples were sorted within one day and the organisms preserved in 70% ethanol. Identification was to the generic level except for water mites (Hydracarina), leeches (Hirudinea), and Oligochaets, identification of which is difficult and would have been too expensive and time consuming to be worthwhile. The keys in Edmondson (1959), Usinger (1956), and Pennak (1953) were used in identifying invertebrates.

Zooplankton

Samples were taken approximately every two weeks from May 29 to September 19, 1974, at three stations on Ruth Lake (Figure 2, page 13). The samples were collected with a #20 Wisconsin-type plankton net having a mesh size of 76μ and a mouth diameter of 12 cm. The volume of each sample for any station consisted of three vertical hauls taken through the total depth of the water column except for approximately 0.4 m taken up by the height of the plankton net. Duplicate samples were taken at each site in order to reduce variability. Each sample was preserved immediately with 10% formalin.

The net was hauled at about 0.5 m/sec., a speed considered slow enough not to force the plankton out of the net by back pressure, but fast enough to catch the stronger swimming organisms. It is known that a small amount of water must be lost from the net, depending upon depth sampled, speed of haul, and density of organisms (zooplankton and especially phytoplankton) in the lake (Edmondson and Winberg, 1971). The actual efficiency of sampling was not determined in our case, but was assumed to be high due to the shallowness of the water being sampled, the consistent speed of sampling, and the relatively low densities of phytoplankton organisms in the lake on most sampling dates. Hence, while the numbers of organisms presented in this report are not absolute, they are comparable between sites; over time; and with reference to other lakes.

Samples were counted in the laboratory with a Wild M-5 stereomicroscope* at 30-50x. Counting was preceded by suspending the organisms in a mixture of alcohol and glycerine (3:1) and allowing the alcohol to evaporate to hold the animals in position. Either the total sample or some fraction (subsample) was counted depending upon the number of organisms present. In the case of subsamples, several were counted to reduce variability--the number of subsamples involved depending upon the concentration of organisms. In some cases a small amount of lignin pink was added to facilitate counting and identification. All identifications were according to Edmondson (1959), and Brandlova *et. al.* (1972). For counting purposes, four main groups were distinguished:

* A dissecting microscope giving binocular vision, fitted with selectable magnification of 6x, 12x, 25x, 50x, 100x, and 200x, and illuminated by incident or transmitted light.

Daphnia Type;

Daphnia pulicaria

Diaphanosoma brachyurum

Bosmina Type;

Bosmina longirostris

Chydorus sphaericus

Alona guttata

Graptoleberis testudinaria

Cyclopoida;

Cyclops bicuspidatus thomasi

Mesocyclops edax

Macrocyclops ater

Calanoida;

Diaptomus oregonensis

The immatures of each group were assigned accordingly, but copepod nauplii were not included. While it is recognized that the groups were selected along somewhat arbitrary lines, existing formulae for calculating biomass require that some such grouping be made. Biomass is given in terms of wet weight and calculated from the formulae of Pecken (1965) for daphnia and bosmina types, and Klekowski and Shushkina (1966) for copepods. These formulae may also be found in Edmondson and Winberg (1971). The wet weight for Conchostraca was not calculated since no reliable formula exists for this group. Because the Conchostraca occur mainly as benthic organisms and are not therefore true plankton animals (Hickman, 1967), they were most conveniently grouped with the benthos. The numbers and wet weight of organisms are expressed directly on a per cubic meter basis or as the cube root of these numbers and wet weights ($\sqrt[3]{N}$), as outlined by Ruttner (1963). To minimize variability in zooplankton counts arising from horizontal stratification (see Hutchinson, 1967), in most cases the values for the three stations have been averaged. Numbers/m^3 were calculated in the following manner:

$$\text{Numbers or Weight/m}^3 = \frac{\text{Total number or weight in sample}}{\text{Total volume of haul (m}^3\text{)}}$$

where: Total volume of haul (m^3) = number of hauls X area of net mouth X depth of haul

Total number of weight in sample = number or weight in subsample X $\frac{\text{volume of total sample}}{\text{volume of subsample}}$

and given that:

Area of net mouth = 0.0113 m^2 (diameter = 12 cm)

Depth of haul = depth of water - 0.4 m (~height of net).

Fish

Ruth Lake was sampled for fish using seines and gill nets. A 20 foot (~6 m) seine was used at the four sites indicated in Figure 2 to collect small fish near shore on June 11, June 25, and August 21. A test gang gill net 83 1/2 yards (76.4 m) in length and containing stretched mesh of 1 1/2, 2 1/2, 3 1/2, 4 1/2, and 5 1/2 inch (3.8, 5.0, 8.9, 11.4, and 14.0 cm) was set between 900 and 1600 hours on June 12 at site G1, between 1430 on August 6 and 900 on August 7 at site G1, and between 930 on August 7 and 930 on August 8 at site G2.

3. RUTH LAKE: RESULTS AND DISCUSSION

3.1 Morphometry

Morphometric measurements for Ruth Lake are placed in Table 1, and the water depth contours are presented in Figure 2. Ruth Lake is relatively shallow, having a mean depth of only 1.5 m and a maximum depth of 3 m. The substrate is mostly soft mud except that at seining site S4 the substrate contained some sand and was therefore somewhat firmer. Scattered rocks were observed along the shoreline in places.

3.2 Physical and Chemical Factors

The results of the March sampling trip are presented in Table 2. Approximately 60 m of ice and 25 cm of snow covered Ruth Lake at the time. Water temperatures ranged from 0°C at the surface to a record maximun of 3°C near the bottom.

Oxygen concentrations at that time were low (0-0.3 ppm). The shallowness of the water and the abundant growths of macrophytes in the lake (discussed later) may contribute to impart a high oxygen demand to the water. This would produce low oxygen levels during late winter when snow and ice cover prevents sufficient penetration for oxygen producing photosynthesis. Oxygen concentrations were much higher during the May to September sampling period (Table 3) being between 5.8 and 11.0 ppm. Consistent differences in oxygen concentrations between stations were not obserbed, nor was depth stratification of oxygen recorded.

Temperature readings are placed in Table 4. A maximum of 21.5°C was recorded on both July 25 and August 8. As with oxygen concentrations, the shallowness of the lake did not allow thermal stratification of the water column. Temperatures surpassed 20°C by the end of June and maintained this level into August, after which the water began to cool. The shallow nature of the lake apparently allows temperatures of the water column to follow the air temperatures fairly closely.

The water in Ruth Lake was usually clear enough for the Secchi disc to be visible on the bottom sediments. Only at Station 2 (depth about 2.65 cm) was the water deep enough for the turbidity to reach the point where the disc disappeared before touching the bottom. The dates and maximum visible depths for such observations at station 2 were:

Date	Depth (m)
July 25	2.2
August 8	2.6
August 19	2.0
August 21	2.6

Results of the water chemical analysis are contained in Table 5. Ruth Lake can be characterized as a hardwater bicarbonate lake. The pH is about 8.4 and total alkalinity is around 180 ppm. Total and orthophosphate levels were generally less than 0.05 ppm after mid-July, but were somewhat higher previously. Similarly, nitrate concentrations were less than 0.02 ppm after mid-July but were higher on earlier dates during the summer. Not surprisingly the reduced levels of these two important nutrients in the latter part of the season varied inversely with the extent of plant growth in the lake; in late summer the lowest levels of the nutrients occured simultaneously with highest aquatic macrophyte biomass. The plant community appears to be withdrawing these nutrients from the lake water and incorporating them into plant biomass.

Total organic carbon was the only parameter to show differences between stations. Levels were consistently and noticeably higher at station 1 than at station 3. It has not been possible to provide a reason for this.

RUTH LAKE

DATA FOR MORPHOMETRY AND PHYSICAL-CHEMICAL FACTORS

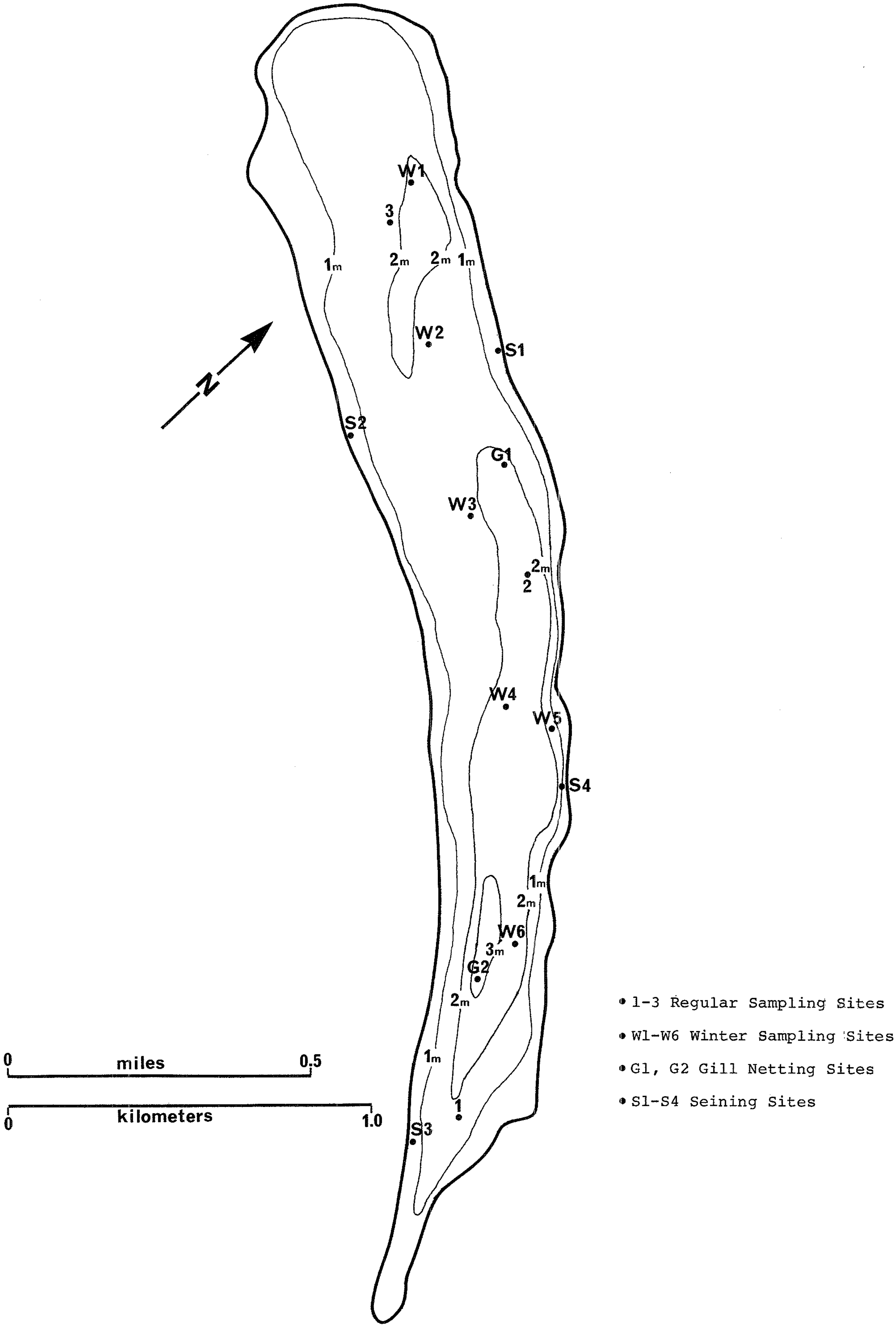

Figure 2. Ruth Lake. Depth contours in meters.

Table 1. Ruth Lake morphometry.

	English Units	Metric Units
Area	0.554 $mile^2$	1.435 km^2
Maximum effective length	1.983 miles	3.19 km
Maximum breadth	0.347 miles	0.558 km
Maximum recorded depth	9.8 ft	3 m
Mean depth	4.9 ft	1.5 m
Volume	76.388×10^6 ft^3 (1754 acre feet)	2.163×10^6 m^3
Shoreline length	4.84 miles	7.8 km
Shoreline development	3,304	
Elevation	1,013 ft	308.8 m

Table 2. Ruth Lake winter habitat inventory, March 21, 1974.

	Bore Hole Number					
	W1	W2	W3	W4	W5	W6
Average Snow Depth (cm)	20	20	22	22	25	30
Drifts of ( ) cm.		(30)	(33)	(30)		
Total Depth (ft)	6.5	6	5.5	8	6	7
(m)	2	1.8	1.7	2.4	1.8	2.1
Ice Depth (cm)	65	60	60	60	62	56
Dissolved O_2 (mg/l)						
Water Surface	0.30	0.25	0.2	0.30	0.20	0
2 feet (0.6 m)	0.28	0.15	-	0.10	0.1	0
4 feet (1.2 m)	0.28	0.15	*0.2	0.10	0.15	*0
6 feet (1.8 m)				0.15		
Water Temperature °C						
Water Surface	0	0	0	0	0	0
2 feet (0.6 m)	1	1.5		1.2	1.2	2
4 feet (1.2 m)	3	2	*1.5	2	1.5	*2
6 feet (1.8 m)				2		

*Indicates that reading taken at bottom, otherwise taken every 2 feet, although height of probe did not allow readings lower than the last readings stated above.

NOTE: Total depth includes water depth and ice depth.

Table 3. Recorded oxygen concentrations (ppm) in Ruth Lake, 1974.

Date→	20/1/74[1]	6/3/74[1]	2/4/74[1]	29/5/74[2]		12/6/74[2]			25/6/74[2]		
Station→	N/A	N/A	N/A	1	2	1	2	3	1	2	3
Depth (m)↓											
N/A	2.4	0	0								
0				10.1	9.8	8.2	8.9	8.3	8.5	8.2	7.7
0.5				10.05	9.9	8.0	8.3	8.2	8.5	8.1	7.7
1.0				9.95	9.9	8.5	8.1	8.2	8.3	8.0	7.7
1.5				9.90	9.9	8.4	8.0	8.2	8.1	7.9	7.7
2.0				*9.90	9.97	*8.4	7.9	8.1	*8.1	7.7	*7.7
2.5					10.0		7.8	*8.1		7.5	
					*10.1		*7.8			*7.5	

*Reading taken 20 cm above sediment.
N/A Not Available.
[1]Results from Syncrude baseline data collection. Method as in #2 below.
[2]Readings taken with electric dissolved oxygen - temperature meter, model 490-051 - Int. Biophysics Corp.

Table 3. Continued.

Date→	12/7/74[2]			25/7/75[3]			8/8/74[3]		
Station→	1	2	3	1	2	3	1	2	3
Depth (m)↓									
N/A									
0	7.5	8.5	8.5	10.0	8.0	8.5	11	9.5	9.5
0.5	7.5	8.4	8.7						
1.0	7.4	8.5	8.8				10.5		
1.5	7.1	8.5	8.8	10.0		8.5			10.0
2.0	*7.1	7.7	*8.8						
2.5		*5.8			8.25			8.5	

[3]Readings taken using the Winkler method (azide modification) on samples collected the stated depths. Dissolved oxygen - temperature meter not working.

Table 3. Concluded.

Date→	21/8/74[3]			4/9/74[3]			19/9/74[2]		
Station→	1	2	3	1	2	3	1	2	3
Depth (m)↓									
N/A									
0	9	8.5	9.5	10.25	10	10.5	7.5	7.9	8.1
0.5							7.5	8.0	8.1
1.0							7.7	8.1	8.1
1.5	9.5		9.5	10		10.5	7.6	8.0	8.1
2.0							*7.8	8.0	*8.2
2.5		8.75			10			8.0	
								*8.0	

Table 4. Recorded temperatures (°C) in Ruth Lake, 1974.

Date→	20/1/74[1]	6/3/74[1]	2/4/74[1]	29/5/74[2]		12/6/74[2]			25/6/74[2]		
Station→	N/A	N/A	N/A	1	2	1	2	3	1	2	3
Depth (m)↓											
N/A	0.5	1	0.8								
0				11	11.7	17.5	17.5	17.2	20.5	21.0	21.0
0.5				11	11.7	17.0	17.5	17.3	20.5	21.0	21.2
1.0				11	11.9	17.0	17.4	17.4	20.5	21.0	21.2
1.5				11	11.9	17.0	17.3	17.2	20.5	20.5	21.2
2.0				*11	11.9	*17.0	17.2	17.2	*20.5	20.5	*21.2
2.5					11.9		17.0	*17.2		20.5	
					*11.9		*17.0			*20.5	

*Reading taken 20 cm above sediment.
N/A Not Available.
[1]Results from Syncrude baseline data collection. Method as in #2 below.
[2]Temperatures taken with electric dissolved oxygen - temperature meter, model 490-051 - Int. Biophysics Corp.

Table 4. Continued.

Date→	12/7/74[2]			25/7/74[3]			8/8/74[3]		
Station→ Depth (m)↓	1	2	3	1	2	3	1	2	3
N/A									
0	20	20.5	20.5	21.5	21.0	21.5	21.0	21.5	22
0.5	20	20.5	20.5						
1.0	20	20.5	20.5			20.5			
1.5	20	20.5	*20.2	21.5			21.0		21.5
2.0	*20	20.5			N/A				
2.5		*20.5						21.0	

[3]Temperatures taken with a pocket thermometer by immersing in lake surface (top reading) or by immersing in Kemmerer sample from stated depth (bottom reading). Dissolved oxygen-temperature meter not working.

Table 4. Concluded.

Date→	21/8/74[3]			4/9/74[3]			19/9/74[2]		
Station→	1	2	3	1	2	3	1	2	3
Depth (m)↓									
N/A									
0	16	16	15	15	15	14.9	12.5	13	13
0.5							12.5	13	13
1.0							12.5	13	13
1.5	16		15.5	15		15.2	12.5	13	13
2.0							*12.5	13	*13
2.5		16			14.3			13	
								*13	

Table 5. Water chemistry results for Ruth Lake.

Analysis	20/1/74*	6/3/74*	2/4/74*	20/6/74**	26/6/74	2/7/74	12/7/74
pH	8.2	N.A.	8.6	8.3	8.4	8.4	8.6
Hardness ($CaCO_3$)	204	N.A.	N.A.	N.A.	188.6	184.4	117.7
T.O.C.	N.A.	41.	N.A.	N.A.	24	20	17
Alkalinity							
Phenolphthalein	-	N.A.	2	0.5	0.4	0.6	4.9
Total	305	N.A.	370	188.7	183.8	181.2	170.0
Phosphates							
Ortho	0.03	N.A.	N.A.	N.A.	0.01	0.01	-
Total	0.14	0.12	0.16	N.A.	0.69	3.38	0.01
NO_3	0.5	0.5	N.A.	0.36	0.36	0.5	0.05
Turbidity (FTU)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table 5. continued.

Analysis	25/7/74	8/8/74 Station 1	8/8/74 Station 3	22/8/74 Station 1	22/8/74 Station 3	4/9/74 Station 1	4/9/74 Station 3	19/9/74 Station 1	19/9/74 Station 3
pH	8.6	8.3	8.6	8.3	8.1	8.4	8.5	8.1	8.1
Hardness ($CaCO_3$)	128.6	131.7	126.8	131.2	134.0	137.0	141.0	146.6	144.9
T.O.C.	33	95	92	414	98	592	109	222	60
Alkalinity									
Phenolphthalein	1.3	6.3	6.9	4.2	2.7	4.8	3.6	5.8	8.2
Total	181.1	177.2	173.9	179.7	181.7	181.1	123.3	191.14	165.5
Phosphates									
Ortho	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.2
Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
NO_3	0.02	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01
Turbidity (FTU)	N.A.	0.5	-	0.02	0.3	2.0	1.5	1.0	1.0

N.A. Not Available
\- None Detected
* Previous Samples, Syncrude baseline water analysis
** Syncrude baseline water analysis
All units are expressed as ppm except pH and Turbidity

3.3 Phytoplankton

Because top and bottom samples from individual stations revealed no marked or consistent differences in number or composition of algal cells (undoubtably a result of the shallowness of Ruth Lake), phytoplankton counts were averaged for each station to simplify presentation of the results. Phytoplankton identified and counted are listed in Table 6.

Figure 3 depicts the total numbers and composition by numbers of the phytoplankton at the three stations as divided into blue-greens, flagellates, greens, and ultraplankton. Diatoms have not been included because they always accounted for less than 3% (by number) of the total cells present, and usually less than 1%. Because of the littoral nature of Ruth Lake, a low level of turbulence was assumed and this in turn was expected to give rise to differences in samples obtained from different stations. That such differences were not found indicated constant conditions throughout the lake.

During most of the summer, total cell numbers were from 3000 to 5000 cells/ml. A slight trend towards higher cell counts of about 6000 cells/ml was apparent by the end of the season, mainly at sites 2 and 3.

Phytoplankton cell crops are not excessively high in Ruth Lake, nor do they show much fluctuation throughout the summer. The fact that blue-green algae did not dominate the phytoplankton at any time in the season indicates that Ruth Lake is not fully eutrophic. Further evidence is provided by the orthophosphate levels listed in Table 5 which rank with those given by Hutchinson (1957) and Vollenweider (1968) for moderately eutrophic lakes.

Principal phytoplankton species present in Ruth Lake are discussed below.

Ultraplankton

Ultraplankton dominated the phytoplankton community in numbers throughout the summer of 1974, generally forming about 60% of all cells collected.

Flagellates

Flagellates of various taxa were the next most important in terms of cell numbers, comprising 10% to 25% of the standing crop. No temporal periodicity was apparent in the graphs of percentage importance of this group. Important flagellates were *Cryptomonas* sp., *Dinobryon sertularia* Ehrenberg, and *Rhodomonas* sp. Of these, only *Dinobryon sertularia* showed a marked periodicity during the study. The species occurred in May; was rare during July and early August; and then reappeared during late August and September. This effect is illustrated in Figure 4.

Table 6 contains a summary of cell count data for important plankters. *Cryptomonas* was fairly constant in cell numbers throughout the study but showed a slight increase towards September, with an abundance of around 200 cells/ml. *Rhodomonas* had cell numbers in the order of 300-500 cells/ml with highest numbers found in May but otherwise it showed no obvious fluctuations.

Blue-green Algae

Blue-green algae were not abundant in the phytoplankton, usually comprising less than 10% by number of the total crop, although a maximum of 44% was reached in one sample. No single genus dominated the blue-greens, but filamentous types (including *Lyngbya limentica, Oscillatoria* sp. and unidentified forms) were most common. No evident seasonality occurred in the group as a whole.

Chlorophyta (green algae)

These comprised a small percentage (less than 10%) of the total phytoplankton, but consisted of a large number of forms (26 taxa). Total greens showed a slight and gradual build-up in numbers through the summer. *Ankistrodesmus convolutus* has counts ranging from 30 to 80 cells/ml; coccoid green algae (unidentifiable further) were found at concentrations of 30-300 cells/ml; *Oocystic* sp., which was more prominent in August-September (Table 7), showed abundances from 10 to 70 cells/ml; and *Scenedesmus* sp. (highest in September) had counts of 10 to 200 cells/ml.

Diatoms were rare in the plankton, usually comprising less than 1% of the total algal cells. Some of the pennate diatoms observed may have been benthic and epiphytic forms that merely occurred in the plankton by chance because the forms that usually dominate the diatom plankton (*Asterionella*, *Fragilaria*, *Cyclotella*, *Stephanodiscus*, *Melosira*, *Synedra*, *Tabellaria*) are extremely rare.

Probably no single theory can entirely explain the phytoplankton characteristics of Ruth Lake, but account may be taken of the following effects.

a. Distribution by Space

Ruth Lake is littoral and in the second half of the summer contained dense growths of macrophytes including *Nuphar*. These properties ensure that the lake will lack turbulence to any great extent. However, such is the shallowness of the water in Ruth Lake that the weak turbulence may be intense enough to sustain a fairly uniform vertical distribution of phytoplankton in the water column. Indeed, Table 6 was assembled on this assumption. Furthermore, although gross horizontal turbulence is unlikely in Ruth Lake, it has already been noted that conditions are sufficiently constant throughout the lake for stations to provide similar samples. That is, small and motile algae appear to be evenly distributed. Small and motile algae dominated the phytoplankton, perhaps because turbulence is too weak to encourage the development of larger phytoplankton organisms. It should be emphasized that this interpretation is only one of several possibilities and must be considered speculative in the absence of conclusive data.

b. Distribution in Time

Epiphytes and macrophytes are known to inhibit phytoplankta (Hasler and Jones, 1948) so that it might be expected that phytoplankta would be abundant in the first half of the summer and reduced in the second half as the other plants develop. In fact phytoplankta were found to be steady throughout the season. A possible explanation of this constancy is that high levels of zooplankta were recorded in the first half of the season and these would graze on the phytoplankta keeping them relatively low in the earlier part of the season.

3.4 Aquatic Macrophytes

General Remarks

The entire bottom of Ruth Lake is of soft silty nature conductuve to macrophyte growth and this, coupled with the shallowness of the water, has allowed the macrophyte community to establish itself in all areas of the lake. Extensive growths of *Nuphar* have a damping effect on wave action so that strong winds blowing the length of the lake produce only moderate waves. This makes the lake even more suitable for macrophytes by reducing wave action that can be damaging to aquatic plants.

A list of all species of aquatic macrophytes identified from Ruth Lake is presented in Table 8 along with notes on their abundance.

3.5 Submergent Plants

The area of the substrate covered by submergents is listed in Table 9. A *Nuphar* survey is included in Table 9, four intensities of cover being designated: abundant, common, occasional, and rare.

For ease of description the lake was divided into three regions according to percentage cover of the substrate and the species of macrophytes present. The regions were: *Chara* dominated (c), i.e., greater than 50% *Chara*; Open (O), i.e., less than 50% substrate cover by submergents; and Mixed (M), a region of variable cover and diverse species composition (see Figure 5).

Chara Dominated (Greater than 50% *Chara*)

The total area in this regime was 26% of the lake. Besides totally covering the substrate in some areas, *Chara* often grew in very dense mats up to about 30 cm tall. This profuse growth had the property of releasing numerous bubbles, presumably of oxygen, as the wave of the sampling boat disturbed the weed bed. On sunny afternoons the evolution of gas was so prolific that a 50 ml vial inverted in the water could be filled in a few minutes.

Nuphar variegatum occurred in this region to some extent, but the densest growths of *Nuphar* and of *Chara* were not found together.

Other frequently-occurring macrophytes were *Potamogeton richardsonii*, *P. zosteriformis*, *P. pectinatus*, *P. praelongus*, *P. vaginatus* and *Utricularia vulgaris*.

Mixed

44% of the lake bottom was included in the regime. It was not so much a recognisable assemblage of macrophytes as an area not classifiable as "*Chara* dominated" or "open". No one species dominated the regime but the most common were: *Myriophyllum exalbescens*, *Najas flexilis*, *Fontinalis* sp., *Potamogeton foliosis*, and *P. richardsonii*. The region is generally restricted to the shallower parts of the lake, and occupies most of the shoreline.

Open (Less than 50% substrate cover by submergents)

The area of the lake in this regime is 30%. This benthic assemblage was found largely in the center of the lake and was associated with the densest growths of *Nuphar*. It also occupied the central area of the lake containing the emergent *Scirpus validus* (S12, Figure 6). The biomass of macrophytes in this open region was low, perhaps because the deep water, combined with the heavy *Nuphar* cover, prevented light from reaching the bottom.

3.6 Floating-Leafed Plants

Three species of floating-leafed plants were identified.

(a) *Sagittaria cuneata* - occurred close to shore in water up to 30 cm deep. It also occurred in the submergent form and as such was occassionaly an important member of the emergent zones.

(b) *Potamogeton natans* - not abundant in Ruth Lake. It was located in several separate patches in water about 1 m deep.

(c) *Nuphar variegatum* - This is the most commonly occurring floating-leafed plant in Ruth Lake. It is found over the entire lake in some density but is not abundant in the plotted areas of Figure 6, labelled "N". These regions of high abundance coincide with lake depths of more than 2 m, possibly because the weak light at such depths would give *Nuphar* a competitive advantage over submergent plants.

The growth sequence in 1974 was noted as follows:

May 30. Lily pads seen starting to grow on the lake bottom.

June 12. Shoots and leaves part way to the surface.

July 12. All leaves had reached the surface.

September 19. Leaf cover had decreased by about one quarter of its mid-July maximum due to physical damage apparently by wind and wave action, and attack by organisms.

3.7 Emergent Plants

Although Ruth Lake is classified as littoral, emergents do not grow over the whole area of the lake but are limited to the shallower water at the edges. On the long sides, emergents extended up to 15 m into the lake but growth is more extensive at the south east end where the lake bottom slopes more gently. One group of emergents (Section S12, Figure 6) occurs in the center of the lake, and consists of *Scirpus validus* distributed in clumps about 4 m in diameter and about 20 m apart.

The sections of the lake supporting emergent plants were placed in categories according to dominant species. The categories and the extent of their occurrence are listed below:

1. *Scirpus validus* dominant
   Where found: S2 and S4 (8% of shoreline), and Section S12
   Associated species: *Typha latifolia, Scirpus caespitosus, Sagittaria cuneata*
   Extent of the listed species within the sections: 75%.

2. *Typha* and *Scirpus validus* dominant
   Where found: Section S1 (12% of shoreline)
   Associated species: *Scirpus caespitosus, Sagittaria cuneata*
   Proportion of section occupied by the dominant species: 50%.

3. *Equisetum fluciatile* dominant (see Plate 2)
   Where found: Section S8 (11% of the shoreline)
   Associated species: *Scirpus validus, Typha latifolia, Carex*
   Proportion of the section occupied by the dominant species: Growths of horsetail in this area were dense and almost pure.

4. Dense extensive *Carex* and *Typhus latifolia.*
   Where found: Section S6 (see Plate 3) and S11, (23% of shoreline)
   Associated species: *Scirpua validus*
   Extent of the three listed species within the sections: Only these 3 species were found in these sections.

5. Medium density. No dominants.
   Where found: Sections S3 and S10 (8% of shoreline)
   Most common species: *Typha latifolia, Scirpus caespitosis, Scirpus validus, Carex.*
   Extent of common species within the sections: 50%.

A dense band of *Sagittaria cuneata* was identified in Section S3 along the shoreline growing to a depth of about 30 cm (see Plate 6).

6. Low Density. Variable dominants.
   Where found: Sections S5, S7, and S9, (38% of shoreline)
   Species present and their extent: *Scirpus validus* and *Typha latifolia* may dominate the emergent vegetation in places but overall coverage of the shoreline by these two species is less than 10% in the above 3 sections.

Thick stands of dead and flooded brush occupy Section S5 (Plate 7) and are virtually without associated emergents. It is of interest that flooded trees are found to some extent around the whole lake shore. That they occur in water up to 80 cm deep indicates that at some time in the past the lake surface must have been this much lower than at present. It appears from Plate 7 that the brush vegetation is almost entirely willow (*Salix* sp.), and is up to 4 m high. Jarvis (1968) gives the height growth of aspen poplar in a poor site in Saskatchewan as about 1 foot per year. It is not unreasonable to suppose that this is also the rate of growth for the *Salix* of Ruth Lake. If this were to be true it suggests that the water level of the lake was low for at least 12 years to allow the trees to grow to their current measured height.

3.8 Distribution of Macrophytes in Ruth Lake

Considering the distribution of all the aquatic macrophytes of Ruth Lake, it is possible to divide the lake into three areas which have noticeably different characteristics:

1. Dense lily pad growth. This area (outlined in Figure 6) is characterized by the densest cover of *Nuphar variegatum*, poor coverage of the substrate by other aquatic macrophytes, and water depths about equal to or greater than 2 m.

2. Dense submergent growth. *Nuphar* occurs in medium to very low levels in this type, while submergent plants form a nearly continuous cover of the substrate throughout. The submergent cover may be dominated in portions of this area by thick growths of *Chara* sp., or by a mixed assemblage of plants. Water depths are generally less than 2 m in this area.

3. Emergent growth. Other than the clumps of *Scirpus validus* in the middle of the lake, this area is found along the shorelines of the lake and is best developed at the south-east end of the lake. It is dominated by different species in different locations but the most important species are *Typhia latifolia*, *Scirpus validus*, and *Carex*.

Ruth Lake is essentially littoral in nature--aquatic macrophytes being present in all areas of the lake. The description and delineation of the macrophyte community found in the data presented here are for one year only and may not obtain in the longer term. Although the broader categories outlined here would probably not change from year to year, details of dominance, individual species distribution, standing crop sizes, and density of certain stands, can be expected to alter as a result of normal fluctuations in such environmental variables as water level, amount of sunshine, and summer air temperatures. This has been observed in other Alberta lakes (Allen 1973). Evidence has been presented above for the previous occurrence of relatively large water level fluctuations in Ruth Lake.

RUTH LAKE

DATA FOR AUTOTROPHES

Table 6: Phytoplankton cell counts (cells/ml) - mean of top and bottom samples.

Date→	29/5/74			12/6/74			25/6/74		
Station→	1	2	3	1	2	3	1	2	3
Phytoplankton↓									
ULTRAPLANKTON	2,463	2,252	1,604	1,838	2,884	2,056	4,594	4,008	2,360
% of Grand Total	64	66	62	71	86	75	74	81	49
CYANOPHYTA (BLUE-GREEN)									
*colonial coccoid forms									
*Filamentous forms							+	+	727
Anabaena sp.									104
Aphanocapsa sp.									1,302
Coelosphaerium sp.	+						261		
Chroococcus sp.				210	+	102			
Gomphosphaeria sp.			21					+	
Lyngbya limnetica Lemmermann	135	139	200	2	+	+	457	78	
Merismopedia sp.		56							
Oscillatoria sp.									
Total blue-greens	135	195	221	212	-	102	718	78	2,133
% of Grand Total	3	6	9	8	-	4	12	1	44
CHLOROPHYTA (GREENS)									
*Coccoid forms	5	21	42		10		50	256	43
*Colonial coccoid forms	+		10			14	50		
Actinastrum sp.									
Ankistrodesmus convolutus Corda	15	15	20	+	+	+	36	34	51
A. falcatus (Corda) Ralfs									
A. spiralis (Turner) Lemmermann									
Ankistrodesmus sp.	+							+	
Coelastrum reticulatum (Dang.) Senn									
Coelastrum sp.									
Cosmarium sp.		+	+						
Crucigenia quadrata Morren		44	31						
C. tetrapedia (Kirch.) West & West	+	+	+						
Crucigenia sp.	42						42		
Kirchneriella sp.			11						
Oocystis sp.	14	14	6	4	4	5		+	5
Pediastrum tetras (Ehrenb.) Ralfs			+						
P. boryanum sp. (Turp.) Meneghini				+	+	+			
Quadrigula sp.				+	+	+			
Scenedesmus quadricauda (Turp.) de Brébisson									24
Scenedesmus sp.	42	45		13	+	19	31	5	34
Schroederia sp.									
Selenastrum westii Smith									
Staurastrum sp.		+							
Tetraedron caudatum (Corda) Hansgirg							+	+	
T. minimum (A. Braun) Hansgirg	+			+	4	5			
Tetraedron sp.	5			9					
Total greens	124	139	119	26	18	43	209	295	157
% of Grand Total	3	4	5	1	<1	1	3	6	3
FLAGELLATES									
*Unidentified flagellates	83			40		27	139	62	36
Ceratium sp.									
Cryptomonas ovata Ehrenberg							+	+	
Cryptomonas sp.	47	7	4	41	41	22	86	49	
Dinobryon sertularia Ehrenberg	+	116	63						
Peridinium sp.									
Rhodomonas sp.	949	653	559	421	403	486	425	433	162
Trachelomonas sp.									
Total flagellates	1,079	776	626	502	444	535	650	544	198
% of Grand Total	28	23	24	19	13	19	10	11	4
BACILLARIOPHYTA (DIATOMS)									
*Pennate diatoms	68	36	17	5	+	+	16	24	10
Cyclotella sp.									
Fragilaria crotonensis Kitton	+								
Synedra sp.									
Tabellaria sp.									
Total diatoms	68	36	17	5			16	24	10
% of Grand Total	2	1	1	<1			<1	<1	<1
GRAND TOTAL	3,869	3,398	2,587	2,583	3,346	2,746	6,187	4,949	4,848

*not identified further, probably more than one genera involved.

+occurred in quantities too low for enumeration.

Table 6: continued.

Date→	12/7/74			25/7/74			8/8/74		
Station→	1	2	3	1	2	3	1	2	3
Phytoplankton↓									
ULTRAPLANKTON	2,567	2,293	2,067	1,823	3,703	2,567	1,578	3,706	2,708
% of Grand Total	69	61	65	61	76	75	56	76	70
CYANOPHYTA (BLUE-GREEN)									
*Colonial coccoid forms		31	42	+	28	47	83		
*Filamentous forms		521	52	260	+	+	313		+
Anabaena sp.					78	41			217
Aphanocapsa sp.	+	+							
Coelosphaerium sp.	240						+		+
Chroococcus sp.				+	21	+		35	
Gomphosphaeria sp.									
Lyngbya limnetica Lemmerman	292	+	+						18
Merismopedia sp.	+	+	+						
Oscillatoria sp.				208					
Total blue-greens	532	552	94	468	177	88	396	35	235
% of Grand Total	14	15	3	16	4	2	14	<1	6
CHLOROPHYTA (GREENS)									
*Coccoid forms	17	16	37	109	99	57	+	221	39
*Colonial coccoid forms	+	+	+			+			
Actinastrum sp.									
Ankistrodesmus convolutus Corda	45	48	26	21	104	84	32	96	152
A. falcatus (Corda) Ralfs				+		+			
A. spiralis (Turner) Lemmerman			+						
Ankistrodesmus sp.									
Coelastrum reticulatum (Dang.) Senn.									
Coelastrum sp.								+	
Cosmarium sp.				5					+
Crucigenia quadrata Morren									
C. tetrapedia (Kirch.) West & West									
Crucigenia sp.	72			+	21	+	117	+	+
Kirchneriella sp.									
Oocystis sp.	30		+		+	+		+	39
Pediastrum tetras (Ehrenb.) Ralfs									
P. boryanum (Turp.) Meneghini									
Quadrigula sp.									
Scenedesmus quadricauda (Turp.) de Brébisson									
Scenedesmus sp.	+			+	52	31	29	8	26
Schroederia sp.		+	+			+			
Seleastrum westii Smith	+								
Staurastrum sp.									
Tetraedron caudatum (Corda) Hansgirg									
T. minimum (A. Braun) Hansgirg	+								
Tetraedron sp.				31			9		
Total greens	164	64	63	166	276	172	187	325	308
% of Grant Total	4	1	2	5	6	5	6	7	8
FLAGELLATES									
*Unidentified flagellates	133	169	120	135	151	88	311	321	293
Ceratium sp.									
Cryptomonas ovata Ehrenberg									
Cryptomonas sp.	102	135	172	135	183	177	83	112	78
Dinobryon sertularia Ehrenberg	12			11			150	96	4
Peridinium sp.				21	10				4
Rhodomonas sp.	181	511	682	255	322	339	98	265	217
Trachelomonas sp.									
Total flagellates	428	815	974	556	666	604	642	794	597
% of Grand Total	12	21	30	18	13	18	23	16	15
BACILLARIOPHYTA (DIATOMS)									
*Pennate diatoms	22	6	+	+	5		9	8	5
Cyclotella sp.									
Fragilaria crotonensis Kitton									
Synedra sp.									
Tabellaria sp.									
Total diatoms	22	6			5		9	8	5
% of Grand Total	<1	<1			<1		<1	<1	<1
GRAND TOTAL	3,713	3,730	3,196	3,013	4,827	3,431	2,812	4,868	3,853

Table 6: continued.

Date→	21/8/74			4/9/74			19/9/74		
Station→	1	2	3	1	2	3	1	2	3
Phytoplankton↓									
ULTRAPLANKTON	3,790	3,054	3,147	2,692	4,013	3,526	2,916	3,819	4,454
% of Grand Total	77	61	75	64	73	74	50	60	59
CYANOPHYTA (BLUE-GREEN)									
*Colonial coccoid forms	+	279					174		
*Filamentous forms	+	827	135		130	+	972	469	912
Anabaena sp.	83			140	40	201	+		40
Aphanocapsa sp.						+		+	+
Coelosphaerium sp.						+			
Chroococcus sp.	+	+			9				10
Gomphosphaeria sp.									
Lyngbya limnetica Lemmermann								87	26
Merismopedia sp.							+		40
Oscillatoria sp.							+	+	
Total blue-greens	83	1,106	135	140	179	201	1,146	556	1,028
% of Grand Total	2	22	5	4	3	3	19	9	14
CHLOROPHYTA (GREENS)									
*Coccoid forms	183	129	134	197	49	9	321	325	391
*Colonial coccoid forms									
Actinastrum sp.									
Ankistrodesmus convolutus Corda	80	81	52	36	37	42	52	118	25
A. falcatus (Corda) Ralfs									
A. spiralis (Turner) Lemmermann									
Ankistrodesmus sp.			9	4	+		5	4	47
Coelastrum reticulatum (Dang.) Senn.	70								
Coelastrum sp.								69	115
Cosmarium sp.									
Crucigenia quadrata Morren									
C. tetrapedia (Kirch.) West & West									
Crucigenia sp.		19							
Kirchneriella sp.									87
Oocystis sp.	42	74	74	+	10	8	22	61	59
Pediastrum tetras (Ehrenb.) Ralfs							18		
P. boryanum (Turp.) Meneghini				+					
Quadrigula sp.									
Scenedesmus quadricauda (Turp.) de Brébisson									
Scenedesmus sp.	8	27	+	9	36	59	234	96	192
Schroederia sp.									
Selenastrum westii Smith									
Staurastrum sp.	+								
Tetraedron caudatum (Corda) Hansgirg									
T. minimum (A. Braun) Hansgirg									
Tetraedron sp.	5				19		4	4	5
Total greens	388	330	269	246	151	118	656	677	921
% of Grand Total	8	6	9	6	3	2	11	10	12
FLAGELLATES									
*Unidentified flagellates	91	62	48	19		+	187	265	150
Ceratium sp.									
Cryptomonas ovata Ehrenberg									
Cryptomonas sp.	151	143	96	209	80	151	156	243	208
Dinobryon sertularia Ehrenberg	182	166	12	517	635	474	282	339	400
Peridinium sp.	5	10	+	+	9		13		
Rhodomonas sp.	198	156	178	320	386	311	460	386	386
Trachelomonas sp.							+		
Total flagellates	640	537	334	1,065	1,110	936	1,098	1,233	1,144
% of Grand Total	12	11	11	25	20	19	19	21	14
BACILLARIOPHYTA (DIATOMS)									
*Pennate diatoms	13	+	13	23	9	10	26	48	29
Cyclotella sp.	+								
Fragilaria crotonensis Kitton									
Synedra sp.				9	+	+			
Tabellaria sp.								+	
Total diatoms	13		13	32	9	10	26	48	29
% of Grand Total	<1		<1	1	<1	<1	<1	<1	<1
GRAND TOTAL	4,914	5,027	3,147	4,175	5,462	4,791	5,842	6,333	7,576

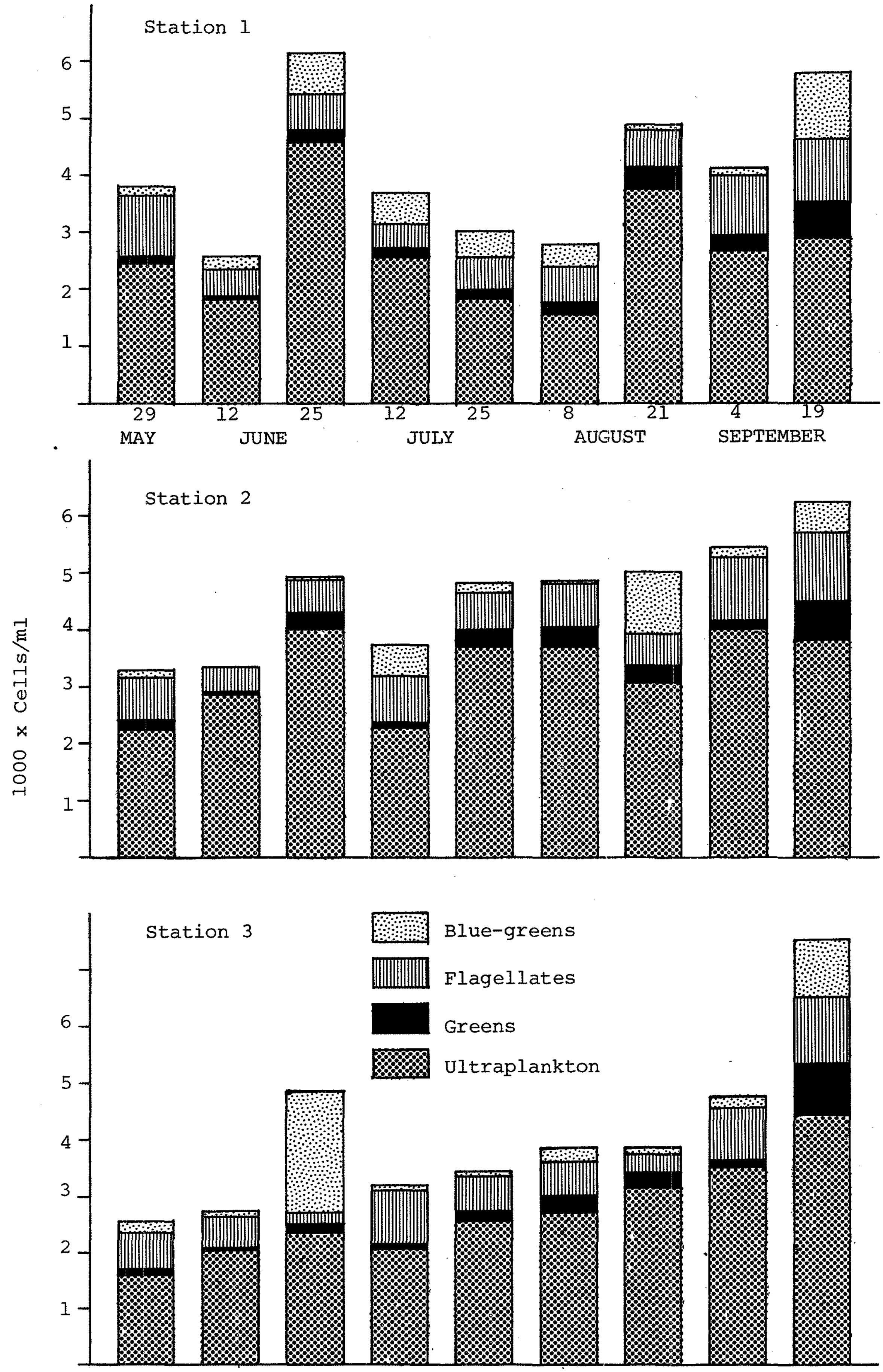

Figure 3. Phytoplankton numbers and composition, Ruth Lake.

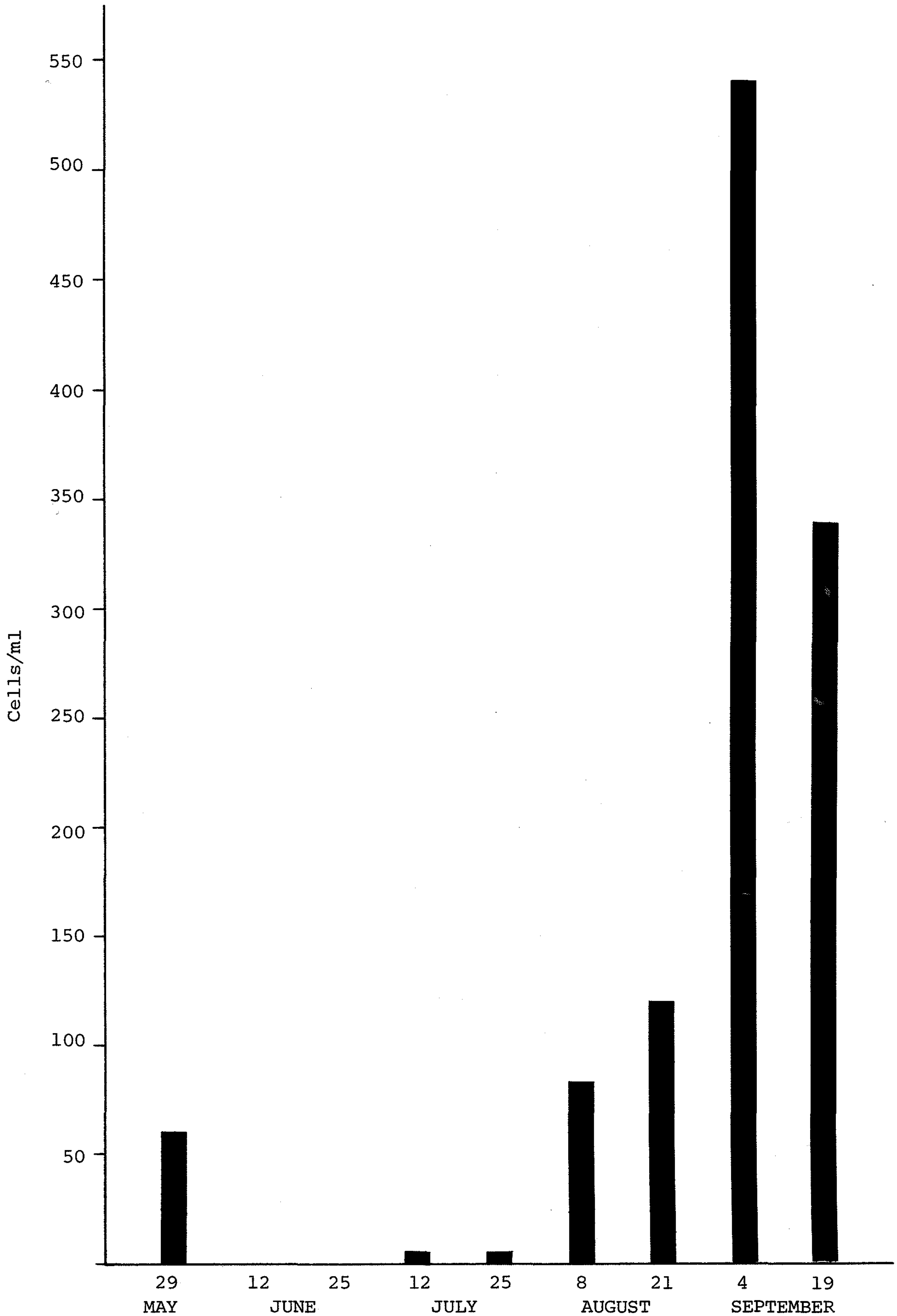

Figure 4. *Dinobryon sertularia* numbers in Ruth Lake.

Table 7: Monthly mean cell numbers (cell/ml) of important Ruth Lake phytoplankton. Means of 3 stations for each month. Two dates sampled in each month except only one date in May.

	May	June	July	August	September
*Filamentous blue-greens	158	210	222	163	433
Ankistrodesmus convolutus	17	20	55	82	52
Oocystis sp.	12	3	5	38	27
Scenedesmus sp.	29	21	14	16	104
**Coccoid green algae	26	21	56	118	215
Cryptomonas sp.	19	40	151	111	175
Rhodomonas sp.	720	388	382	185	375
Ultraplankton	2,106	2,957	2,503	2,997	3,570

*Including *Lyngbya limnetica*, *Oscillatoria* sp. and unidentified forms.

**Not identified further.

Table 8: Aquatic macrophytes collected in Ruth Lake, summer, 1974, with notes on their occurrence

Species*		Occurrence**	
	Submerged Species		
(Ch)	*Chara* sp.	A;	widespread, often dominant
(F)	*Fontinalis* sp.	C-A;	widespread, sometimes dominant
(Hv)	*Hippuris vulgaris* L.	O;	scattered, near shore
(Mx)	*Myriophyllum exalbescens* Fernald.	C-A;	widespread, to about 1.5 m depth
(Nf)	*Najas flexilis* (Willd.) Rostk. & Schmidt.	C;	more abundant in NW third of lake
(Pfo)	*Potamogeton foliosus* Raf. form a	O;	found near shore
(Pfo-a)	*P. foliosus* Raf. form b	R;	only found at one location (H2)
(Pfr)	*P. friesii* Rupr.	R;	only found at J3
(Ppc)	*P. pectinatus* L.	O;	near shore, to 0.5 m depth
(Ppr)	*P. praelongus* Wulf.	C;	in mid-lake, usually at depths greater than 1.5 m with dense *Nuphar* and *P. zosteriformis*
(Pps)	*P. pusillus* L.	O;	near shore
(Pr)	*P. richardsonii* (Benn.) Rydb.	C-A;	widespread, to 2.0 m depth
(Pv)	*P. vaginatus* Turcz.	O;	scattered, between 0.5 and 2.0 m depth
(Pz)	*P. zosteriformis* Fernald.	C;	widespread, at all depths
(Uv)	*Utricularia vulgaris* L.	C;	widespread, to 1.5 m depth

Table 8: Concluded.

	Species*	Occurrence**
	Floating-Leafed (F) and Emergent (E) Species	
(Cl)	*Carex laeviconica* Dewey	(E)R; only found at section S1
(Ef)	*Equisetum fluviatile* L.	(E)C; dominant in some sections
(Nv)	*Nuphar variegatum* Engelm.	(F)A; dominates middle of lake
(Pn)	*Potomogeton natans* L.	(F)O; scattered in patches near shore
(Scu)	*Sagittaria cuneata* Sheldon.	(E)C; widespread, to about 20 cm depth - forms rosettes
(Sa)	*Carex* sp.	(E)A; forms extensive stands at NW and SE ends of lake
(Scs)	*S. caespitosus* L.	(E)C; widespread, to about 0.5 m depth
(Sv)	*S. validus* Vahl.	(E)C; forms stands around shore and in mid-lake
(Sp)	*Sparganium* sp.	(E)R; noticed in S5 and S6
(Tl)	*Typha latifolia* L.	(E)C; widespread around the lakeshore.

*With abbreviation used in Table 9.
**A-abundant, C-common, O-occasional, R-rare).

Table 9: Percentage cover of the substrate by submerged macrophytes, and abundance of *Nuphar variegatum*, at sampling points. Sampling points are indicated by transect (A-K) and position on the transect (S = starting point on shore, E = end point on opposite shore). *Nuphar* abundance is rated as Abundant, Common, Occasional, and Rare. Where percentage macrophyte cover does not sum to 100%, substrate is correspondingly lacking vegetation. Macrophyte symbols are from Table 8 . Species not assigned a percentage occurred incidentally (<5%) in sample.

Sample Point	Macrophyte Cover	*Nuphar*	Sample Point	Macrophyte Cover	*Nuphar*
A-S	F70%, Uv10%, Pz10%, +Mx, Ch	R	B-S	F40%, +Pr, Pfo, Mx	R
1	Ch50%, Pr40%, +Uv, Ppc, Pz	O	1	Mx40%, +Pr	C
2	Ch90%, Pz10%	R	2	Pr70%, +Pz, Uv	C
E	Pr20%, Pfo20%, Mx20%, F20%	R	3		A
			4	Ch40%, Uv20%, Ppc20%, +Pr, F	O
C-S	Mx50%, +Pr, Pz	R	E	F90%, +Mx, Uv, Pr	O
1		A			
2		A	D-S	Ch90%, +Pv, Mx	O
3	F20%	C	1		C
4	Pr20%, Mx20%	O	2		A
E	Mx, F	R	3	+Ppr	A
			4		A
E-S	Pps50%	O	5		C
1		A	6	Ch70%, Pr20%, +Uv	O
2	Ch90%, Ppr10%	C	E	Ch70%, Pps20%, +Pr	R
3		A			
4	Pz	C	G-S	Hv, F, +Pn	R
5		C	1	Ch90%, +Pv	R
E		C	2	Pr, Pz, Ch	R
			3	Pz, Mx	R
F-S	Mx40%, F40%, +Pps	C	4	Ch, Uv, Mx, Pz, Pr	R
1		O	5	Ch, Pr, Nf, Pz	R
2	Ppr, Pz, F, Nf	O	6	Pz, Pr	R
3	Pz, Pv, F	O	E	Mx20%	O
4	Ch80%, +Pz, Pv, Uv	O			
5	Ch100%	R			
6	Ch100%	R			
7	Ch90%, +Pv	O			
E	Mx30%, Pr20%	C			

Table 9: . Continued.

Sample Point	Macrophyte Cover	*Nuphar*	Sample Point	Macrophyte Cover	*Nuphar*
H-S	Pfo20%, Mx20%	R	I-S	Mx50%	R
1	Pfo10%, Mx10%, F10%, Nf10%	R	1	Ch100%, +Pr	R
2	Nf20%, Ch20%, +Pz, Pfo-a	O	2	Ch100%, +Pz	R
3		A	3	Ch90%, +Pz	C
4	Ppr, Pz, Nf	C	4		A
5	Ch90%, Ppr10%	R	5	Pz, Nf	C
6	Ch100%	R	6	Pz	O
E	F, Mx	R	E	Pr10%, +Pz	O
J-S	F50%, +Uv, Mx, Pz, Pfo	O	K-S	Pfo, Pr, F, Mx	R
1		A	1	Ch100%, +Pz	R
2		C	2	Nf20%, +Pz, Pv	R
3	Nf50%, +Pz, Pv, Uv	O	3	Pz20%, Ch20%	R
4	Ch90%, +Pz	O	4	Ch100%, +Pz	R
5	Ch90%, Pz10%	O	5	Nf, Pz, Mx, Pr	R
6	Ch90%, Pz10%	O	6	Pfo, Mx	O
7	Ch90%, +Pr, Pz, Pv	O	E	Mx10%	R
E	F80%, +Pr	R			

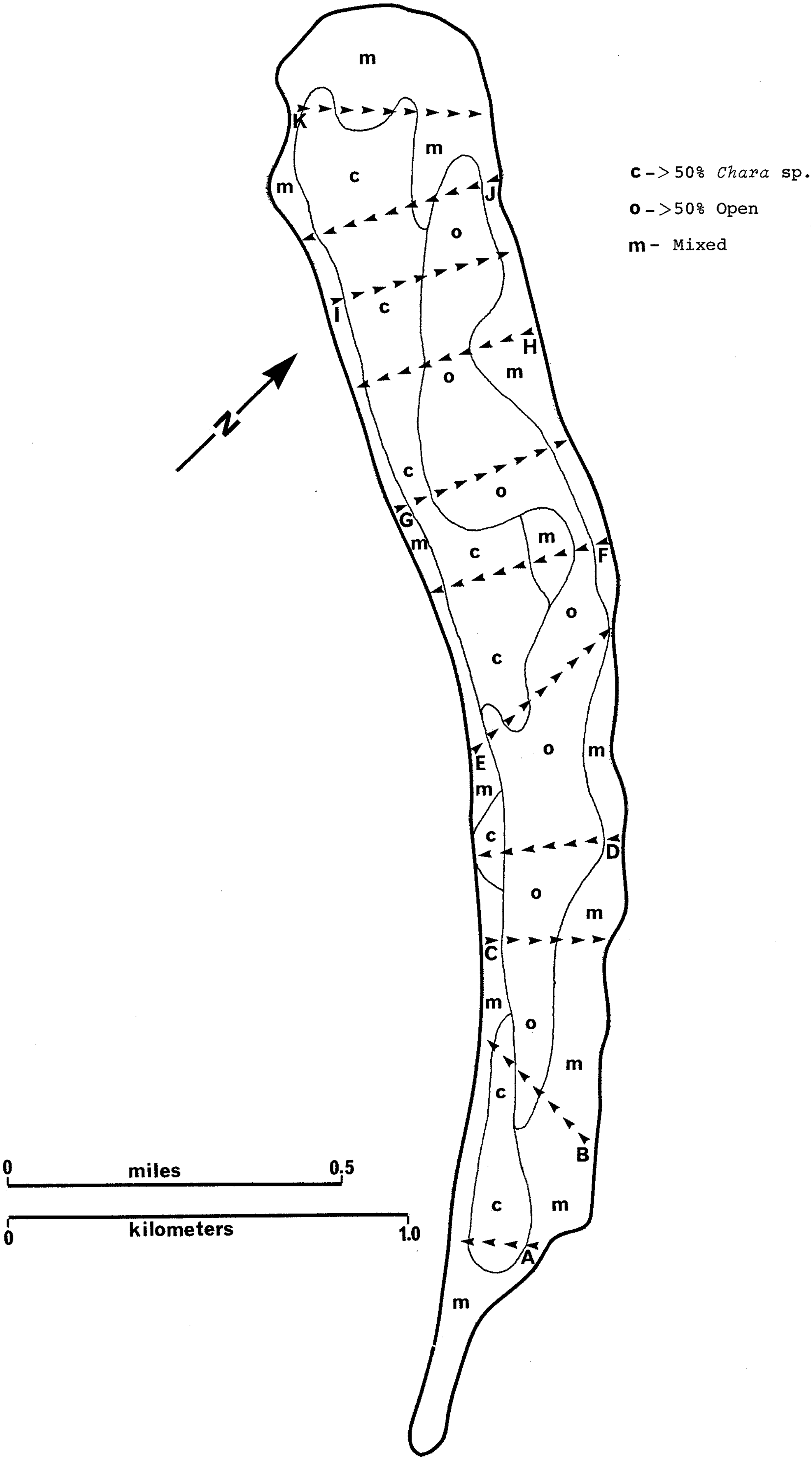

Figure 5. Distribution of submergent macrophytes in Ruth Lake, with sampling points and transects (A-K). Arrows indicate direction of travel on transects.

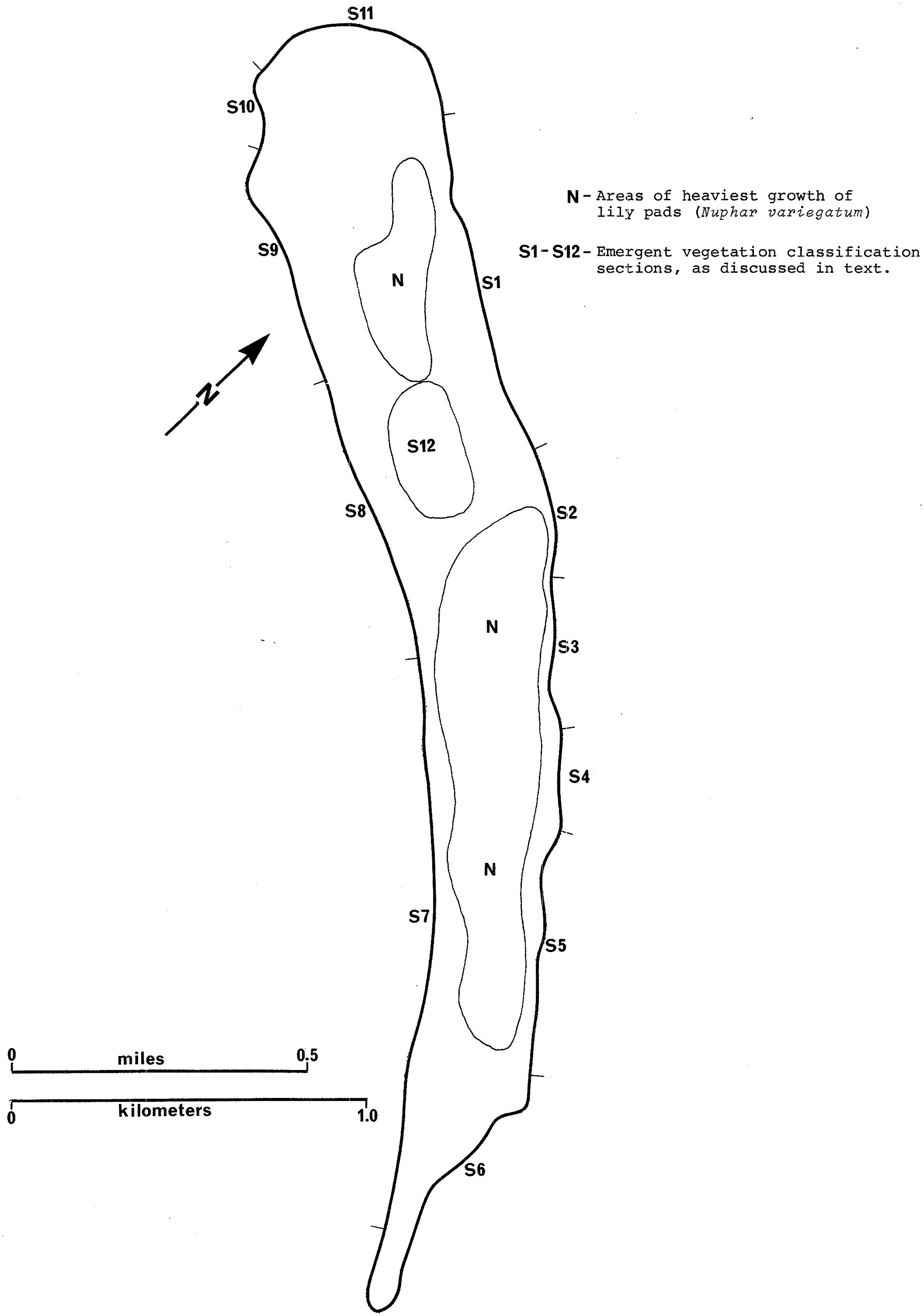

Figure 6. Areas of dense *Nuphar* growth, and sections of emergent plants discussed in text.

3.9 Zooplankton

The corrected depths, volume of individual samples, and combined sample volumes for Stations 1, 2, and 3 are given in Table 10. Results are expressed as organisms per m^3. Station 1 was the shallowest site, Station 2 the deepest, and Station 3 intermediate. These depths are reflected in the aquatic plant communities: *Chara* sp. existed as benthic mats at Station 1 and 3, but was missing at Station 2. In short, the shallower the site the larger the aquatic plant community. Pennak (1973) has evidence that certain aquatic macrophytes repel limnetic species of *Daphnia*. Such a trend is only illustrated intermittently in the results listed in Table 10, possibly as a result of there being insufficient sampling stations, or, for the more general reason that Ruth Lake, being shallow, behaves as a littoral zone in which the zooplankton does not respond systematically to the presence of macrophytes.

Adult species of zooplankton identified on three dates during the study are given in Table 11. The species diversity in Ruth Lake is relatively low: only six species of Cladocera, three species of Cyclopoid copepods and one species of Calanoid copepod were found. It is quite likely that a more intensive sampling program carried out over a twelve month period, and especially among the aquatic macrophytes, would capture adult organisms of different species. However, the discovery of additional species would not alter the conclusions arrived at here since, given the level of sampling thoroughness used in 1974, those organisms not located are evidently of minor importance.

<u>Cyclopoida</u>

Generally the major species of Cyclopoida are littoral while the Calanoida are more planktonic (Pennak, 1953). This difference is not clear from the samples of May 29, June 12, and June 25, but manifests itself in the July 12 to September 19 samples when station 2, the deepest site, provided the smallest numbers of cyclopoid copepods (Table 12). A factor that complicates the differentiation is that the dominant species of cyclopoid copepod, *Cyclops biscupidatus thomasi*, is generally considered to be one of the few planktonic species of this group, but can apparently exist equally well in the littoral zone. *Mesocyclops edax*, generally considered a planktonic form and *Macrocyclops ater* a benthic littoral species (Hutchinson, 1967) were less common in the plankton, being found only at Stations 1 and 3, the shallower sites (Table 11).

The high numbers of cylopoid copepods collected on May 29 and June 6 at all stations, and at station 3 on June 25 (Table 12) were probably due to the presence of *Cyclops bicuspidatus thomasi* which shortly thereafter went into summer diapause (resting stage). Hutchinson (1967) mentions a possible seasonal alternation between *Cyclops bicuspidatus thomasi* and *Mesocyclops edax*, with the former species entering diapause in the sediments during the summer and latter species leaving the sediments early in the summer to become common in the plankton. This course seems to have been followed in Ruth Lake, where *Mesocyclops edax* and *Macrocyclops ater* were probably dominant after June 25, but were considerably lower in numbers as compared with earlier counts of *Cyclops bicuspidatus thomasi*. Definite species identifications could not be made in later summer because adults are necessary for this purpose and only immature stages were present.

Calanoid Copepods

Calanoid copepods are generally considered to be planktonic organisms (Hutchinson, 1967). Only one species is found in Ruth Lake, *Diaptomus oregonensis*, reflecting the littoral nature of the lake habitat. As indicated in Table 10, the species is not found at any one sampling site in consistantly greater numbers than at others.

Unfortunately the data are insufficient to tell how many generations are produced each year, but comparison with other lakes gives helpful evidence towards the solution of this question. Lai and Carter (1970) have shown the population in Sunfish Lake, Ontario, to have three generations per year (spring, summer and fall), with the largest numbers of organisms occurring in May of the years studied. These authors also mention that the females of the last generation carry eggs through the winter to give rise to the spring pulse. On the other hand, in their study of Lake Erie, Watson and Carpenter (1974) found the highest number of adult *Diaptomus oregonensis* during late July - early August with juvenile *Diaptomus* of all species occurring in maximum numbers on the same date. However, it is not known how many generations per year occur in Lake Erie. The situation in Ruth Lake resembles that of Sunfish Lake since higher numbers of immature *Diaptomus oregonensis* (copepodite stage) occurred on May 29 and June 12 (Table 12). Mature individuals did not appear until some time just prior to July 25 and remained until at least September 19 (Table 12). Because our sampling season was limited, it is not known if the maximum numbers of adult *Diaptomus oregonensis* occur in November in Ruth Lake as is reported for Sunfish Lake and as is probably the case for Lake Wabamun. In the latter lake, large numbers of adults are found in November or December carrying eggs to be hatched in the following spring (Gallup, personal observation). Table 12 does reveal a general increase in numbers of *Diaptomus oregonensis* from August 21 suggesting a fresh pulse of reproduction in the summer.

The population of *Diaptomus oregonensis* may reasonably be expected to be governed by one of the following mechanisms:

1. The population is trivoltine (i.e., shows three reproduction periods per year) allowing the species to be the main contributor to zooplankton secondary production in Ruth Lake.

2. Periods of reproduction are limited to a maximum of two per year as a result of harsh environmental conditions.

3. Resting eggs are produced in the fall and require low winter temperatures as a preliminary to the initiation of hatching in the spring (Cooley, 1971).

Daphnia

The Daphnia type as defined in this report (*Daphnia pulicaria* and *Diaphanosoma brachyurum*) did not show any preference for sampling station sites until July 25 (Table 12). This can be explained by considering the ecology of the two species.

Daphnia pulicaria is generally a lake-dwelling species, but is also found in pond habitats. Relatively little is known about the ecology of the species in Canada, the organism having only recently been reported from Manitoba and Ontario (Brandlova *et al.*, 1972). The present report is the first published record of its occurence in Alberta. In Europe, *Daphnia pulicaria* is confined to two different kinds of habitat- glacial lakes above the limit of the dwarf pine, and lowland carp ponds (Brandlova *Op cit*). While the lowland type prefers a temperature of around 20^{o}C the high mountain type is unable to reproduce above this temperature. Apparently the population of *Daphnia pulicaria* found in Ruth Lake is of the high mountain type since it is found only in the coldest waters.

Diaphanosoma brachyurum on the other hand is a more benthic littoral species, preferring warmer water. The large numbers of Daphnids recorded in Ruth Lake for May 29 when the water temperature was approximately 11^{o}C were due solely to *Daphnia pulicaria* (Table 11). There was a complete species shift from *Daphnia pulicaria* to *Diaphanosoma brachyurum* some time before July 25 as water temperatures rose to 21^{o}C (Table 4, p. 19). Adult *Daphnia pulicaria* did not appear again during the study (up to September, 1974) even though the water temperature had dropped to approximately 13^{o}C by this date. Evidentally drastic conditions, such as freezing and thawing or desiccation, as would occur in a harsh northern winter, are a necessary stage in egg development and prepare the eggs for hatching in the following spring. *Diaphanosoma brachyurum* were more plentiful at stations 1 and 3 which were shallow and had more aquatic vegetation, than at the deeper station 2 (Tables 11 and 12).

Bosmina

The Bosmina group, as defined for Ruth Lake, encompasses *Bosmina logirostris, Chydorus sphaericus* (planktonic species), and *Alona guttata* and *Graptoleberis testudinaria* (littoral species). *Bosmina longirostris* appeared in maximum numbers in the spring (May 29) when the water was cold, and had completely disappeared by June 12 (Tables 11 and 12). Hutchinson (1967) reports that the general reproductive pattern for *Bosmina longirostris* is for a large spring maximum sometimes followed by a smaller peak in the fall. The spring maximum observed at Ruth Lake agrees with this behavior for the first part of the year but in the absence of fall data the appearance of a subsequent peak could not be confirmed. The largest concentration (on May 29) was found at the deepest station (No. 2). Contrary to the predictions of several studies in Hutchinson (1967), but in agreement with the general findings of Whiteside (1974), *Chydorus sphaericus* showed the same seasonal occurrence as *Bosmina longirostris* (Table 11).

The littoral species of the Bosmina group (*Alona guttata* and *Graptoleberis testudinaria)* only occurred as adults in late summer and early fall (Table 11). The presence of adult *Alona guttata* at this time of year in Ruth Lake corresponds to Anderson's observations (1972) of the same species at an alpine lake in Banff National Park. *G. testudinaria* is a more benthic species than *A. guttata*, generally being found crawling among aquatic vegetation, and probably collected in plankton samples by chance. This tends to support the theory that Ruth Lake has harsh environmental conditions more closely approximating lakes of the alpine region with limited species diversity and the presence of cold-water-adapted organisms.

Conchostraca

The detection of the conchostraca, *Lynceus brachyurus*, was surprising. Because, according to generally acknowledged theory, conchostracan eggs must pass through a desiccation-freezing cycle before hatching, these organisms are usually associated with temporary ponds (Klots, 1966). The largest numbers of *Lynceus brachyurus* were recorded on May 29 at station 1. They had declined considerably by June 12 (Table 12). Conchostracans continued to exist in the plankton in low numbers until they completely disappeared by August 21.

Relative Abundance of Zooplankton in the 1974 Sampling Season

Variation of the major groups of zooplankton with respect to time is given in Figure 7. The increase in calanoid copepods in August is possibly the result of a period of summer reproduction. The apparent disappearance of Bosmina plankters in June and again in July/August is due to the intermittent absence of adults of all species.

Comparison With Other Lakes

As a rule, studies of other lakes in Alberta show a greater number of cladoceran species than are found in Ruth Lake (Gallup, personal observation). Also, a few more species of cyclopoid copepods together with possibly two species of calanoid copepods are usually found. For instance, Nursall and Gallup (1971) report 13 species of Cladocera in Lake Wabumun compared with six for Ruth Lake, however, they found the same number of cyclopoid (three) and calanoid copepods (one). Interestingly, *Diaptomus oregonensis*, the only calanoid copepod found in Ruth Lake, is also the only one found in Lake Wabamun. Also, the cyclopoid *Cyclops bicuspidatus thomasi* is dominant in both lakes. From further afield, Watson and Carpenter (1974) report a greater species diversity for Lake Erie while lakes in the National Parks of the Canadian Rockies generally show a more limited range of species, varying however in proportion to the complexity of the aquatic habitat (Anderson, 1974).

The maximum numbers of cyclopoid copepods in Ruth Lake especially *Cyclops biscuspidatus thomasi* are comparable to those in Lake Erie except that the Lake Erie maximum occurs in July rather than May (Watson and Carpenter, 1974). The population maximum of the calanoid copepods in Ruth Lake is also comparable to that found in Lake Erie but whereas only one population peak is noted for Lake Erie (late July), there are two maxima in Ruth Lake (May and August). Data presented by Menhinick and Jensen (1974) for a lake in North Carolina show a lower maximum for the cyclopoid group than in Ruth Lake, but the North Carolina lake maintained a larger number over time. Values given by Lai and Carter (1970) for *Diaptomus oregonensis* in Sunfish Lake, Ontario, while not directly comparable with Ruth Lake because they are reported as number/m^2, give an indication that the maxima are comparable for the two lakes. The numbers of the *Daphnia* group in Ruth Lake are considerably lower than all *Daphnia* spp. found in Lake Erie (Watson and Carpenter, 1974). This can be attributed to species differences and the littoral nature of Ruth Lake. The numbers of *Daphnia pulicaria* in Ruth Lake are much lower than those for *Daphnia galeata mendotae* in Lake Michigan (Hall, 1964). For both *Daphnia* and *Diaphanosoma*, maxima and overall numbers collected throughout the sampling period were higher in Ruth Lake than in Lake Wabamun.

Numbers of organisms in the *Bosmina* group are extremely low when compared with many other studies (Hutchinson, 1967). Mean count per cubic meter of *Bosmina longirostris* in Lake Wabamun is approximately 4000/m^3 over the winter period (with the maximum expected in the spring), while Ruth Lake as late as May 29 had a maximum of only 491/m^3 (Table 13). Watson and Carpenter (1974) report that the maximum for Lake Erie (in June) at 34523/m^3.

It is not easy to explain the paucity of species in Ruth Lake since this lake is large enough to support more species and, although not supporting the complex community of aquatic plants reported by Nursall and Gallup (1971) for Lake Wabamun, has a well developed plant community by the standards of some mountain lakes. Possible explanations are:

1. Fairly harsh environmental conditions.
2. Low lake levels during the dry periods (extending over several years) that allow the water to freeze down to, or near to, the substrate in a large portion of the lake.
3. The small mean depth of the lake that tends to exclude truly planktonic species since light penetration allows growth of aquatic macrophytes in most regions of the lake, with a repellant effect for some limnetic species as shown by Pennak (1973).

Generally, a greater number of adult species occurred in Ruth Lake in late spring (May 29) than during the summer or early fall.

The Importance of *Diaptomus oregonensis* to the Ecology of Ruth Lake

From June 25 to the end of the study contributions to the biomass, in descending order of importance, were from Calanoida, Daphnia types, Cyclopoid and Bosmina types. The biomass contribution of the Calanoida ranges from 2 times that of all of the other groups combined on June 25, to 74 times on September 19. The mean contribution of the Calanoida from June 25 to September 19 was 22 times that of all other groups: only during late spring and early summer did the other groups contribute markedly to the total biomass. When the mean biomass is analyzed by group for the whole sampling period it becomes plain that a single cyclopoid copepod contributes much less weight than the individual organisms in any of the other groups. This fact shows the overal importance of one species, *Diaptomus oregonensis*, in the total ecology of Ruth Lake since these organisms, as well as being large individuals, are collectively one of the major contributors to the biomass.

Biomass as a Measure of Eutrophic Status

The variation of biomass throughout the sampling season is depicted in Figure 8. Change of group biomass with time incorporates two quantities - number of organisms, and the development of individuals. For instance, while the numbers of Calanoida remained constant from May 29 to June 12 (Figure 7) the biomass of this species increased sharply due to the growth of individuals (Figure 8). An increase in both numbers and growth occurred between July 12 and July 25 in this group, while the increase in biomass from August 8 to August 21 was mainly due to an increase in numbers. The progress of the Daphnia group was as follows:

Dates	Numbers of Organisms	Effect on The Biomass	Explanation
May 29-June 12	Reduced	Increased	Development of individual *Daphnia pulicaria*
July 25-August 8	Increased	Increased	Increased numbers of *Diaphanosoma brachyrum*
August 8-August 21	Steady	Increased	Development of individual *Diaphanosoma brachyurum*

Little can be said about the other two groups due to the undifferentiated mixture of species present in the samples, and insufficient population data.

Detailed quantitative comparisons of this biomass data with those presented by other authors are not possible because of the varied systems of reporting results (weight/m^3; weight/m^2 of lake surface; wet weight; and dry weight), but some comparisons may be made. Total numbers of all zooplankton groups in Ruth Lake declined sharply between May 29 and July 12 and then rose slightly by August 21 gradually declining again until the end of the study (Figure 11). Values from 2739 to 103566 organisms/m^3 (excluding Conchostrata, Table 11) were recorded from Ruth Lake. By comparison, total numbers of crustacean zooplankton in the eutrophic Lake Erie ranged from approximately 12500 to 204000 organisms in oligotrophic Lake Huron from 2300 to 20500 (Watson and Carpenter, 1974; Patalas, 1972). When crustacean zooplankton numbers are used as a measure of trophic status, Ruth Lake is seen to be mesotrophic to moderately eutrophic. This classification is supported by other characteristics of the lake, namely nutrient levels, and the nature and extent of the aquatic macrophyte community.

Total biomass, as given by Patalas (1970) for two lakes in Poland, shows the differences between a highly eutrophic lake and one that is in the mid-eutrophic range. The values obtained for both the lakes, while not directly comparable, appear to be higher than the mean value for Ruth Lake (Table 13). The mean value for Ruth Lake is approximately one half that of the value given by Patalas for his mid-eutrophic Polish lake, but is only about one seventh the value for his highly eutrophic lake. This again suggests that Ruth Lake should be classified as mesotrophic to moderately eutrophic. The low phytoplankton count in Ruth Lake, which appears to contradict this rating may be a result of: (a) the inhibiting effect of the aquatic macrophyte, and (b) cropping by zooplankton (Burns, 1969).

3.10 Benthic Macroinvertebrates

Results of Ekman dredge sampling are plotted in Figures 10 and 11, and all the counts for the identified taxa are placed in Table 14.

Mayflies are represented in the benthos by one genus, *Caenis*, which was fairly common. During July and early August it was absent from the samples, possibly because this was its time of emergence. It reappeared in later samples.

Caddis fly larvae (Trichoptera) occurred in small numbers in the Ekman samples. Five families were found, and as with the mayflies, no larvae were collected during July and early August. The low overall sample sizes of trichopterans make it difficult to determine if this absence was a result of emergence patterns.

Dragonfly and damselfly nymphs (Odonata) were represented by several genera (13 and 2 genera, respectively) all low in numbers. *Libellula* was the most common genus. Seasonal periodicity was not evident from the few individuals collected.

Chironomids accounted for most of the Diptera and dominated the bethos in numbers (Figure 11). Eighteen genera of chironomids were identified with *Chironomus* spp. being by far the most abundant, while *Polypedilum* sp., *Procladius* sp., and *Tanytarsus* sp. were next in numerical importance. Numbers of *Polypedilum* sp. collected in July were low, but none of the other 3 mentioned genera showed notable seasonal fluctuations. This may be a result of there being more than one species present for each of these genera such that emergence patterns were obscured.

Hyallela azteca was common in the benthic samples although *Gammarus lacustris*, another geographically widespread amphipod crustacean, was not abundant at the sampled stations. Conchostracans (clam shrimps) were frequently collected in the benthos but were also common components of the zooplankton and are discussed under that heading.

Leeches occurred occassionally in the Ekman samples. They were often seem swimming at variable depths in the water column at all sampling stations and numerous other locations throughout the lake, as were damselfly nymphs and amphipods. This illustrates the littoral/pond nature of the lake.

Oligochaetes were quite low in numbers throughout the samples. Gastropods (snails) and pelecypods (clams) were common components of the benthos at the sampled stations. Nine taxa belonging to these two groups were collected. *Gyraulus* sp. and species of *Valvata* accounted for most of the gastropods while *Pisidium* and *Sphaerim* were the two genera of clams found in Ekman samples.

Two different forms of fresh water sponge were observed in near shore areas although identification was not possible because collected samples did not contain the gemmules necessary for this purpose.

Except in the case of a few samples, total numbers of benthic macroinvertebrates did not vary much during the course of the summer (Figure 10) although lower numbers of organisms were usually taken at station 2 than at the other two sampling stations. Also, snails, caddis fly larvae, mayfly nymphs, and Odonata were all rare in occurrence at station 2. The lack of aquatic vegetation on the bottom sediment at station 2 and the profuse amounts of such vegetation at the other two stations probably accounts for this difference in the benthic fauna.

Figure 11 illustrates the composition (by numbers) of the benthos at the three stations during the summer. The organisms are placed into five groups for this presentation: *Chironomus* spp., other chironomids, Crustaceans (Amphipoda and Conchostraca), Molluscs (Gastropoda and Pelecypoda), and others (the remainder of the benthos, i.e., mayflies, Odonata, caddis flies, etc.). The importance of chironomids and in particular members of the genus *Chironomus*, is easily seen. Ruttner (1963) noted that the genus *Tanytarsus* often dominates the benthos in oligotrophic lakes while *Chironomus* is found to be dominant in eutrophic lakes where oxygen deficiencies occur. Ruth Lake is largely littoral in nature and is well oxygenated during the summer. A winter oxygen deficit does develop however, and this may account for the dominance of *Chironomus*. *Tanytarsus* may be able to maintain its position as a sub-dominant as a result of a higher oxygen concentration in the summer.

3.11 Fish

Table 15 contains the results of seine hauls taken in Ruth Lake. Only two species of fish, fathead minnows and brook sticklebacks were found. Both species are common, and are known to be reproducing in the lake, since young-of-the-year and gravid females of both species were collected. These two species are known to be able to tolerate low oxygen levels (Paetz and Nelson, 1970) and in fact individuals of both species were observed in the lake in March at the time of low oxygen. No other species appear to live in the lake, probably because of its low oxygen, winter-kill condition. No fish were caught in any of the gill net sets.

RUTH LAKE

DATA FOR HETEROTROPHES

Table 10. Volume of water sampled by Wisconsin plankton net per station and date.

Date	Sta.	Depth (m) (Corrected*)	Volume (liters) (3 hauls)	Total Volume (liters) (3 stations)
29/5/74	1	1.25	42	
	2	2.25	75	168
	3	1.50	51	
12/6/74	1	1.25	42	
	2	2.25	75	174
	3	1.65	57	
25/6/74	1	1.30	45	
	2	2.30	78	174
	3	1.50	51	
12/7/74	1	1.25	42	
	2	2.00	69	162
	3	1.50	51	
25/7/74	1	1.45	48	
	2	2.13	72	162
	3	1.27	42	
8/8/74	1	1.00	33	
	2	2.10	72	147
	3	1.20	42	
21/8/74	1	1.10	36	
	2	2.20	75	159
	3	1.40	48	
4/9/74	1	1.20	42	
	2	2.10	72	156
	3	1.25	42	
19/9/74	1	1.10	36	
	2	2.10	72	162
	3	1.60	54	

*Corrected by 0.4 m for height of plankton net above substrate.

Table 11. Adult species of zooplankton identified on selected dates by station.

Species	29/5/74 Station 1	29/5/74 Station 2	29/5/74 Station 3	25/7/74 Station 1	25/7/74 Station 2	25/7/74 Station 3	19/9/74 Station 1	19/9/74 Station 2	19/9/74 Station 3
Cladocera									
Daphnia pulicaria	x	x	x						
Diaphanosoma brachyurum					x	x	x	x	x
Bosmina longirostris	x								
Chydorus sphaericus	x								
Graptoleberis testudinaria									x
Alona guttata							x	x	
Copepoda									
Cyclopoida									
Mesocyclops edax	x		x						
Macrocyclops ater			x						
Cyclops bicuspidatus thomasi	x	x	x						
Calanoida									
Diaptomus oregonensis				x	x	x	x	x	x
Conchostraca									
Lynceus brachyurus	x	x	x		x				

x - present.

Table 12. Zooplankton results.

Group	Station 1 #/m³	Station 1 mg/m³	Station 2 #/m³	Station 2 mg/m³	Station 3 #/m³	Station 3 mg/m³
			29/5/74			
Cyclopoid	155,119	531	72,933	241	27,647	171
Calanoid	14,642	192	12,533	206	10,588	122
Conchostraca	7,619	NC	667	NC	588	NC
Daphnia type	5,952	95	3,733	113	6,078	218
Bosmina type	476	6	800	23	196	5
Total[1]	183,808		90,666		45,097	
Total[2]	176,189	824	89,999	583	44,509	516
Nauplii					78,431	
			12/6/74			
Cyclopoid	13,905	29	23,360	119	35,614	267
Calanoid	18,976	431	7,907	203	11,754	193
Conchostraca	190	NC	107	NC	175	NC
Daphnia type	4,000	223	3,520	652	1,228	64
Bosmina type	-	-	-	-	-	-
Total[1]	37,071		34,894		48,771	
Total[2]	36,881	683	34,787	974	48,596	524
			25/6/74			
Cyclopoid	467	1	718	2	1,039	4
Calanoid	2,178	49	4,513	101	3,843	80
Conchostraca	-	-	26	NC	196	NC
Daphnia type	3,333	70	3,064	17	3,627	33
Bosmina type	-	-	-	-	59	2
Total[1]	5,978		8,321		8,764	
Total[2]		120	8,295	120	8,568	119
			12/7/74			
Cyclopoid	667	3	174	0.5	333	1
Calanoid	1,238	18	1,159	32	2,588	65
Conchostraca	381	NC	14	NC	294	NC
Daphnia type	762	7	652	6	549	6
Bosmina type	95	4	-	-	-	-
Total[1]	3,143		1,999		3,764	
Total[2]	2,762	32	1,985	39	3,470	72

Table 12 continued.

Group	Station 1 #/m³	Station 1 mg/m³	Station 2 #/m³	Station 2 mg/m³	Station 3 #/m³	Station 3 mg/m³
			25/7/74			
Cyclopoid	146	0.3	69	0.2	71	0.2
Calanoid	813	23	4,153	161	3,786	138
Conchostraca	-	-	194	NC	-	-
Daphnia type	417	3	153	3	214	3
Bosmina type	-	-	-	-	-	-
Total[1]	1,376		4,569		4,071	
Total[2]	1,376	26	4,375	164	4,071	141
			8/8/74			
Cyclopoid	545	1	56	0.1	95	0.2
Calanoid	3,697	77	4,403	82	1,881	32
Conchostraca	-	-	83	NC	-	-
Daphnia type	1,939	19	306	5	452	6
Bosmina type	-	-	-	-	-	-
Total[1]	6,181		4,848		2,428	
Total[2]	6,181	97	4,765	87	2,428	38
			21/8/74			
Cyclopoid	556	2	-	-	167	0.5
Calanoid	8,472	245	3,800	99	6,375	172
Conchostraca	-	-	-	-	-	-
Daphnia type	556	14	133	9	1,083	48
Bosmina type	-	-	67	4	-	-
Total[1]	9,584		4,000		7,625	
Total[2]	9,584	261	4,000	112	7,625	221
			4/9/74			
Cyclopoid	-	-	-	-	95	0.6
Calanoid	1,786	43	2,917	52	12,476	313
Conchostraca	-	-	-	-	-	-
Daphnia type	-	-	139	1	381	12
Bosmina type	238	1	-	-	95	2
Total[1]	2,024		3,056		13,047	
Total[2]	2,024	44	3,056	53	13,047	328

Table 12 concluded.

Group	Station 1 #/m^3	Station 1 mg/m^3	Station 2 #/m^3	Station 2 mg/m^3	Station 3 #/m^3	Station 3 mg/m^3
			19/9/74			
Cyclopoid	-	-	69	0.1	148	
Calanoid	3,667	102	7,153	180	6,148	160
Conchostraca	-	-	-	-	-	-
Daphnia type	-	-	69	3	111	2
Bosmina type	83	0.2	69	0.7	-	-
Total[1]	3,750		7,360		6,407	
Total[2]	3,750	102	7,360	184	6,407	163

NC = not calculated
[1]Total including Conchostraca
[2]Total excluding Conchostraca

Table 13. Mean number and biomass (wet weight) of zooplankton by date (mean of Stations 1, 2 and 3).

Group	#/m³	mg/m³	#/m³	mg/m³	#/m³	mg/m³
	29/5/74		12/6/74		25/6/74	
Cyclopoid	85,233	314	24,293	138	741	2
Calanoid	12,588	173	12,779	276	3,511	77
Daphnia type	5,254	142	2,916	313	3,341	40
Bosmina type	491	11	-	-	20	1
Conchostraca	2,958	NC	157	NC	74	NC
Total[1]	106,524		40,145		7,687	
Total[2]	103,566	640	39,988	727	7,613	120
	12/7/74		25/7/74		8/8/74	
Cyclopoid	391	2	95	0.2	232	0.4
Calanoid	1,662	38	2,917	107	3,327	64
Daphnia type	654	6	261	3	899	10
Bosmina type	32	1	-	-	-	-
Conchostraca	230	NC	65	NC	28	NC
Total[1]	2,969		3,338		4,486	
Total[2]	2,739	47	3,273	110	4,458	75
	21/8/74		4/9/74		19/9/74	
Cyclopoid	241	1	32	0.2	72	0.3
Calanoid	6,216	172	5,726	136	5,656	147
Daphnia type	591	24	173	4	60	2
Bosmina type	22	1	111	1	51	0.3
Conchostraca	-	-	-	-	-	-
Total[1]						
Total[2]	7,070	198	6,042	141	5,839	150

For All Dates, Excluding Conchostraca $\bar{X}$

#/m³	mg/m³
20,065	245

NC - not calculated.
[1]Total including Conchostraca.
[2]Total excluding Conchostraca.

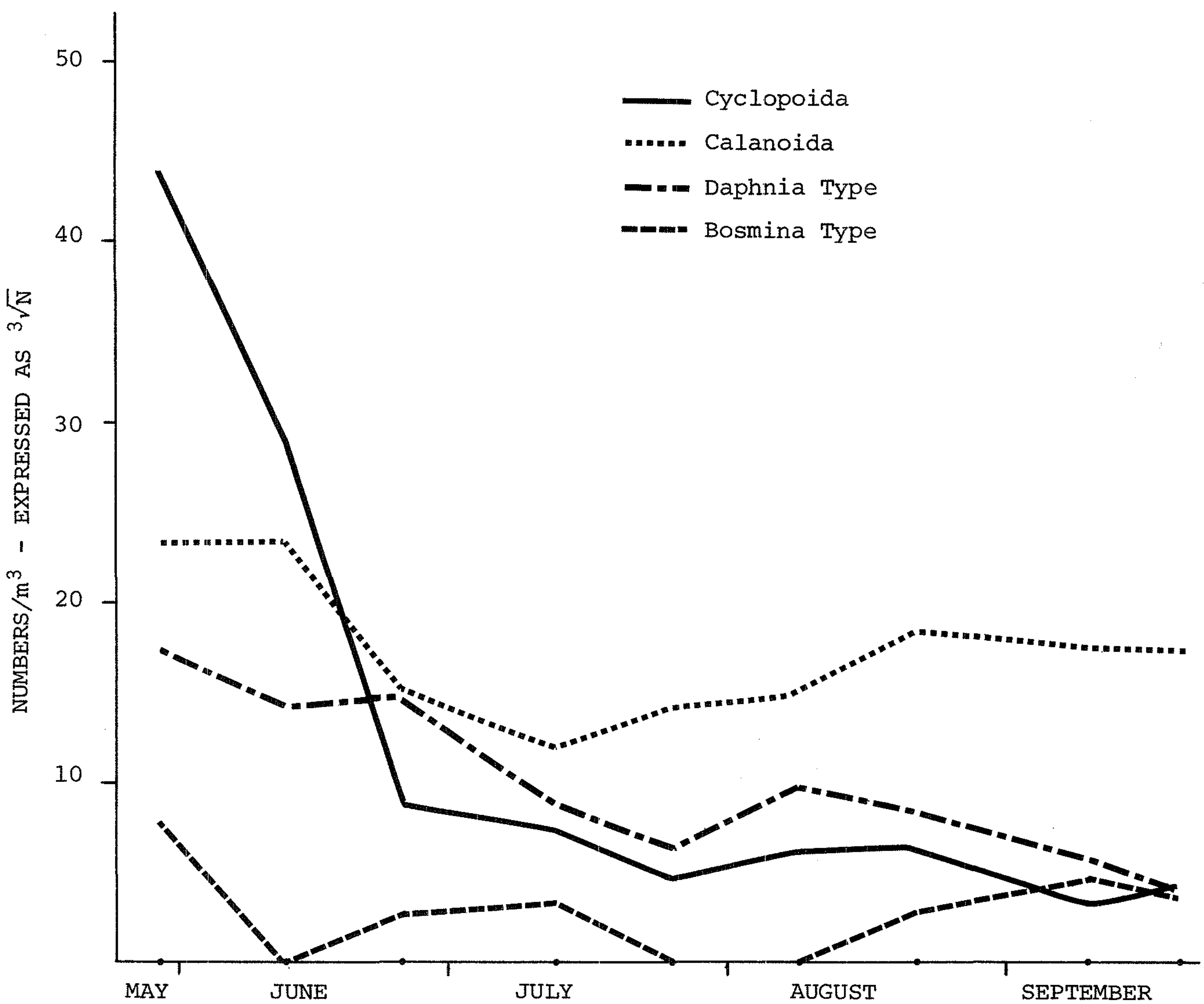

Figure 7. Numbers of the major groups of zooplankton - May 29 to September 19, 1974. Each value is the mean of three stations.

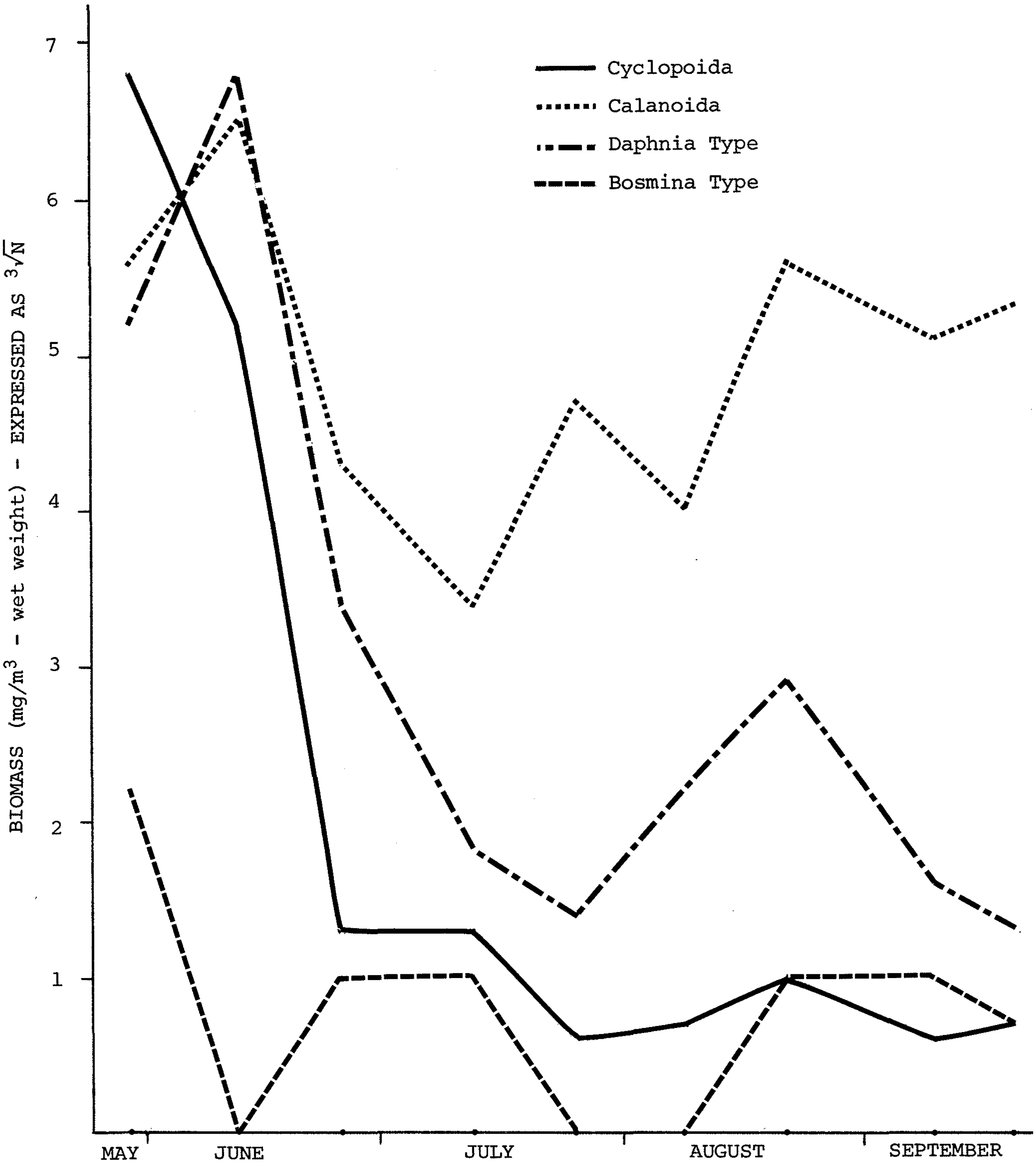

Figure 8. Biomass of the major groups of zooplankton - May 29 to September 19, 1974. Each value is the mean of three stations.

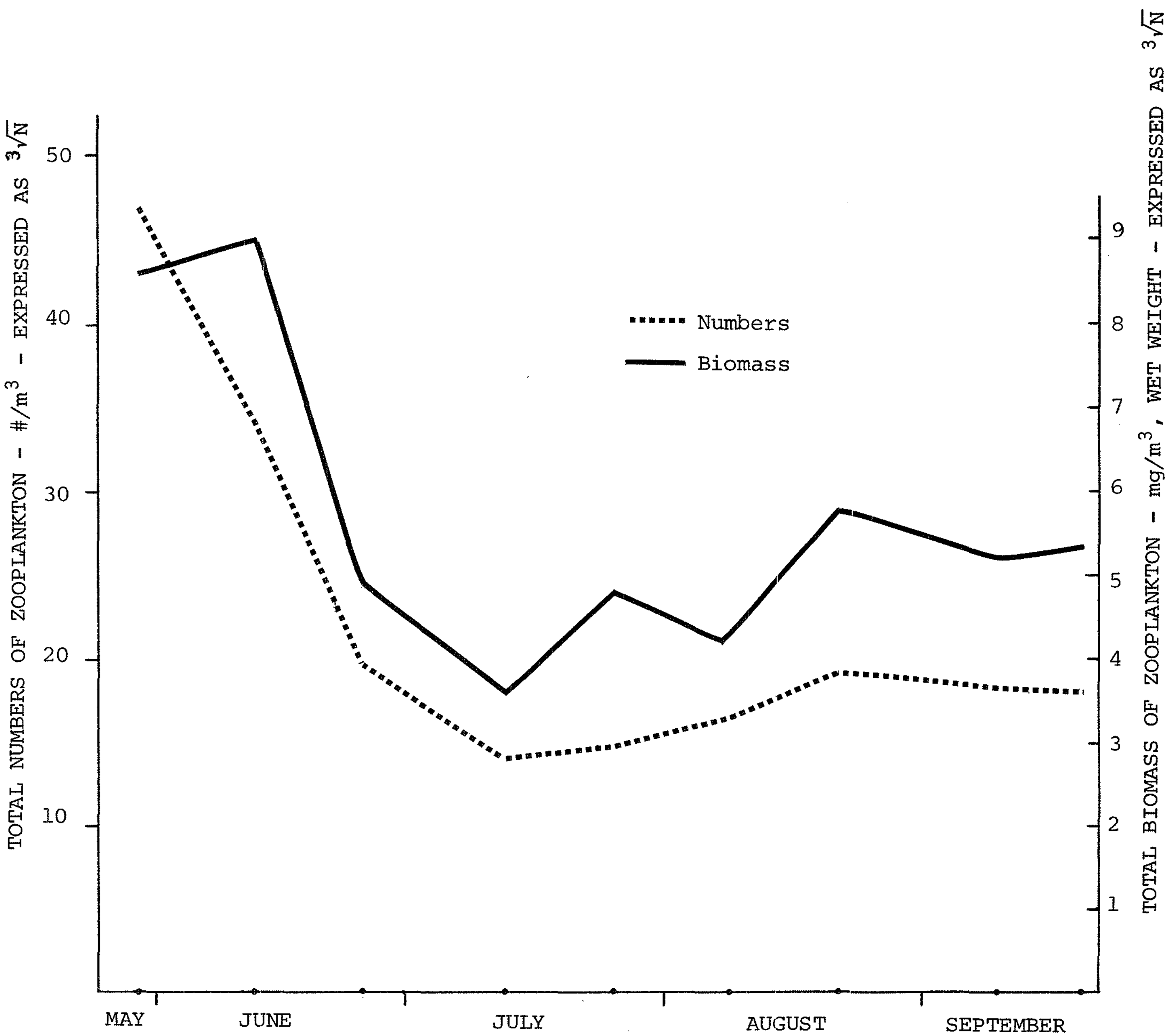

Figure 9. Total numbers and biomass of all zooplankton organisms - May 29 to September 19, 1974. Each value is the mean of three stations, excluding Conchostraca.

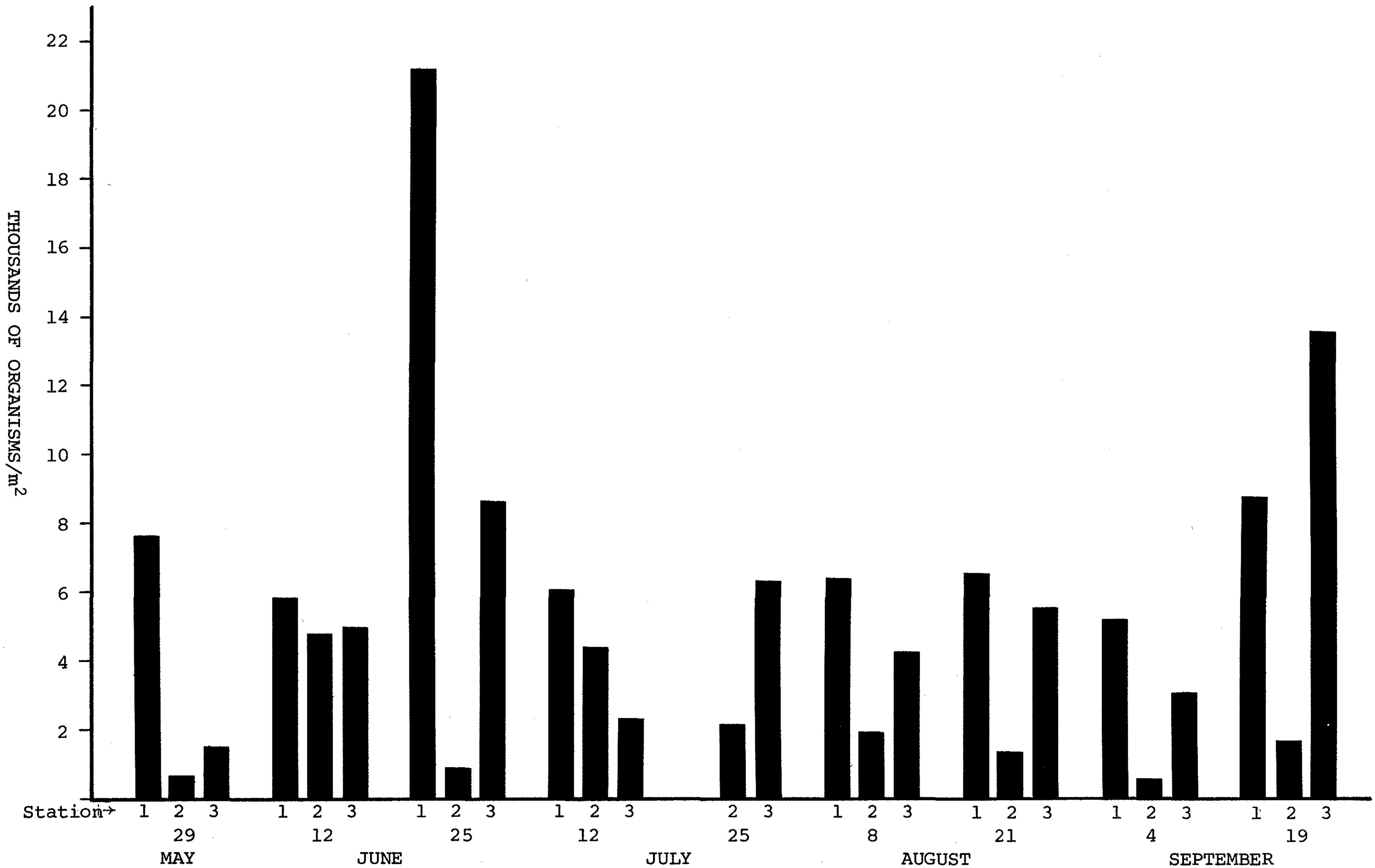

Figure 10. Numbers of benthic macroinvertebrates in Ekman dredge samples from Ruth Lake.

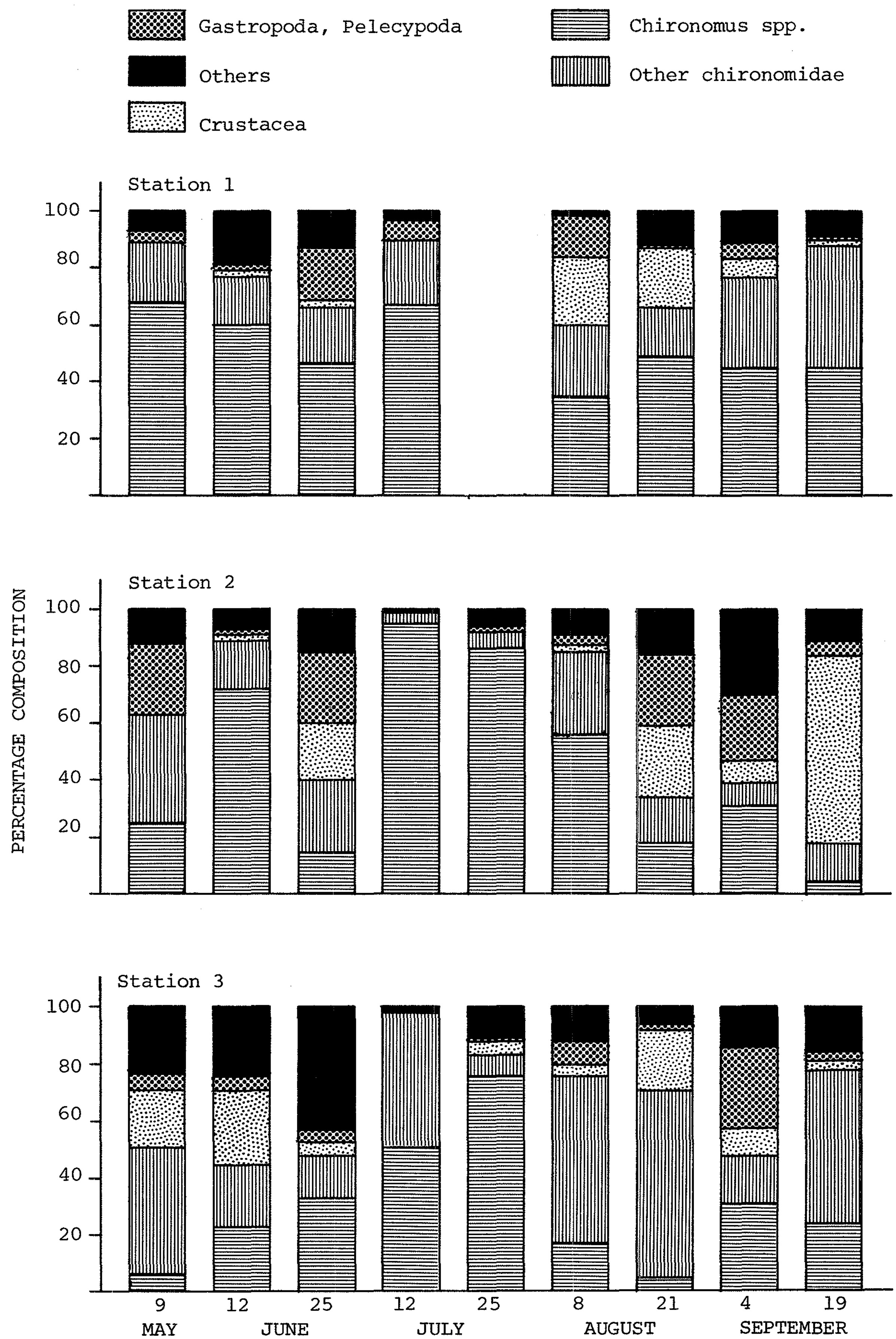

Figure 11. Percentage composition by numbers of benthic macroinvertebrate in Ruth Lake Ekman dredge samples.

Table 14: Organisms in Ekman dredge samples from Ruth Lake. One dredge per station. Area of 1 Ekman dredge sample = 0.02 m^2. Where counts occur for taxa larger than genus, identification was not done to lower levels.

Date→	29/5/74			12/6/74			25/6/74		
Station→	1	2	3	1	2	3	1	2	3
INSECTA									
Ephemeroptera									
Baetidae									
Caenis sp.	4		8	21	8	24	56		77
Trichoptera									
Hydroptilidae									
Leptoceridae									
Oecetis sp.									
Limnephilidae	1	1				3			
Philopotamidae									
Sericostomatidae									
Sericostoma sp.							1		
Odonata - Anisoptera									
Aeschnidae									
Aeschna sp.									
Libellulidae									
Cordulia sp.									1
Leucorrhinia sp.									
Libellula sp.	5			2			2		
Macrodiplax sp.									
Miathyria sp.				1					
Nannothemis sp.									
Orthemis sp.									
Paltothemis sp.							2		
Perithemis sp.									
Pseudoleon sp.									
Somatochlora sp.									2
Tetragoneuria sp.	1			1			3		
Odonata - Zygoptera				1					
Coenagrionidae									
Anomalogrion sp.									
Enallagma sp.									1
Diptera									
Ceratopogonidae									
Palpomyia sp.	1								
Empididae									
Chironomidae							1		
Ablabesmyia sp.	9			1		2	4		1
Chironomus spp.	122	4	2	82	81	27	231	3	66
Dicrotendipes sp.							1		5
Einfeldia sp.		2							
Endochironomus sp.						1			
Eukiefferiella sp.	13						4		
Harnischia sp.							15		1
Hydrobaenus sp.									
Micropsectra sp.							2		1
Microtendipes sp.						1		1	2
Natarsia sp.	3		1		1				
Parachironomus sp.	2						4		3
Phaenopsectra sp.					1	1			
Polypedilum spp.	1		11	9	5	8	31	2	7
Procladius sp.	4	1	4	3	3	8	1	2	
Pseudodiamesa sp.									
Rheotanytarsus sp.									
Tanytarsus sp.	6	3		10	9	4	30		11
ARACHNOIDEA									
Hydracarina									
CRUSTACEA									
Amphipoda									
Gammarus lacustris Sars									
Hyalella azteca (Saussure)				2	2	2			
Conchostraca			7			28	19	4	11
HIRUDINEA								1	
OLIGOCHAETA		1						2	5
GASTROPODA									
Gyraulus sp.	3			1		3	17		1
Helisoma sp.							6		2
Physa sp.							3		1
Valvata sincera ontariensis Baker							2		
V. tricarinata (Say)	2						26		
Valvata sp.		1							
PELECYPODA									
Pisidium spp.	2	2	2		2	3	31	3	4
Sphaerium rhomboideum (Say)		1		2	1			2	
Sphaerium spp.							2		
TOTAL	179	16	35	136	113	115	492	20	202

Date→	12/7/74			25/7/74			8/8/74		
Station→	1	2	3	*1	2	3	1	2	3
INSECTA									
Ephemeroptera									
Baetidae									
Caenis sp.									1
Trichoptera									
Hydroptilidae									
Leptoceridae									
Oecetis sp.									
Limnephilidae									
Philopotamidae									
Sericostomatidae									
Sericostoma sp.									
Odonata - Anisoptera									
Aeschnidae									
Aeschna sp.									
Libellulidae									
Cordulia sp.							1		
Leucorrhinia sp.									
Libellula sp.									
Macrodiplax sp.									
Miathyria sp.									
Nannothemis sp.						2			
Orthemis sp.									3
Paltothemis sp.						2	1		
Perithemis sp.									
Pseudoleon sp.	1								
Somatochlora sp.									
Tetragoneuria sp.									2
Odonata - Zygoptera									1
Coenagrionidae									
Anomalogrion sp.									1
Enallagma sp.									
Diptera									
Ceratopogonidae									
Palpomyia sp.						1			
Empididae									
Chironomidae									5
Ablabesmyia sp.							1		
Chironomus spp.	94	97	28		43	112	52	25	28
Dicrotendipes sp.			18		1	4	10	3	7
Einfeldia sp.									
Endochironomus sp.									
Eukiefferiella sp.							1		
Harnischia sp.						1			
Hydrobaenus sp.						1	4		
Micropsectra sp.									
Microtendipes sp.							2		
Natarsia sp.									
Parachironomus sp.	4					1	1		1
Phaenopsectra sp.									
Polypedilum spp.	1		1				1	3	23
Procladius sp.	15	4	6		2	2	8	3	6
Pseudodiamesa sp.	1								
Rheotanytarsus sp.							1		3
Tanytarsus sp.	11		1			1	9	4	5
ARACHNOIDEA									
Hydracarina						1			1
CRUSTACEA									
Amphipoda									
Gammarus lacustris Sars									
Hyalella azteca (Saussure)			1			8	36		
Conchostraca								1	4
HIRUDINEA	1							4	1
OLIGOCHAETA	3	1			3	11			2
GASTROPODA									
Gyraulus sp.							1		
Helisoma sp.	1								
Physa sp.									
Valvata sincera ontariensis Baker									
V. tricarinata (Say)	6						1		2
Valvata sp.	3								
PELECYPODA									
Pisidium spp.								2	4
Sphaerium rhomboideum (Say)					1				
Sphaerium spp.						1	20		2
TOTAL	141	102	55		50	148	150	45	102

*Sample lost for Station 1, 25/7/74.

Table 14: Concluded.

Date→ Station→	21/8/74 1	21/8/74 2	21/8/74 3	4/9/74 1	4/9/74 2	4/9/74 3	19/9/74 1	19/9/74 2	19/9/74 3
INSECTA									
Ephemeroptera									
Baetidae									
Caenis sp.	1		2	3			6		23
Trichoptera									
Hydroptilidae							1		1
Leptoceridae									
Oecetis sp.									1
Limnephilidae			3	1		5	1		
Philopotamidae				1					1
Sericostomatidae									
Sericostoma sp.									
Odonata - Anisoptera									
Aeschnidae									
Aeschna sp.				2					
Libellulidae			3						
Cordulia sp.	1								
Leucorrhinia sp.	11								
Libellula sp.				3			3		1
Macrodiplax sp.				1		1	4		2
Miathyria sp.									
Nannothemis sp.									
Orthemis sp.									
Paltothemis sp.									
Perithemis sp.									1
Pseudoleon sp.									
Somatochlora sp.						2			
Tetragoneuria sp.									1
Odonata - Zygoptera									
Coenagrionidae									
Anomalogrion sp.									
Enallagma sp.									1
Diptera									
Ceratopogonidae									
Palpomyia sp.									2
Empididae				1					
Chironomidae									
Ablabesmyia sp.	1	1					1		25
Chironomus spp.	75	6	6	55	4	22	102	2	74
Dicrotendipes sp.				1		4	8	1	34
Einfeldia sp.				3			1		2
Endochironomus sp.									
Eukiefferiella sp.									3
Harnischia sp.									
Hydrobaenus sp.									
Micropsectra sp.	3								
Microtendipes sp.	4			1					
Natarsia sp.						1			
Parachironomus sp.	4		2			4	18		70
Phaenopsectra sp.									
Polypedilum spp.	12	1	41	11		1	39	1	2
Procladius sp.	2	3	22	3	1		11	3	8
Pseudodiamesa sp.									
Rheotanytarsus sp.									9
Tanytarsus sp.			21	21		2	20		17
ARACHNOIDEA									
Hydracarina				1			5		7
CRUSTACEA									
Amphipoda									
Gammarus lacustris Sars		1			1			21	
Hyalella azteca (Saussure)	32	3	26	4		1	4	3	11
Conchostraca		4	2	3		6		1	
HIRUDINEA	3	5		1		2		3	
OLIGOCHAETA	2				4			1	9
GASTROPODA									
Gyraulus sp.						2		1	1
Helisoma sp.									
Physa sp.						15			1
Valvata sincera ontariensis Baker		1							
V. tricarinata (Say)	1				1	1	2		1
Valvata sp.									
PELECYPODA									
Pisidium spp.		6		4	2	2			1
Sphaerium rhomboideum (Say)		1		1					3
Sphaerium spp.	1		2	2			1	1	3
TOTAL	153	32	130	123	13	71	227	38	315

Table 15: Results of seine hauls in Ruth Lake.

	S1	S2	S3	S4
11/6/74	1 gravid F FTMN Numerous 0+ BRST	1 breeding M FTMN Numerous 0+ BRST	4 adult BRST 1 gravid F BRST	5 0+ BRST
25/6/74		12 FTMN Numerous 0+ BRST		10 FTMN Numerous 0+ BRST
21/8/74		∿200 0+ FTMN 20 BRST		

BRST - Brook stickleback - *Culaea inconstans*
FTMN - Fathead minnow - *Pimephales promelas*

4. POPLAR CREEK: METHODS

4.1 Sampling Program

Poplar Creek was first visited by the field party in late March, 1974, to select sampling sites. Samples for temperature, dissolved oxygen, and benthic macroinvertebrates were taken at this time, and again on May 30 and thereafter once in each month until September 18. A fishery inventory and habitat evaluation were conducted in July.

4.2 Methods

Physical and Chemical Factors

Water temperature and oxygen content were measured at each point where benthic samples were taken - one measurement of each parameter being made at each station. Temperatures were measured with a pocket thermometer or with a dissolved oxygen/ temperature meter[1] (model No. 490-051 - International Biophysics Corporation). Oxygen concentrations were measured with the same meter, or by the Winkler method (azide modification)[2].

Benthos

Samples were taken in March, and monthly from May to September inclusive, for benthic macroinvertebrates in Poplar Creek. No samples were taken in April because the extremely high water level and flow rate in Poplar Creek at that time made sampling impractical.

1. An electronic meter permitting measurement of temperature and oxygen concentration, by means of a single temperature-compensated submersible probe.
2. The standard chemical method of measuring oxygen concentration in water. The azide modification prevents interference in the test from nitrate and ferrous iron.

Three sites for sampling the benthos of Poplar Creek (B2, B3, and B4, see Figure 12, p. 94) were established in March. These sites had riffles convenient for sampling but none could be found downstream of B2. Station B4 was located upstream from "Ruth Creek" (the tributary entering Poplar Creek from the direction of Ruth Lake, and so named in the rest of this report) so as to be unaffected by the diversion of Beaver Creek/Ruth Lake into Poplar Creek, while stations B2 and B3 were located downstream from there. After the June 27 sampling it was learned that the diversion canal from Ruth Lake would enter at a point close to site B2 (as shown in Figure 12). This meant that only one site was located downstream from the spillway point and consequently it was decided to establish another site (B1) downstream of this point so as to have two stations in the region that was to be affected by the increased flow from the diversion. B1 was different from the other stations in having a sand/silt substrate.

Station B4 was not sampled in July because station B3 then served as the control site upstream of the spillway. A beaver dam, appearing below site B3 after the July 23 sampling, caused the riffle at B3 to be flooded, and it was necessary to abandon this site and resume sampling at B4 for the August and September samples.

Three Surber samples were taken for benthic macroinvertebrates at B2, B3, and B4. Because of the possibility that the weak current at B1 might allow organisms to escape the Surber sampler, two Surber samples were supplemented by 8 Ekman dredge samples taken from the soft sand/silt substrate. While the Surber covered 2 ft^2 the Ekman dredge dealt with an area of 1/4 ft^2, i.e., 8 Ekman samples were equivalent to 1 Surber. There were no apparent differences in quality or relative quantity of benthos captured by these two samplers.

Mesh aperture of the Surber was about 0.3 mm, and the wash pail (Plate 8) used to screen Ekman samples in the field had a mesh aperture of about 0.6 mm. Samples were packaged in the field, preserved with 70% ethanol within 12 hours, then sorted and picked in the laboratory.

Benthic macroinvertebrates were identified only to genus except for uncommon individuals from such groups as Empididae, Simuliidae, Hydracarina, and Oligochaetes. The diversity (d) of sampled invertebrates was calculated for each Surber sample using the Shannon-Weaver function as outlined in Weber (1973), in which

$$d = \frac{C}{N} (N\log_{10}N - \Sigma n_i \log_{10} n_i),$$

where

C = 3.321928 (converts base 10 log to base 2),

N = total number of individuals, and

n_i = total number of individuals in the i^{th} taxa.

Equitability (Lloyd and Ghelardi, 1964 in Weber, 1973) was calculated for the samples as well, with the formula

$$e = \frac{S'}{S}$$

where

e = equitability

S = number of taxa in the sample examined, and

S' = number of taxa predicted from d, assuming a distribution of taxa similar to that described by MacArthur (1957).

Fishery and Habitat

A sampling of the physical dimensions and characteristics of Poplar Creek was carried out on July 24. The method of Herrington and Dunham (1967) was used, where width, depth of 3 points, pool quality, pool/riffle proportions, substrate type and proportions, bank stability, and bank vegetative cover were assessed and recorded in the field. Stream gradient was obtained from a 1:50000 topographical map. The creek was sampled once at each of 24 transects (H1-H24, Figure 12) located at uniform intervals along its length in such a way as to avoid biases in habitat sampling. The creek was too wide and deep to sample downstream from H1. Sampling was carried out on July 24.

To sample representative areas for fish, sections of between 100 and 300 feet were chosen at locations along the stream (S1-S9, Figure 12, p. 94) and sampled with a back-pack fish shocker (type VII Electrofisher, Smith-Root Inc.). Occassionally fish were sampled upstream from the highway by angling. Difficulty of access to the creek, deep water, and the congestion of logs and deadfall in the creek (Plate 9) did not always allow a complete sampling within any one section. Sampling was carried out on July 10 and 11.

5. POPLAR CREEK: RESULTS AND DISCUSSION

5.1 Physical-Chemical

The results of temperature and oxygen measurements are given in Table 16. The table includes some measurements made by Syncrude Canada Ltd.

Temperature ranged from 0^{o}C under the ice in March, to 20^{o}C at site B3 on July 23. Oxygen levels were lowest in mid-summer when they reached 8 ppm and highest in March and September (11.8 and 10.8 ppm respectively) when the water was at its coolest. No levels of oxygen low enough to be deleterious to aquatic organisms were observed during the study period.

Table 17 contains measurements of ice and snow depths recorded in March, 1974. Snow was quite deep at that time (Plate 10), and apparently provided an insulating cover such that ice thickness on the stream was not great.

Poplar Creek has a fairly steep-sided and deep valley as it approaches the Athabasca River. Tar sand deposits are exposed in this valley and consequently much tar sand has been eroded by and deposited in the stream and is thus a major component of the stream substrate. Although the rubble substrates encountered at sites B2, B3, and B4 are composed mostly of hard rock, the underlying gravel contains much tar sand in the form of pebbles and small aggregations. Plate 11 illustrates this tar sand/gravel and Plate 8 shows the sand/silt substrate, characteristic of much of the stream bottom, which contains much tar sand. The substrate and other physical characteristics of the stream are discussed further in the section on Fishery and Habitat.

Although not a subject of investigation in this study, some water chemistry data is included in Table 15 to provide a better picture of the nature of Poplar Creek. This data was obtained from Syncrude Canada Ltd. and is part of their baseline water analysis.

The pH levels in the creek are around 8.0. Levels of total dissolved solids surpassed 1000 ppm on one occasion and levels of the chloride ion regularly surpass 200 ppm and were greater than 700 ppm on one occasion. Highest levels of total dissolved solids and chlorides are found during winter, a time of low flow in the creek (Table 18). Of interest are the levels of chloride which are similar to chloride levels found in Beaver Creek (Renewable Resources Consulting Services Limited, 1974) although the salinity of the latter stream has been temporarily increased by pre-mining operations. The relatively high chloride level in Poplar Creek appears to be naturally-occurring.

POPLAR CREEK

DATA FOR PHYSICAL-CHEMICAL FACTORS

Table 16: Recorded temperatures (°C) and oxygen concentrations (ppm) in Poplar Creek, 1974.

Date	Station	Temp.	Oxygen
19/1/74[1]	Hwy	0	10.5
24/3/74[2]	B2	0	N/A
20/3/74[2]	B3	0	11.8
	B4	0	N/A
3/4/74[1]	Hwy	0.8	11.25
17/4/74[2]	Hwy	1	N/A
	B3	0	N/A
30/5/74[2]	B2	9.2	11.05
	B3	8.5	11.39
	B4	8.8	11.2
27/6/74[2]	B2	15.5	8.4
	B3	16	8.2
	B4	17	8
23/7/74[3]	B1[4]	17.5	8.5
	B2	19	8
	B3	20	9
20/8/74[3]	B1	13	10
	B2	13	10.5
	B4[5]	13.5	10
18/9/74[4]	B1	N/A	10.5
	B2	N/A	10
	B4	N/A	10.8

[1]Results from Syncrude baseline data collection at highway crossing. Method as in #2 below.

[2]Readings taken with an electric dissolved oxygen-temperature meter, model 490-051 - Int. Biophysics Corp.

[3]Readings taken with a pocket thermometer and the Winkler dissolved oxygen method (azide modification). Dissolved oxygen meter not working.

[4]New station established because of apparent new positioning of Ruth Lake spillway. Station B4 correspondingly discontinued.

[5]Station B3 stopped because it was flooded out by a beaver dam. Consequently, sampling was resumed at station B4.

Table 17: Ice and snow depths at sampled stations on Poplar Creek, March, 1974.

	Site B2 24/3/74	Site B3 20/3/74	Site B4 20/3/74
Snow (cm)	60-70	65-70	68-72
Ice (cm)	*30	8-10	8-10

*20 cm of under ice and 10 cm of solid overflow ice separated by thin layer of compacted snow - See Plate 10.

Table 18. Total dissolved solids (evaporated) and chloride in, and pH of, Poplar Creek. Data from Syncrude baseline water analysis. Samples collected at highway, unless noted otherwise.

Date	TDS (ppm)	Cl (ppm)	pH
30/9/72	531	126	8.2
29/11/72		85	
6/3/73	1,778	747	7.9
15/5/73	254		
9/7/73	268	10.5	
21/9/73	384	56	7.9
21/11/73	352	51	
19/1/74	828	232	7.9
7/3/74	899	257	
20/3/74	921	304	
3/4/74		274	8.5
29/5/74 Site B2		19	
Site B3		17	
Site B4		16	

5.2 Aquatic Macrophytes

Vascular aquatic macrophytes were rare in Poplar Creek during the summer of 1974. Only one large clump of plants was seen, which proved to be *Potamogeton vaginatus* Turcz, located just downstream from B2.

5.3 Benthos

<u>Site Description</u> (See Figure 12)

As explained in the Methods section it had been intended to sample only riffle areas on Poplar Creek for benthos but the scarcity of riffle sites downstream from station B2 necessitated the use of a site (station B1) with a sand/silt substrate and a slower current (0.2-0.25 m/sec) than the higher stations. For illustration see Plates 3 and 12. The mean depth of site B1 was 28 cm on July 23 and this had decreased to 22 cm by September 18. The site was shallower than the immediate stream vicinity.

Site B2 (Plate 13) was situated on a riffle where the substrate was rubble (Plate 14) overlying a gravel base. Mean depth was 10 cm on March 24, had increased to 33 cm on May 30, then decreased through the summer to 13 cm on September 19. Total width of the riffle was about 6 m. The current at the water surface was about one meter per second in the middle of the riffle in May. By September, the current had decreased to 0.5 m/sec.

Rubble with a sand/gravel base, formed the substrate at site B3 (Plates 15 and 16). The riffle was 6 m wide, while the mean depth rose from 13 cm on March 20 to 30 cm on May 30, and then decreased to 20 cm on July 23. Subsequently, a beaver dam raised the water level at this site by about 30 cm. Current speed was about the same (1 m/sec) on sampling dates in May, June, and July.

Station B4 (Plate 17) had a rubble substrate (Plate 18) with a few boulder-sized rocks (>12" in length) and a sand/gravel base. The stream was about 5 m wide at this point. Mean depth was 6 cm in March, 28 cm in May, and 19 cm in September. Current speed in the middle of the riffle and at the surface of the water did not vary noticeably through the sampling season and was about 0.6 m/sec.

Summary of Benthos Data

The macroinvertebrate benthos of Poplar Creek consists of a diverse assemblage of organisms. At sites with rubble substrates groups typical of undisturbed clean water conditions were prevalent (mayflies, stoneflies, and caddis flies). Sand/silt substrates supported fewer genera (largely Chironomidae) but which nevertheless gave a high calculated diversity index.

The raw data for numbers of the various taxa identified and counted from the samples of benthos from Poplar Creek are placed in Table 19. A total of 69 taxa was distinguished in the samples.

Total Benthos

Figure 13 presents total counts of benthic macroinvertebrates. Values graphed are mean numbers of individuals per two square feet of sample and are based on 3 samples taken on each date at each station.

March samples contained about 150 organisms per sample, the actual numbers ranging from 128 to 172. There was a scarcity of organisms (less than 15 per sample) in the May samples, an occurrence also noted in May samples from Beaver Creek (Renewable Resources Consulting Services Limited, 1974). Possible explanations for low numbers in May are (a) that the spring runoff was vigorous enough to scour the substrate and either eradicate much of the benthos or force benthic organisms to retreat deep into the substrate, or (b) that samples were taken at a time when most of the benthic macroinvertebrates had emerged. June samples contained abundances similar to those of March, and thereafter (except for site B1) levels increased, on the whole, through to September when numbers were about 350/2 ft^2. This density may be compared with figures for other streams in Alberta as follows:

Stream	Abundance of Total Benthos (No. per 2 ft^2)	Reference
Poplar Creek	350	This report
Wampus Creek (West Central Alberta)	360	Zelt (1970)
Wapiti River (near Grande Prairie)	282	Paetkau and Bishop (1971)
Wandering River	1319	Robertson (1967)

The high density in the Wandering River was attributed to the influence that an upstream lake exercises on the river benthos (Robertson, 1967). It should be noted that after the diversion of Beaver Creek, Poplar Creek will receive water from the Ruth Lake system.

Site B1 differs from the other sampling stations in physical characteristics (especially in having a sand/silt substrate) and this differences was reflected in much lower numbers of benthic organisms. When first sampled on July 27, only 18 individuals per 2 ft^2 were found, and this increased to only 39 per 2 ft^2 by September 18. The greater stability, variety, surface area and cover offered by a rubble substrate *versus* a sand/silt substrate is generally thought to account for higher invertebrate populations on rubble bottoms (Hynes, 1970).

Differences in total numbers of invertebrates between the other stations (B2, B3 and B4) were not pronounced at at any one sampling, although site B2 had somewhat higher populations than the other rubble stations during the July to September period.

Composition of Benthos

The composition of the Poplar Creek benthos is illustrated in Figure 14. Five groups were selected into which the benthos was separated for this graph: Ephemeroptera (mayflies), Plecoptera (stoneflies), Diptera (flies), Trichoptera (caddis flies), and "others". "Others" included taxa not usually abundant in the samples, these being Collembola, Odonata, Coleoptera, Lepidoptera, Hydracarina, Amphipoda, Hirudinea, and Oligocheata. Important families of Diptera were Chironomidae (midges), Empididae, and Simuliidae (black flies).

Change of Dominance During the Sampling Season

Considering the upstream riffle sites as a group, the seasonal pattern as found with Surber samples was of a Dipteran-Mayfly fauna in March being replaced by a low population dominated by Empididae in May and then a return to higher populations in June dominated by Mayfly nymphs. Mayfly dominance increased in July but was replaced by a Trichoptera-Plecoptera dominance in August-September. Site B1 was dominated from July to September by chironomid Diptera. The samples from the upstream riffle sites do not show any marked differences in benthos composition amongst themselves. Analysed by month the sequence of dominance was as follows:

March Diptera (largely chironomids) formed about 70% of the total numbers of benthic invertebrates in March, with Mayfly nymphs being second (13-385) in importance.

May May samples contained few total organisms, but those collected were mostly Empididae of the order Diptera. At sites B2 and B3 the balance of the May samples was dominated by Oligochaetes.

June Mayfly nymphs (mainly *Baetis* sp.) dominated during June (about 63%) at the rubble stations B2 and B3. Dipterans of the families Chironomidae, Empididae and Simuliidae were subdominants forming about 25% of the benthos.

July By July Mayfly nymphs had increased to 85% (mostly *Baetis* sp., and with some *Ephemerella* sp.) at stations B2 and B3 but there were no distinct subdominants. Station B1 however had a dominant chironomid Diptera fauna forming about 80% of the total numbers when first sampled on July 23.

August/September Chironomid dipterans continued to dominate the benthic macroinvertebrates at B1 but their importance decreased to about 60% of total numbers by September, at which time stonefly nymphs (Plecoptera) and "others" became common.

At the upstream rubble stations (B2 and B4), Mayflies dropped to subdominant levels during August and September while stoneflies (*Nemoura* sp. and Chloroperlinae) and caddis flies (*Hydropsyche* sp. in August, and with *Cheumatopsyche* sp. and *Glossosoma* sp. in September) were comprising 15% to 50% of the benthos each.

Seasonal Fluctuations of Individual Taxa

The seasonal periodicity of some of the more sommon taxa is discussed below.

Baetis sp. was the most common mayfly genus present, and occurred in abundance in March, was absent in May, abundant in June and very abundant in July. It decreased in numbers during August and September but was still common.

The genus *Nemoura* was present but not abundant in March, June, and July samples, and like much of the benthos, absent in May. After July, it increased to higher levels of abundance and in August and September produced up to 169 individuals per sample.

The caddis fly *Hydropsyche* sp. (Plate 19) was quite abundant in August and September, with densities of about 50-100/2 ft^2, but had been only common in July, nearly absent in June (a total of 3 specimens obtained) and absent in May. In March, *Hydropsyche* was present at low levels of abundance.

The family Empididae showed a pattern of abundance somewhat the reverse of stoneflies, in being common to abundant in March and May and decreasing thereafter to almost disappear in September. Simuliidae (black fly larvae) appeared in the samples in peak levels in June, but were only occassional or scarce at other times of the sampling period. This compares with the findings from Beaver Creek (Renewable Resources Consulting Services Limited, 1974) that Simuliidae were scarce in Surber samples from the same period: however, as was discussed in that report, there were pollution inputs to that stream which may have adversely affected the benthic macroinvertebrates.

Equitability and Index of Diversity

Diversity indices were calculated for samples from Poplar Creek using the formula presented in the Methods chapter. These indices are places in Table 20: values of equitability of the sampled invertebrates are shown in the same table. All samples for May 30, and some other samples from site B1 were too small to allow indices to be calculated. Mean diversity with respect to station and date is plotted in Figure 15.

Diversity did not show pronounced fluctuation either between stations or over time. The reduced diversity of June and July for the upstream sites was the result of increased dominance of the benthos by mayflies. It is interesting to note that site B1 had diversities at least as great as those of the rubble stations during the July to September period, despite the fact that the fauna was dominated by Chironomids and that there were fewer genera present there. The high diversities are apparently a result of a very even distribution of individuals among the genera present (Table 19).

<u>POPLAR CREEK</u>

DATA FOR BENTHOS

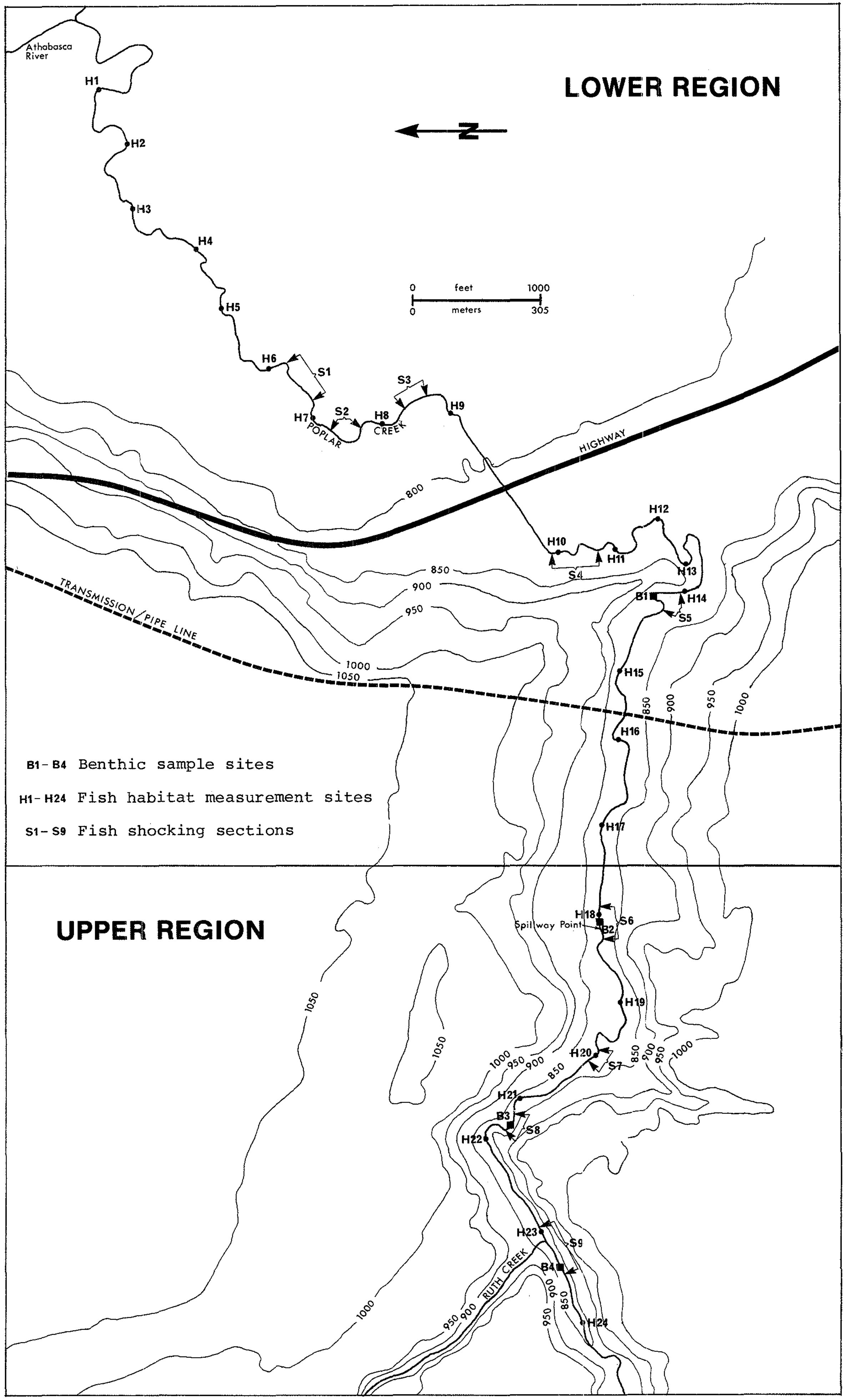

Figure 12. The sampled reach of Poplar Creek.

Table 19. Organisms in benthic samples from Poplar Creek, 1974. Sample C from Station 1 on 23/7/74, 20/8/74 and 18/9/74 consisted of 8 Ekman dredge samples each time. All others were Surber samples.

Date	20/3/74			24/3/74					
Station		2			3			4	
Sample	A	B	C	A	B	C	A	B	C
INSECTA									
Collembola									
Ephemeroptera									
Baetis sp.	15	78	46	12	34	12	84	3	8
Caenis sp.						1			
Cinygma sp.									
Ephemerella sp.		1	5		1	2	1	3	2
Heptagenia sp.			1	2		6			
Rhithrogenia sp.		1							
Plecoptera									
Arcynopteryx sp.									
Brachyptera sp.					1				
Chloroperla sp.			1						
Chloroperlinae									
Isocapnia sp.				4	10	5			
Isogenus sp.		1		2					
Isoperla sp.			1		2				
Nemoura sp.	1	6	1	1	5	4		4	6
Pteronarcella sp.									
Taeniopteryx sp.									
Odonata-Anisoptera									
Anax sp.									
Libellula sp.									
Somatochlora sp.									
Trichoptera									
Arctopsyche sp.									
Brachycentrus sp.									
Cheumatopsyche sp.									
Glossosoma sp.									
Hydropsyche sp.		1	2	3	4	1		2	4
Hydroptila sp.									
Ochrotrichia sp.									
Rhyacophila sp.									
Wormaldia sp.									
Limnephilidae									
Coleoptera									
Agabus sp.									
Bidessus sp.						1			
Rhantus sp.									
Elmidae			4						
Narpus sp.		2							
Optioservus sp.									
Stenelmis sp.				2					
Lepidoptera									
Diptera									
Ceratopogonidae									
Chironomidae									
Ablabesmyia sp.									7
Calopsectrini									
Cardiocladius sp.		2					10	2	1
Cladotanytarsus sp.					9				
Corynoneura sp.									
Cricotopus sp.				10		1			
Crytochironomus sp.									
Diplocladius sp.	2	2	3	14	30	24	40	3	1
Eukiefferiella sp.	19		34	8	60		36	2	2
Harnischia sp.									
Hydrobaenus sp.	1	5	1	1	3	6	1		
Limnochironomus sp.									
Metriocnemius sp.									
Micropsectra sp.	4		10	93		56	69	11	
Natarsia sp.			2	2		12	4		
Polypedilum sp.									
Potthastia sp.			1						
Stenochironomus sp.									
Stictochironomus sp.									
Tanytarsus sp.		4			3				33
Trichocladius sp.	21	44	16	48		3	127	3	2
Empididae	4	9	17	4	3	18	18	5	5
Rhagionidae									
Atherix sp.	1		2	3	1				4
Simuliidae	6	5	2						
Tabanidae									
Tipulidae									
Tipula sp.									1
Triogma sp.									
ARACHNOIDEA									
Hydracarina									
CRUSTACEA									
Amphipoda									
Hyallela azteca (Saussure)									
HIRUDINEA									
OLIGOCHAETA				2					
TOTAL	73	161	149	211	166	152	390	38	75

Table 19. . Continued.

Date				30/5/74					
Station		2			3			4	
Sample	A	B	C	A	B	C	A	B	C
INSECTA									
Collembola									
Ephemeroptera									
Baetis sp.									
Caenis sp.									
Cinygma sp.									
Ephemerella sp.									
Heptagenia sp.									
Rhithrogenia sp.									
Plecoptera									
Arcynopteryx sp.									
Brachyptera sp.									
Chloroperla sp.									
Chloroperlinae									
Isocapnia sp.									
Isogenus sp.									
Isoperla sp.									
Nemoura sp.									
Pteronarcella sp.									
Taeniopteryx sp.									
Odonata-Anisoptera					1				
Anax sp.									
Libellula sp.				1					
Somatochlora sp.									
Trichoptera					1				
Arctopsyche sp.									
Brachycentrus sp.									
Cheumatopsyche sp.									
Glossosoma sp.									
Hydropsyche sp.									
Hydroptila sp.									
Ochrotrichia sp.									
Rhyacophila sp.									
Wormaldia sp.									
Limnephilidae									
Coleoptera		1							
Agabus sp.									
Bidessus sp.									
Rhantus sp.									
Elmidae		1							
Narpus sp.									
Optioservus sp.									
Stenelmis sp.									
Lepidoptera									
Diptera					1				
Ceratopogonidae									
Chironomidae									
Ablabesmyia sp.									
Calopsectrini									
Cardiocladius sp.									
Cladotanytarsus sp.									
Corynoneura sp.									
Cricotopus sp.									
Cryptochironomus sp.									
Diplocladius sp.									
Eukiefferiella sp.									
Harnischia sp.									
Hydrobaenus sp.		1							
Limnochironomus sp.									
Metriocnemius sp.									
Micropsectra sp.									
Natarsia sp.									
Polypedilum sp.									
Potthastia sp.									
Stenochironomus sp.									
Stictochironomus sp.				1					
Tanytarsus sp.									
Trichocladius sp.									
Empididae			2	5	13	6		3	1
Rhagionidae									
Atherix sp.									
Simuliidae									
Tabanidae									
Tipulidae									
Tipula sp.									
Triogma sp.			1						
HEMIPTERA					1				
ARACHNOIDEA									
Hydracarina		1		1	1				
CUSTACEA									
Amphipoda									
Hyallela azteca (Saussure)									
HIRUDINEA						1			
OLIGOCHAETA				5		1		1	
TOTAL	0	3	4	12	18	9	0	4	1

Table 19. Continued.

Date				27/6/74					
Station		2			3			4	
Sample	A	B	C	A	B	C	A	B	C
INSECTA									
Collembola			1				1		
Ephemeroptera			4						
Baetis sp.	68	94	49	35	43	99	49	41	56
Caenis sp.									
Cinygma sp.									3
Ephemerella sp.	8	12		8	1	53		2	5
Heptagenia sp.	8	4	2	11		4	9	10	6
Rhithrogenia sp.									
Plecoptera									
Arcynopteryx sp.									
Brachyptera sp.									
Chloroperla sp.									
Chloroperlinae									
Isocapnia sp.									
Isogenus sp.									
Isoperla sp.									
Nemoura sp.	3			1	1	9			1
Pteronarcella sp.				3					
Taeniopteryx sp.									
Odonata-Anisoptera									
Anax sp.									
Libellula sp.									
Somatochlora sp.							1	1	
Trichoptera									
Arctopsyche sp.									
Brachycentrus sp.									
Cheumatopsyche sp.									
Glossosoma sp.	1								
Hydropsyche sp.						3			
Hydroptila sp.	3		3					2	8
Ochrotrichia sp.			1					1	
Rhyacophila sp.	3	4	2	4		2	2	2	8
Wormaldia sp.									
Limnephilidae									
Coleoptera									
Agabus sp.	1					4			
Bidessus sp.									
Rhantus sp.									1
Elmidae		1	1						
Narpus sp.									
Optioservus sp.	3			3		2			1
Stenelmis sp.									
Lepidoptera									
Diptera									
Ceratopogonidae									
Chironomidae									
Ablabesmyia sp.	6	1	2	5	3	6		1	2
Calopsectrini						1			
Cardiocladius sp.									
Cladotanytarsus sp.									
Corynoneura sp.									
Cricotopus sp.	7	7	17	2	5	15	9	7	5
Cryptochironomus sp.									
Diplocladius sp.									
Eukiefferiella sp.									
Harnischia sp.									
Hydrobaenus sp.									
Limnochironomus sp.									
Metriocnemius sp.									
Micropsectra sp.									
Natarsia sp.									
Polypedilum sp.	1					2			
Potthastia sp.									
Stenochironomus sp.							2		
Stictochironomus sp.	1					19			
Tanytarsus sp.									
Trichocladius sp.									
Empididae	3	11	6	12	6	6		16	8
Rhagionidae							1		
Atherix sp.									
Simuliidae	44	58	6	5	1	15	2	1	3
Tabanidae									
Tipulidae									
Tipula sp.									
Triogma sp.		4			1				
ARACHNOIDEA									
Hydracarina	1								
CRUSTACEA									
Amphipoda									
Hyallela azteca (Saussure)									
HIRUDINEA									
OLIGOCHAETA			3		1	38			
TOTAL	161	195	97	89	66	278	76	84	107

Table 19. Continued.

Date					23/7/74				
Station		1			2			3	
Sample	A	B	C	A	B	C	A	B	C
INSECTA									
Collembola									
Ephemeroptera									
Baetis sp.	1	1		358	145	120	199	134	92
Caenis sp.									
Cinygma sp.			2	4	13	9	11	3	6
Ephemerella sp.				56	30	24	26	22	13
Heptagenia sp.				2	2	5	3	1	7
Rhithrogenia sp.									
Plecoptera				1			1		
Arcynopteryx sp.									
Brachyptera sp.									
Chloroperla sp.									
Chloroperlinae						1		1	
Isocapnia sp.									
Isogenus sp.				4	10	4	3	9	3
Isoperla sp.									
Nemoura sp.	1		1	6	2		3	1	1
Pteronarcella sp.									
Taeniopteryx sp.									
Odonata-Anisoptera									
Anax sp.									
Libellula sp.									
Somatochlora sp.									
Trichoptera						1			
Arctopsyche sp.						1			
Brachycentrus sp.									
Cheumatopsyche sp.								1	
Glossosoma sp.				5	3	1		1	4
Hydropsyche sp.				17	11	9	6	3	3
Hydroptila sp.									
Ochrotrichia sp.									
Rhyacophila sp.				3	1	4			
Wormaldia sp.					1		1		1
Limnephilidae									
Coleoptera									
Agabus sp.								1	1
Bidessus sp.									
Rhantus sp.									
Elmidae					1	1			
Narpus sp.									
Optioservus sp.	3			1	8	4	1	2	1
Stenelmis sp.									
Lepidoptera									
Diptera			1					1	
Ceratopogonidae									
Chironomidae									
Ablabesmyia sp.				1	2	1			
Calopsectrini	3						3	1	2
Cardiocladius sp.									
Cladotanytarsus sp.									
Corynoneura sp.									
Cricotopus sp.	17	1		2	18	6	3		
Cryptochironomus sp.			1	1					
Diplocladius sp.									
Eukiefferiella sp.									
Harnischia sp.									
Hydrobaenus sp.	2				1	1			2
Limnochironomus sp.									
Metriocnemius sp.									
Micropsectra sp.									
Natarsia sp.									
Polypedilum sp.	7		1	2	1				
Potthastia sp.									
Stenochironomus sp.	5	3							
Stictochironomus sp.									
Tanytarsus sp.									
Trichocladius sp.									
Empididae	1			2	6	1	4	1	
Rhagionidae							3		
Atherix sp.									
Simuliidae	1			3	9	1	2	1	2
Tabanidae	1								
Tipulidae			1				2		
Tipula sp.									
Triogma sp.									
ARACHNOIDEA									
Hydracarina									
CRUSTACEA									
Amphipoda									
Hyallela azteca (Saussure)									
HIRUDINEA									
OLIGOCHAETA			1				1		1
TOTAL	39	8	8	468	264	194	272	183	139

Table 19. Continued.

Date	20/8/74								
Station		1			2			4	
Sample	A	B	C	A	B	C	A	B	C
INSECTA									
Collembola									
Ephemeroptera									
Baetis sp.	2	2		25	20	5	13	9	18
Caenis sp.									
Cinygma sp.					2				3
Ephemerella sp.				11	12	2	5	8	11
Heptagenia sp.				1	3	1	4	7	4
Rhithrogenia sp.									
Plecoptera						1			
Arcynopteryx sp.			1	1	8	1	3	3	2
Brachyptera sp.									
Chloroperla sp.									
Chloroperlinae			3	41	31	26	9	4	6
Isocapnia sp.									
Isogenus sp.				1					
Isoperla sp.									
Nemoura sp.			2	57	26	5	12	15	36
Pteronarcella sp.									
Taeniopteryx sp.						1	1		
Odonata-Anisoptera									
Anax sp.						1			
Libellula sp.									
Somatochlora sp.						1	1		
Trichoptera				1					
Arctopsyche sp.									
Brachycentrus sp.					1				
Cheumatopsyche sp.				9	2	2		5	8
Glossosoma sp.				33	7		4	17	3
Hydropsyche sp.			1	86	19	1	8	112	22
Hydroptila sp.						2	2		11
Ochrotrichia sp.									
Rhyacophila sp.									
Wormaldia sp.									
Limnephilidae									
Coleoptera							1		
Agabus sp.									
Bidessus sp.									
Rhantus sp.									
Elmidae									
Narpus sp.									
Optioservus sp.				1	7		5	1	4
Stenelmis sp.									
Lepidoptera			1		1				
Diptera									
Ceratopogonidae	1	1	1						
Chironomidae								1	
Ablabesmyia sp.	1				1	3	1		3
Calopsectrini			1			2			
Cardiocladius sp.									
Cladotanytarsus sp.									
Corynoneura sp.		1				1			
Cricotopus sp.	1	1		6	43	5	2		5
Cryptochironomus sp.	10	3	5						
Diplocladius sp.									
Eukiefferiella sp.									
Harnischia sp.						1			
Hydrobaenus sp.		3		1	2				2
Limnochironomus sp.	1								
Metriocnemius sp.	1				5				
Micropsectra sp.									
Natarsia sp.									
Polypedilum sp.	1				28				
Potthastia sp.									
Stenochironomus sp.			2						
Stictochironomus sp.	8	1	10						
Tanytarsus sp.									
Trichocladius sp.									
Empididae					2	4		1	
Rhagionidae									
Atherix sp.									
Simuliidae				6	1				1
Tabanidae	2		1						1
Tipulidae			1						
Tipula sp.									
Triogma sp.									
ARACHNOIDEA									
Hydracarina				1					
CRUSTACEA									
Amphipoda									
Hyallela azteca (Saussure)									
HIRUDINEA						1	1		
OLIGOCHAETA	4		5			1			
TOTAL	32	12	34	281	220	68	72	184	140

Date				18/9/74					
Station		1			2			4	
Sample	A	B	C	A	B	C	A	B	C
INSECTA									
Collembola									
Ephemeroptera									
Baetis sp.		1		9	27	17	9	2	80
Caenis sp.									
Cinygma sp.									
Ephemerella sp.			1	4	3	4		3	4
Heptagenia sp.				11	29	19	4	7	12
Rhithrogenia sp.									
Plecoptera									
Arcynopteryx sp.				6	2	4	11	5	13
Brachyptera sp.									
Chloroperla sp.									
Chloroperlinae	1	6		45	60	50	113	33	74
Isocapnia sp.									
Isogenus sp.									
Isoperla sp.									
Nemoura sp.	1	3	8	119	131	27	49	35	169
Pteronarcella sp.									
Taeniopteryx sp.		1		1		17	18	40	22
Odonata-Anisoptera									
Anax sp.									
Libellula sp.									
Somatochlora sp.									
Trichoptera									
Arctopsyche sp.									
Brachycentrus sp.				1		1			
Cheumatopsyche sp.		1		32	67	15	20	12	37
Glossosoma sp.				36	51	3	10	7	24
Hydropsyche sp.		1		125	172	16	31	10	77
Hydroptila sp.					3		1	1	1
Ochrotrichia sp.									
Rhyacophila sp.							3		
Wormaldia sp.									
Limnephilidae								2	1
Coleoptera			1			1			
Agabus sp.									
Bidessus sp.									
Rhantus sp.									
Elmidae			1	1					
Narpus sp.									
Optioservus sp.						2	1		1
Stenelmis sp.									
Lepidoptera							6	1	7
Diptera									
Ceratopogonidae	1								
Chironomidae									
Ablabesmyia sp.	3		12	8	5	3	1	5	1
Calopsectrini			2					4	
Cardiocladius sp.									
Cladotanytarsus sp.									
Corynoneura sp.									
Cricotopus sp.					3			1	3
Cryptochironomus sp.	2		1						
Diplocladius sp.									
Eukierfferiella sp.									
Harnischia sp.	2	11	6						
Hydrobaenus sp.						3			
Limnochironomus sp.									
Metriocnemius sp.									
Micropsectra sp.									
Natarsia sp.									
Polypedilum sp.			1						
Potthastia sp.									
Stenochironomus sp.									
Stictochironomus sp.	4	2	12						
Tanytarsus sp.									
Trichocladius sp.									
Empididae			1			1			2
Rhagionidae									
Atherix sp.									
Simuliidae				1	14	3			
Tabanidae	1	1	5						
Tipulidae			2						1
Tipula sp.									
Triogma sp.		1							
ARACHNOIDEA									
Hydracarina									
CRUSTACEA									
Amphipoda									
Hyallela azteca (Saussure)			1		1				
HIRUDINEA									
OLIGOCHAETA		1	18						
TOTAL	15	29	72	398	568	183	277	168	532

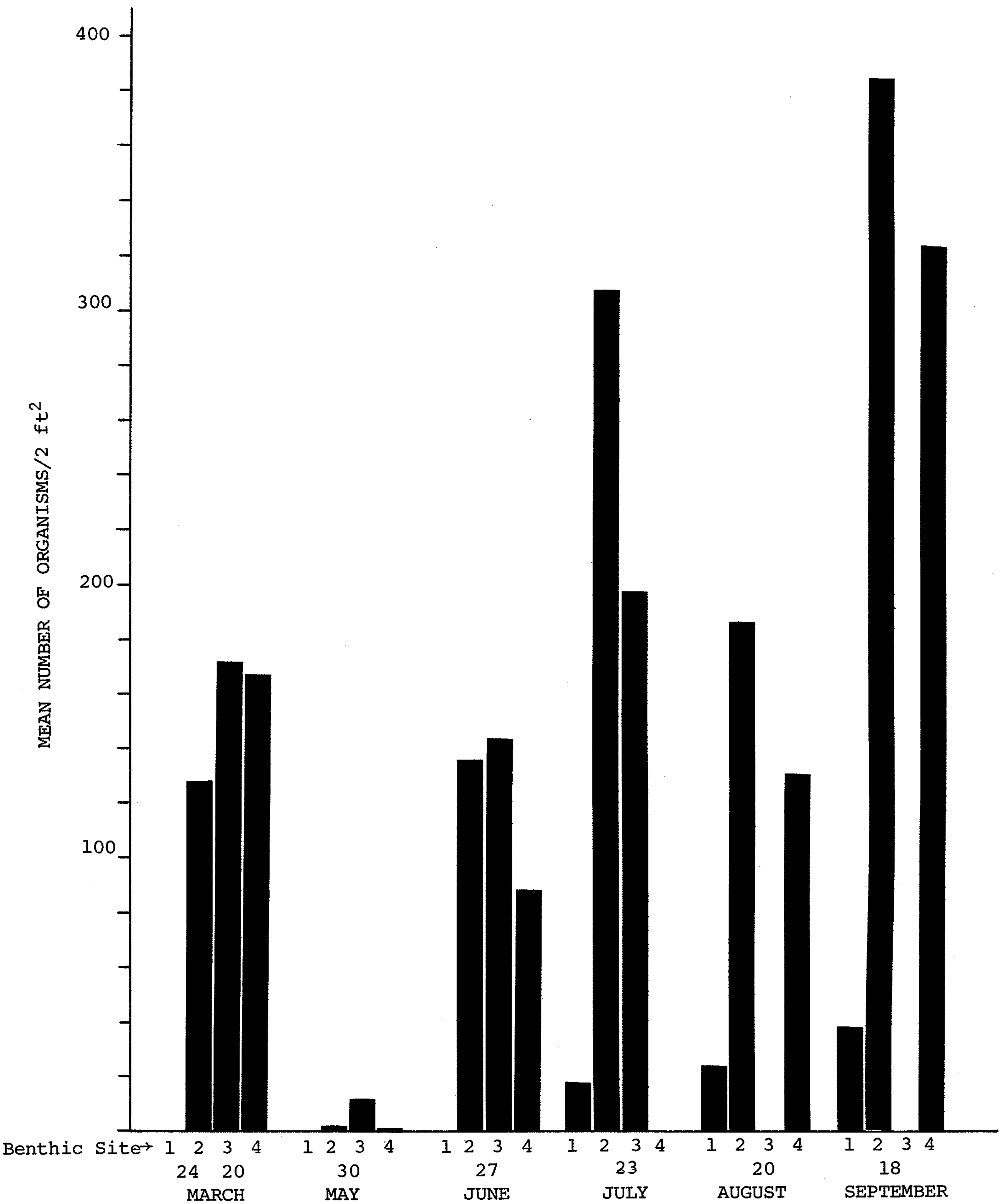

Figure 13. Mean number of sampled invertebrates per 2 square feet at specified times and stations in Poplar Creek, 1974.

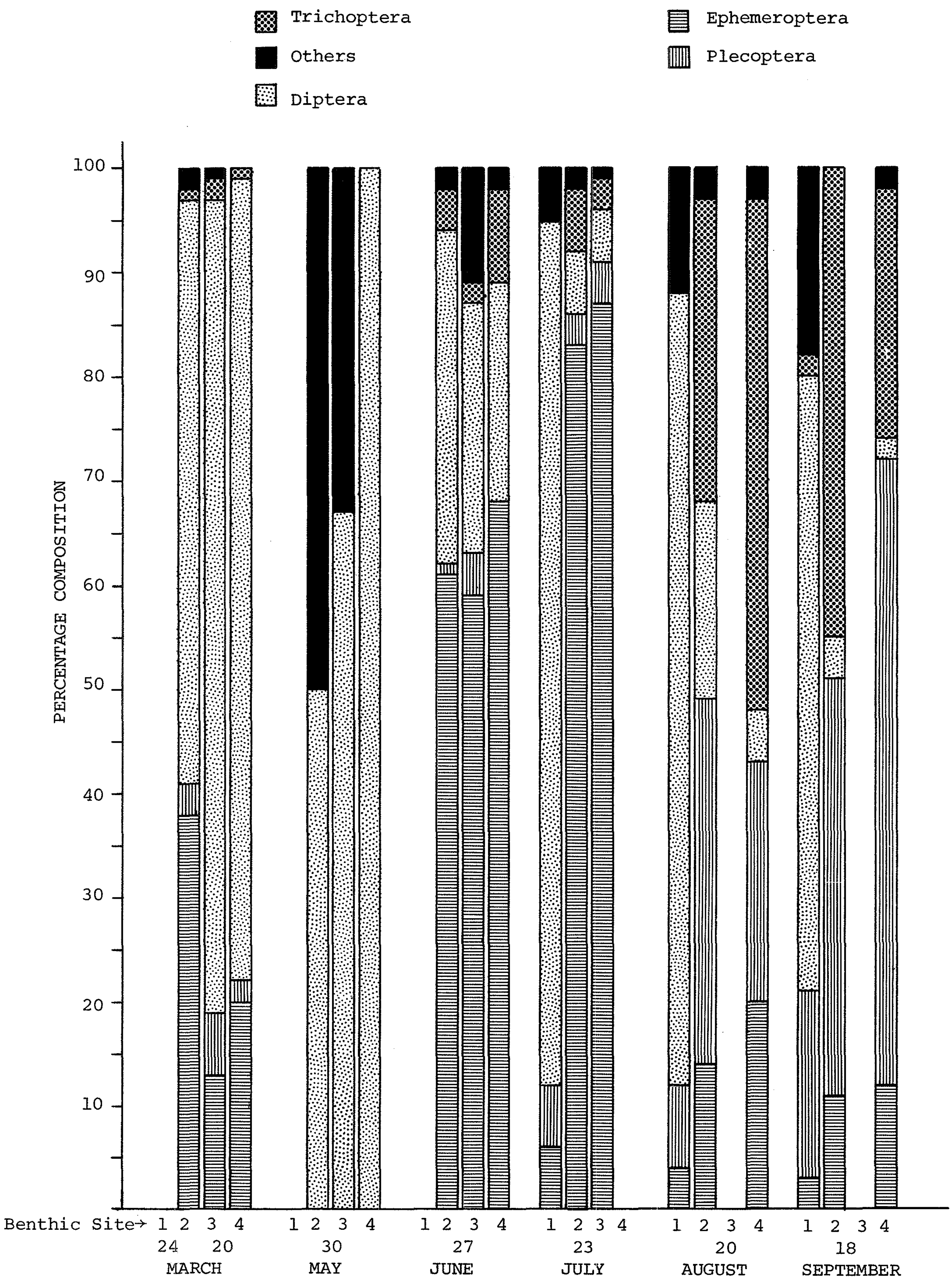

Figure 14. Percentage composition by number of sampled invertebrates from Poplar Creek. Mean of three samples plotted for each station and date.

Table 20. Diversity (d) and Equitability (e) of Sampled Invertebrates from Poplar Creek.

STATION		1			2			3			4		
SAMPLE		A	B	C	A	B	C	A	B	C	A	B	C
DATE													
22/3/74	d							2.72	2.72	2.95	2.55	3.07	2.77
	e							0.47	0.64	0.73	0.80	1.20	0.69
4/3/74	d				2.81	2.29	2.99						
	e				0.91	0.50	0.61						
30/5/74	d				-	-	-	-	-	-	-	-	-
	e				-	-	-	-	-	-	-	-	-
27/6/74	d				2.60	2.07	2.49	2.80	1.90	2.93	2.12	2.31	2.56
	e				0.50	0.56	0.54	0.91	0.50	0.69	0.60	0.64	0.62
23/7/74	d	2.53	-	-	1.41	2.51	2.21	1.71	1.59	2.03			
	e	0.80	-	-	0.17	0.45	0.33	0.24	0.25	0.33			
20/8/74	d	2.90	-	3.17	2.85	3.50	3.47				3.51	2.16	3.41
	e	0.83	-	1.00	0.63	0.84	0.71				1.00	0.46	0.94
18/9/74	d	-	2.78	3.23	2.61	2.81	3.23				2.74	3.14	2.98
	e	-	0.82	0.88	0.62	0.71	0.81				0.64	0.81	0.58

- indicates insufficient organisma present to calculate indices.

Station 1 started on July 23 because of new position of spillway.
Station 3 discontinued on August 20 because it was flooded by a beaver dam.
Station 4 discontinued on July 23 because of new position of spillway; re-initiated on August 20 because of abandonment of Station 3.

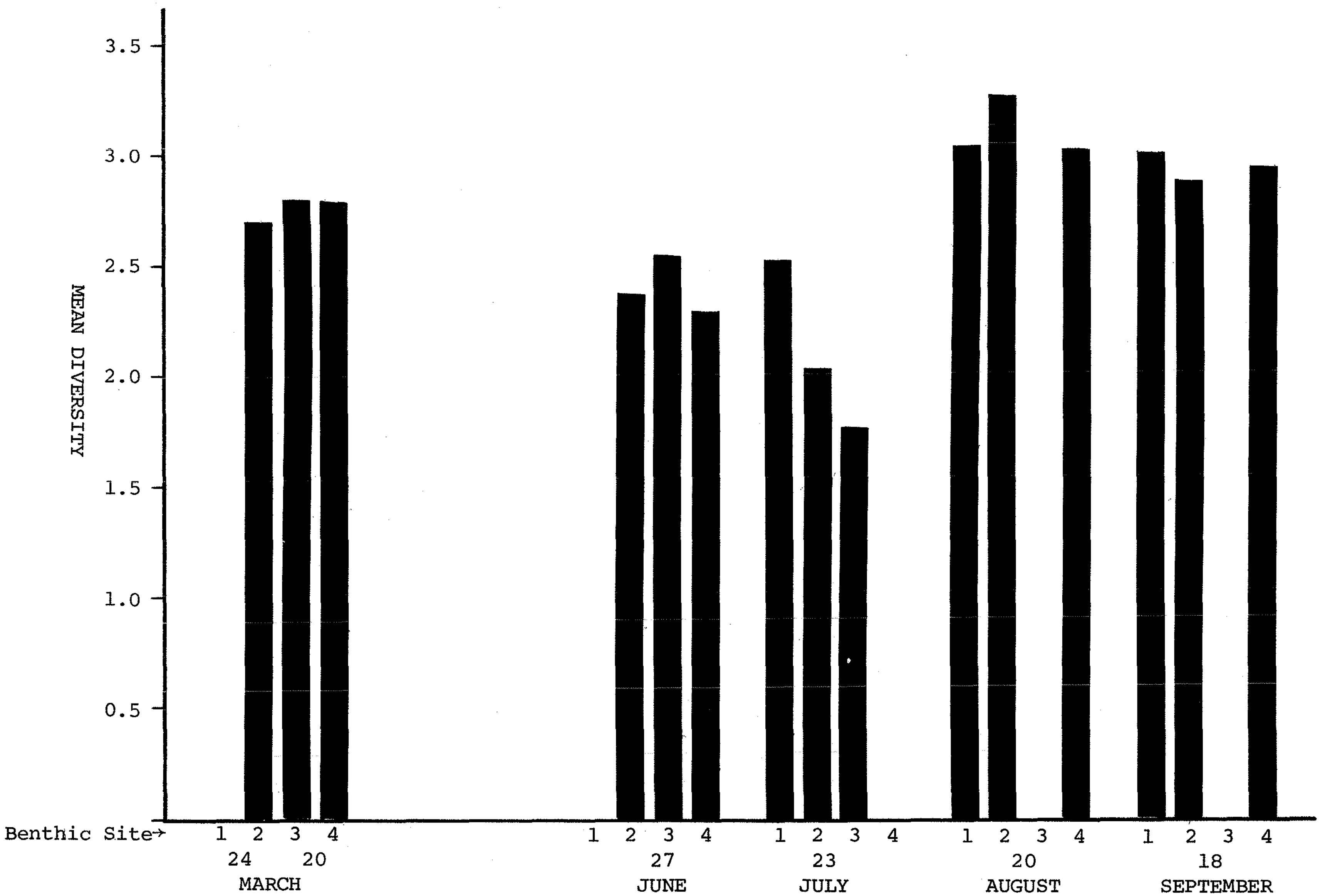

Figure 15. Mean diversity, per station and date, of sampled invertebrates from Poplar Creek.

5.4 Fish and Fish Habitat

A summary of the habitat characteristics is given in Table 21. It was apparent from observations in the field that the creek could conveniently be divided into two sections according to overall characteristics. The lower section from the Athabasca River to a point between H17 and H18 (Figure 12) is of lower gradient with a sand/silt substrate (Table 17). Riffles are uncommon, and such as do occur are fairly calm and smooth-flowing with a sand/ silt substrate (Plate 12). The current is moderate and contains much slackwater (Plate 20) designated as "pools" in Table 21. Despite the slower current, the banks are slightly less stable than in the upper section, as recorded in Table 17 and illustrated in Plate 21. Consequently, erosion of the banks is common and the channel contains much driftwood and deadfall (Plate 9). Starting at about H2 the water becomes deeper (Plate 22) as the stream approaches the Athabasca River, causing the current to slow further. At this point, the water level in the creek appears to be regulated by the water level in the river.

By comparison, in the upper section (H18 and H24) the stream is shallower and slightly narrower, has a higher gradient, and possesses more riffles with gravel or rubble substrate (Plate 23). The banks are not as heavily forested but appear to be somewhat more stable than in the lower section. Generally the substrate consists of about half gravel and half sand/silt. Although rubble is common in this section, it so happened that only a small amount appeared in the transects. A large beaver dam about 2 m in height is situated at the upstream end of Section S7 and produces a pond (Plate 24) extending to transect H21. During mid-summer, a second beaver dam appeared in Section S8. It is not known whether the type of habitat in the upper section continues upstream from transect H24, but such may be expected to be the case because the stream gradient increases above that point (Table 22).

Fish Sighted or Collected

Fish collected from Poplar Creek are listed in Table 23. All fish sighted or collected are described below.

Lower Region (Sites S1 to S5)

Fish	Sighted	Collected
Grayling	None	None
Suckers	1 at S4 1 at S5	1 at S2 (White sucker)

Upper Region (Sites S6 to S9)

Fish	Sighted	Collected
Grayling	4 in pool at S9 1 upstream from S9	1 at S6 1 (by angling) on July 24 at pool (see Plate 25) 1 (by angling) on on August 20 at the pool of S9
White Sucker	1 at S9	1 at S9
Longnose Sucker		3 at S6 1 at S8 1 at S9

No pike were seen or collected during the electrofishing, but two young of the year were seen at H9 on July 24, and sport fishermen reported that pike have been caught in the large pool below the highway culvert.

It appears that grayling are more abundant in the upper zone where the riffle/pool generation is higher and the substrate less silty. The fact that grayling, including a mature female with developing eggs, were found in this region in mid-summer suggests that the species is resident in this area of the creek. It is possible however that grayling are present in the lowest areas of the creek not sampled with the electro-fisher because of the greater depth of water, although they do not appear common in the slackwater zone as represented by Sections S1 to S5. Also, such low gradient slackwater is not commonly inhabited by graying (Huet, 1959).

The large beaver dam near S7 may provide sufficient depth of water to overwinter some Arctic grayling as may some of the deeper pools in the creek, although whether these fish do in fact overwinter in the area is not known. Suckers appear to be resident in both sections of the creek and apparently spawn in at least the upper portion. Fry collected near B4 in early June and raised in an aquarium over summer proved to be white suckers. Little information is available on pike in Poplar Creek although they do occur in the creek and have provided some sports fishing. They do not seem to be common in the areas sampled for fish.

In a preliminary survey of the fisheries of the Athabasca tar sands area, Griffiths (1973) rated Poplar Creek as being a class 4 stream, stating that "Fish habitat appears to be poor.........". However, this was a tentative conclusion because although the study involved the whole length of the creek it was not undertaken in an intensive manner. It is possible that the upper section delineated in our study is atypical of the whole creek in supporting grayling, and that the creek as a whole actually does rate poorly as fish habitat. Nevertheless, the fact that grayling were found in this study in the portion of the creek with the highest gradient, and that upstream from this studied portion (about the 850 foot contour) the gradient is greater (Table 19) suggests that grayling habitat may be more extensive than was indicated by Griffiths. Poplar Creek cannot be conclusively assigned a low rating in fisheries' potential without further investigation.

<u>POPLAR CREEK</u>

DATA FOR FISH AND FISH HABITAT

TABLE 21. Summary of habitat characteristics of Poplar Creek. Lower section from transects H1 to H17; upper section from H18 to H24. English units in brackets.

	LOWER SECTION	UPPER SECTION	TOTAL
Length	4.25 km (2.64 mi)	1.42 km (0.88 mi)	5.67 km (3.52 mi)
Gradient	.3% (17 ft/mi)	.5% (28 ft/mi)	.38%
Number of transects	17	7	
Mean width	5.9 m (19.4')	5.4 m (17.75')	
Mean depth	76.2 cm (30")	58.4 cm (23")	
Total surface area	2.51 ha (6.21 ac)	.32 ha (.78 ac)	
% riffles in transects	12	38	
% pools in transects	88	62	
% pools in transects in:			
Class 1	18	33	
Class 2	23	0	
Class 3	47	17	
Class 4	12	33	
Class 5	0	17	
% width of transects having:			
Boulder	0%	0	
Rubble	0%	1	
Gravel	0%	51	
Sand/Silt	100%	48	
% bank types at transects:			
Forest	30	4	
Brush	47	45	
Open	23	51	
% of transect banks rated stable:	82	93	

Table 22. Average gradients Poplar Creek.

Determined from 1:50,000 maps (Approximate)	
850' contour to 800' contour	24 feet per mile
900' contour to 850' contour	63 feet per mile
950' contour to 900' contour	56 feet per mile
1000' contour to 950' contour	50 feet per mile

Table 23. Fish collected from Poplar Creek, 1974. Data from fish collected by electrofishing and preserved in 10% formalin, except first two grayling caught by angling and measured fresh.

Species	Collection Site	Date	Fork Length (mm)	Weight (g)	Age	Sex	Maturity
Arctic grayling	S9	24/7/74	300		3+	F	Developing eggs
Thymallus arcticus	S8	20/8/74	245	150	2+		
(Pallas)	S6	11/7/74	163	60	1+	M	Maturing
White sucker	S9	11/7/74	186	90.7	2+	M	
Catostomus commersonii	S5	10/7/74	198	120.2	3+	F	Mature
(Lacépède)							
Longnose sucker	S8	11/7/74	93	9.5	1+		Immature
C. catostomus	S9	11/7/74	116	21.2	2+		Immature
(Forster)	S6	11/7/74	99	11.3	1+		Immature
	S6	11/7/74	101	11.3	1+		Immature

6. SUMMARY

6.1 Ruth Lake

Ruth Lake is a small, shallow, moderately eutrophic lake. It is littoral in nature, stagnates in winter, and has a limited fish fauna. Principal results of the baseline study are summarized below.

1. Ruth Lake has a soft, muddy subsurface. Mean depth of the lake is 1.5 m, the length 3.19 km, the area 1.435 km^3 and maximum depth 3 m. The lake volume is 2.163×10^6 (1754 acre-feet).
2. Winter de-oxygenation was found in March, 1974, in Ruth Lake. Summer oxygen levels were around 10 ppm. Water temperatures surpassed $20^{\circ}C$ regularly, and were at about $20^{\circ}C$ for 2 months during the summer. No stratification of oxygen or temperature occurred during the summer because of the shallowness of the lake. Secchi disc visibility was usually greater than 2.5 m. Ruth Lake is a moderately alkaline, hardwater, bicarbonate lake. Phosphate and nitrate levels may be related to aquatic plant growth.
3. Moderate phytoplankton populations (3000-6000 cells/ml) occurred in Ruth Lake during the summer, 1974. Very little temporal or spatial variation occurred in this community, with small motile algae dominating (75% of total numbers). Blue-green algae were not abundant.
4. Twenty-four species of aquatic macrophytes were identified from Ruth Lake. Some combination of emergent, floating-leafed, and submergent plants was found at all points sampled in the lake. The three zones of submergent vegetation were

Chara dominated, mixed dominance, and the poorly covered or open zone associated with dense *Nuphar* and 2 m depth or more. Respectively they accounted for 26%, 44%, and 30% of the lake area. *Nuphar variegatum* was the main floating-leafed macrophyte, reaching high densities in areas of the lake 2 m deep or more. Emergent plants occurred in one area in the center of the lake, and around the shores. Six categories of emergent vegetation were delineated. The most important emergents were *Carex*, *Scirpus validus* (bullrush) and *Typha latifolia* (catttail). The densest and most extensive growth of emergents was found at the southeast end of the lake.

5. Chironomidae and specifically *Chironomus* spp. dominated the benthos sampled during summer, 1974, in Ruth Lake. They formed an average of 65% and 42% respectively of the total numbers of individuals during the summer. Average numbers per square meter for stations 1 and 3 were 8619 and 6014, while Station 2 was 3627. Lower numbers and diversity of zoobenthos at station 2 was probably a result of the lack of benthic vegetation there.
6. Crustacean zooplankton in Ruth Lake were relatively low in species (10), and more typical of a pond than of a lake. Only one species of a calanoid copepod was found, but it was higher in numbers for most of the summer than were all the cyclopoid copepods (3 species) combined. Total numbers ranged from 2739 to 103566 per cubic meter, with highest numbers found in late May. The mean summer value was $20065/m^3$. The zooplankton community is characteristic of a mesotrophic to moderately eutrophic lake based on numbers of zooplankters.
7. Brook stickebacks and fathead minnows form reproducing populations in Ruth Lake, but no other species were found in the lake. Low winter oxygen concentrations would prevent other species from inhabiting the lake.

6.2 Poplar Creek

Poplar Creek is a small, brownwater stream tributary to the Athabasca River. It contains a benthic fauna characteristic of clean streams, and resident fish populations which apparently reproduce in the stream. A summary of the baseline study results follow.

1. Temperature ranged from $0^{o}C$ to $20^{o}C$ during the study, and oxygen concentrations ranged between 8 and 11.39 ppm. Snow depths were high in March (60-70 cm) when ice depths were low (8-30 cm).
   Much of the stream bottom contains tar sand apparently as a result of erosion of this material from the banks by and into the stream.
   Total dissolved solid and chloride levels are highest in winter and chloride levels are similar to those of Beaver Creek which is temporarily receiving a saline effluent. The pH levels are about 8.0.
2. Total of 69 taxa were identified in benthic samples from Poplar Creek. Numbers were lowest in May (less than 20/2 ft^2), similar in March and June (150/2 ft^2), and rose to about 250/2 ft^2 in August and September at the stations with rubble substrates. Site B1 had low populations of about 30/2 ft^2. The former levels are similar to those reported for other streams in the province. Sites B2, B3, and B4 were dominated by mayflies, stoneflies, and/or caddis flies except during May when Empididae dominated the low populations. Site B1 was dominated by Chironomidae. Diversities of all stations were similar, being about 2.75 in March, somewhat lower in June and July, and rising to about 3.0 in August and September.

3. The studied portion of Poplar Creek was divided into a 4.25 km lower section having a lower gradient (0.3%), a mean width of 5.9 m, a mean depth of 76.2 cm, a low proportion of riffles (12%), and a sand/silt substrate; and a 1.42 km upper section with a higher gradient (0.5%), a mean width of 5.4 m, a lower mean depth of 58.4 cm, a higher proportion of riffles (38%), and a gravel-sand/silt substrate.
4. Fish collections indicate a resident, reproducing population of grayling in the upper section, and probably of white suckers throughout. Some pike occur in the lower section. Poplar Creek may have a higher fishery potential than was indicated by Griffiths (1973).

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PLATES

These are a general photographic record of the study area. Not all are specifically referred to in the text.

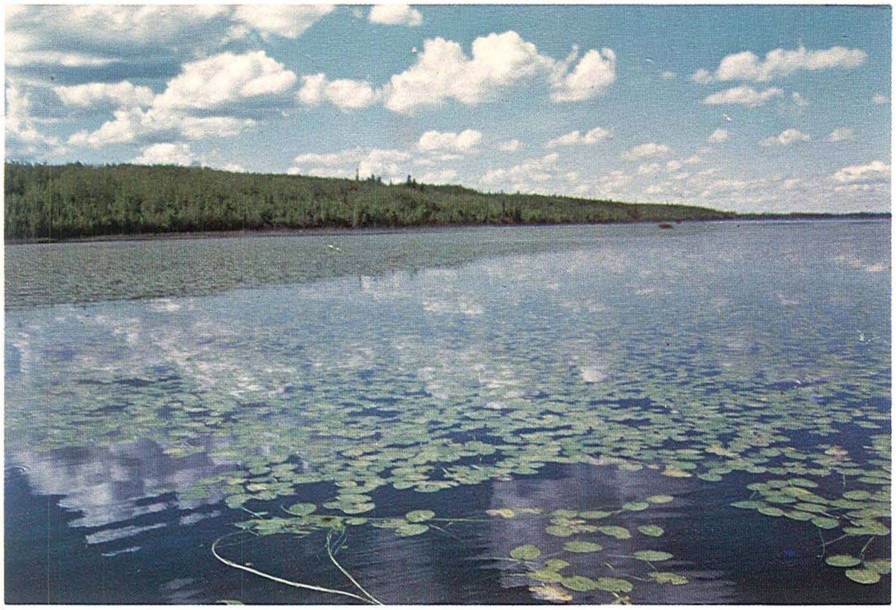

Plate 1. 7 Aug. 1974
Dense growths of lily pads (*Nuphar variegatum*) in Ruth Lake.

Plate 2. 25 June 1974
Horsetail (*Equisetum fluviatile*) growth on the southwest shore of Ruth Lake, showing typical width of the emergent zone.

Plate 3. 6 Aug. 1974
Extensive growths of emergents (mostly *Carex* and *Typha latifolia*) at the southeast end of Ruth Lake.

Plate 4. 6 Aug. 1974
Section S1, Ruth Lake, showing patches of *Typha latifolia* and *Scirpus validus.*

Plate 5. 6 Aug. 1974
Section S4, Ruth Lake, with *Scirpus validus.*

Plate 6. 6 Aug. 1974
Section S3, Ruth Lake, with *Sagittaria cuneata* in a dense band along the shore.

Plate 7. 25 June 1974
Shoreline section S5, Ruth Lake, showing dead, flooded brush.

Plate 8. 23 July 1974
Wash pail for Ekman samples, containing tar sand/silt substrate from Site B1, Poplar Creek.

Plate 9. 10 July 1974
Fish shocking in area S4, Poplar Creek, showing abundant driftwood and deadfall.

Plate 10. 24 Mar. 1974
Surber sampling, Poplar Creek, showing snow depth and overflow ice.

Plate 11. 20 Aug. 1974
Tar sand/gravel substrate near site B2, Poplar Creek. Brown/black pebbles are tar sand, with one broken open in center.

Plate 12. 23 July 1974
Shallow sand/silt "riffle" at site B1, Poplar Creek.

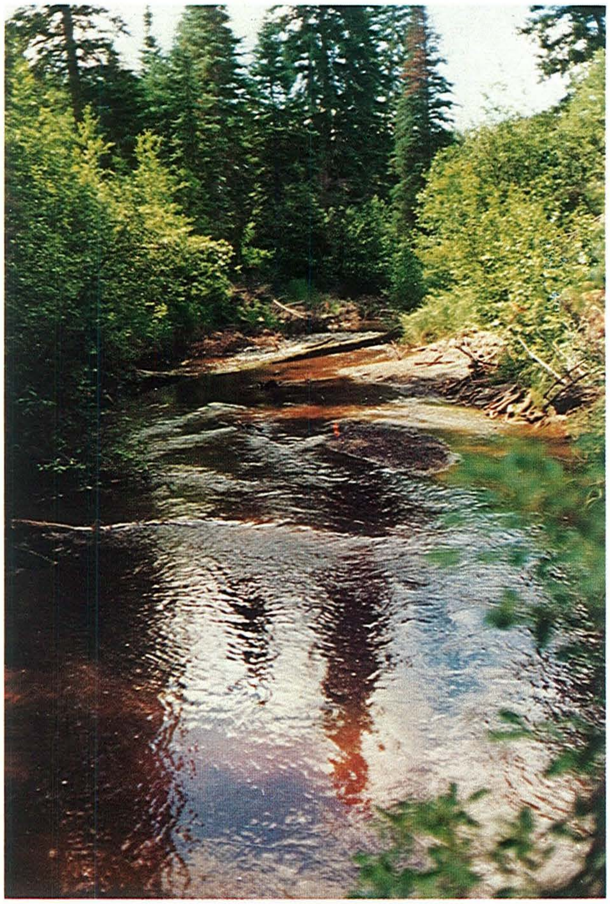

Plate 13. 10 July 1974
Site B2, the uppermost riffle. Poplar Creek.

Plate 14. 23 July 1974
Rubble from substrate at B2, Poplar Creek.

Plate 15. 23 July 1974
Rubble from the substrate of B3, Poplar Creek.

Plate 16. 27 June 1974
Riffle at site B3, Poplar Creek.

Plate 17. 27 June 1974
Riffle at site B4, Poplar Creek.

Plate 18. 18 Sept. 1974
Rubble-boulder substrate at site B4, Poplar Creek.

Plate 19. 20 Aug. 1974
Benthic invertebrates from site B2, Poplar Creek. *Heptagenia* — left; right — *Hydropsyche.*

Plate 20. 24 July 1974
Slackwater in lower section of Poplar Creek.

Plate 21. 23 July 1974
Active erosion on Poplar Creek between B1 and B2.

Plate 22. 24 July 1974
Deep slackwater on Poplar Creek near the confluence with the Athabasca River.

Plate 23. 10 July 1974
Fish shocking, area S6, Poplar Creek, showing upper section with shallow, gravel riffles.

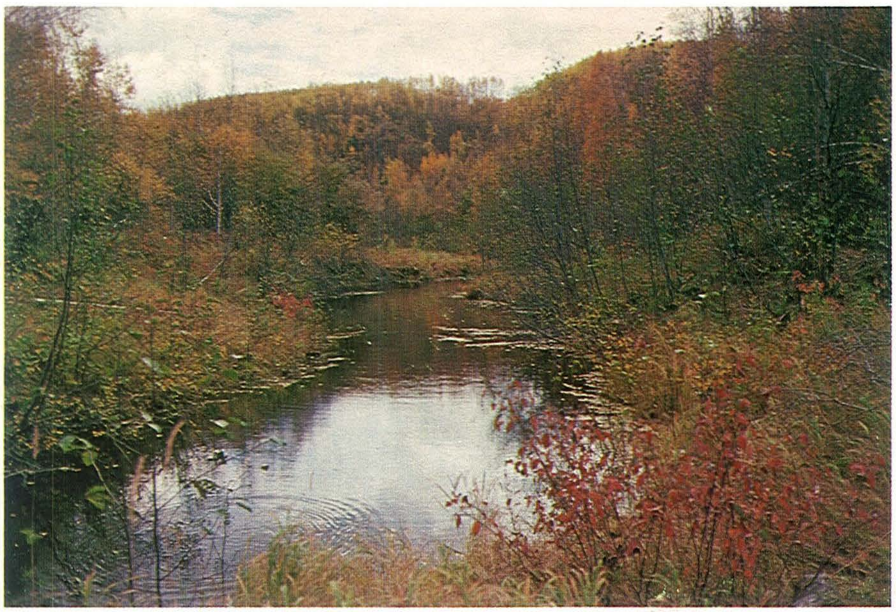

Plate 24. 18 Sept. 1974
Large beaver pond downstream from site B3, Poplar Creek.

Plate 25. 24 July 1974
Arctic grayling from upper section of Poplar Creek.