THE ALGAL TAXONOMY AND ECOLOGY OF A TRANSCONTINENTAL DIVIDE TRANSECT

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This is to certify that the

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ABSTRACT

THE ALGAL TAXONOMY AND ECOLOGY OF A
TRANSCONTINENTAL DIVIDE TRANSECT

by David Eugene Kidd

The algal taxonomy and ecology of a transcontinental divide transect was studied during the summers of 1961 and 1962. A check-list of algae was compiled along with the location, range of altitude, temperature, pH, total alkalinity, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and orthophosphate for each species collected. Six lakes were sampled about every two weeks from June 20, to September 3, 1962, to determine the net phytoplankton forms, quantitative counts of phytoplankton, and the water chemistry. Samples for quantitative counts were concentrated on a membrane filter; the enumeration procedure described by McNabb (1960) was used to estimate the species per liter of lake water. Three stations were sampled on each lake. Phytoplankton collections were made by pouring 7.2 liters of water through a number 25 silk bolting net. This concentrate was then poured through a Gelman polypore membrane filter apparatus. Most samples were collected between 9 o'clock and 11 o'clock in the morning. The results of this investigation are as follows:

1. Of the 195 species of algae collected in Glacier National Park, 96 are new records for the state of Montana.

2. The largest number of phytoplankton species occurs in warmer waters. It seems entirely possible that water temperature is one of the more important factors controlling algal floristic distribution in Glacier National Park.

3. The most frequently encountered abundant species, 656 or more individuals per liter were those in *Coscinodiscus*. The next most prominent phytoplankter genera were *Tabellaria*, *Fragilaria*, and *Asterionella*. Other relatively abundant algae were *Synedra* and *Dictyosphaerium pulchellum*.

4. The diatoms already mentioned above existed over a greater range of elevation and temperature than any of the other algae collected.

5. The community coefficient 2w/a+b was used to show that the phytoplankton populations between different stations sampled at the same time in one lake were heterogeneous in composition.

6. The use of 2w/a+b also showed that Glacier National Park lakes were very dissimilar at the first collecting period, then they became more similar during the second collecting period, and then became less similar again as the summer progressed. Further, the general meaning of the occurrences of stronger similarities was the

common blooming or at least high counts of one organism. The significance of low similarities is that there is shown striking differences in abundance of one or a very few organisms occurred between the lakes.

7. The use of community coefficients of similarity suggest that lakes on the west side of the continental divide appear to be more alike biologically than lakes on the east side of the continental divide.
8. Chemical determinations indicate that values for inorganic nitrogen were similar to values obtained elsewhere for similar habitats in the temperate zone. Fluctuations in the inorganic chemistry values and total organism count per liter indicate that interaction occurs between these two variables in the lakes investigated.
9. Orthophosphate was generally high in comparison to other alpine and subalpine regions. Fluctuations in orthophosphate and total organism count indicate that interaction took place between these two variables in the lakes studied.
10. Glacier National Park waters are mildly alkaline except for a few bog lakes.
11. Lower St. Mary Lake was the most productive lake studied. Productivity was measured in terms of number of organisms per liter.
12. Johns Lake with 72 species had the richest flora qualitatively.

THE ALGAL TAXONOMY AND ECOLOGY OF A TRANSCONTINENTAL DIVIDE TRANSECT

By

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Explanation of Graphs

All graphs were plotted on semi-log paper except for the productivity graphs which were plotted on ordinary graph paper. In certain instances the chemical and physical data require the reader to multiply the Y-axis values by a factor given along the X- axis. On some of the species per liter graphs the Y-axis has been labeled so as to include those species which would not fit on the original scale. A bar with a slanting end indicates a value which is off scale.

INTRODUCTION

The initiation of a limnological investigation of the taxonomy and ecology of algae along a transcontinental divide transect was undertaken to increase our knowledge of alpine and subalpine algal ecology, especially in reference to western Montana.

Introduction: Review of Literature

The intent of the following review of literature is to emphasize how few limnological investigations have been made on Montana lakes. Relatively few papers deal directly with the algae of this region and no previous Montana studies have related the ranges of physical and chemical conditions directly to each species collected. Also altitude ranges have never been recorded for algal species in alpine Montana.

The earliest limnological investigations in Montana were by Evermann in 1891 when he made a reconnaissance of the streams and lakes of western Montana and northwestern Wyoming, and by Anderson and Kelsey (1891), who published on Montana algae. These investigations were followed by Forbes in 1893, who compiled a preliminary report on the invertebrate fauna of Yellowstone National Park, Wyoming, and of the Flathead region, Montana. The first study to include Glacier National Park was by Elrod in 1901. His principal emphasis was on aquatic invertebrates; algae were not included.

Another report dealing with algae in Montana was an unpublished paper by Waters on his 1928 investigations of

Flathead Lake, Montana; included were both algal counts and water chemistry. He recorded no measurable nitrates or nitrites at the surface nor at a depth of 300 ft. He noted that light penetrated to a depth of 300 ft. and that some diatoms were found at this level. He also recorded a pH range from 8.21-8.65 and a low, free carbon dioxide-content. In his notes he stated that in July, 1928 there was an average of 125,000 algae per m^3. His results showed that there was a total of 138 genera and 280 species for Flathead Lake. The Chlorophyta had the most representatives.

A second limnological investigation on Flathead Lake was by Young in 1935, who found a predominence of diatoms in the phytoplankton. Apparently a gap occurs in Montana algal literature until the writing of Vinyard's M.S. thesis in 1951, concerning the Distribution of Alpine and Subalpine Algae in the Western United States. In this he records 19 genera and 39 species for northern Montana. The next study was by Lauff in 1953, who recorded 47 genera of algae in the plankton of Rogers Lake, Montana. Lauff noted that pH does not seem to be a limiting factor for algal growth but that it was related to photosynthetic activity in so far as high photosynthesis was coincident with high pH. He did not draw any conclusions as to correlations between water chemistry and phytoplankton counts.

In 1954 John Schindler gave records of the algae and water chemistry for a series of lakes and ponds in the Flathead Basin region. His data indicate very high bicarbonate measurements. This is of interest because lakes of the park region are low in bicarbonates. In general he recorded low values for nitrogen which is consistent with observations made during the present study. Schindler also noted that the Chlorophyta was represented by the most algal forms.

Potter and Baker (1956) in their study of the microbial populations of Flathead and Rogers Lakes recorded a temperature range for water samples from 11-20° C., and a pH range of 7.6 to 8.2 A further study by Potter and Baker (1961) on Flathead and Rogers Lakes show for the former a range of M. O. alkalinity of 10.2-112.3 ppm., traces of ammonia, nitrite almost absent, small amounts of nitrates, and erratic occurences of small amounts of phosphates. For Rogers Lake their results were approximately the same as for Flathead Lake.

Vinyard, in 1957, wrote a paper which is the only publication dealing entirely with the algae of Glacier National Park.

In addition, a M. S. thesis by Garric in 1960 records a few genera of snow algae from Logan Pass in Glacier National Park.

Introduction: Specific Objectives

The specific objective of this investigation was to study the algal distribution and ecology throughout a trans-continental divide transect. This was accomplished by making hand-grabs, net tows, collection of samples with a Kemmerer sampler for quantitative phytoplankton counts (total organisms per liter will be used to indicate productivity), and the measurement of ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, orthophosphate, pH, total alkalinity, and temperature.

Introduction: Geologic History of Glacier National Park

Important in any consideration of the ecology of a region are those geophysical forces of nature which determine habitats and which subsequently modify them through geophysical energy cycles. In addition, different types of rocks and minerals are formed which eventually provide both essential and nonessential substances that may be metabolized by the biota. Therefore the following geologic account of the park region taken from Dyson (1960) will relate the formation of some of the habitats where algal collections were made and the nature of the various rocks and minerals found there.

Most rocks of the park region are sedimentary. They compose a large syncline whose maximum thickness is about 20,000 feet. The east crest forms the Lewis Range and the west crest the Livingston Range. These are similar in age to the rocks found in the core of the Uinta Range in Utah and in the bottom of the Grand Canyon, Arizona.

During Pre-Cambrian times a giant geosyncline formed over a long narrow section of North America from the Arctic Ocean to Arizona and Southern California. Compaction of mud into shale, sand into sandstone, and the formation of limestone took place in the shallow sea of this geosyncline.

Fossil animals and calcareous algal concretions provide evidence that a sea did exist in Pre-Cambrian times. Today one may see rock outcrops in the park containing fossil algae.

Rock types making up these Pre-Cambrian formations are sandy dolomites (magnesium limestones). These are the oldest rocks in the park and form the dam holding Swift Current Lake and also create Swift Current Falls. On top of this formation is a zone of greenish shales and also shales which have been metamorphosed to argillites (recrystalized shales). Superimposed on these shales is a red zone composed of Grinnel argillites, white layers of interbedded quartzite, and iron oxide which produces the red color. All Glacier National Park rocks possess some iron or iron-bearing minerals. Above this formation occurs a zone of thick limestone which contains a 60-foot-thick bed of fossil algae with masses up to several feet in diameter. Above this zone is another stratum of limestone beds and overlying these are a few outcrops in the park containing casts of salt crystals, evidence of a once arid climate and much evaporation of the sea.

Igneous rocks are to be found in the park interbedded with and cutting across the sedimentary layers. Typical igneous rocks found in the park are basalt, granite and diorite. Igneous rock formations are of interest to aquatic ecology because lakes located in these regions are generally low in salts and are usually low in total hardness.

The Cretaceous period was marked by burying of the Pre-Cambrian layers under thick residues of mud and sand. At the end of the Cretaceous period the Laramide revolution occurred. This effected the rock formations of the park region by causing pressure from a westerly direction to uplift the rock formations into what is now called the Lewis overthrust. This overthrust resulted in a fold which gradually overturned on the more easterly formations and resulted in placing the older formations on top of the younger ones. The younger layers would be the cretaceous shales and slates which underlie the plains to the east of the park. The older formations which are now uppermost in the park underwent gradational changes. After the Lewis overthrust occurred the block broke in a verticle fault and the present valley of the North Fork of the Flathead River lies on the down-faulted portion of this block. The fault line is marked by the western boundary of the Livingston Range. Then this down-faulted region was covered by clay.

On the east side of the park the Swift Current, St. Mary, and other valleys are underlaid by cretaceous shales which generally are overlaid by a glacial moraine; but which are exposed in the Swift Current Valley along the road to Babb and along the shores of the Sherborne Reservoir, and also exposed near the Many Glaciers park entrance. The bumpy topography of the east side of the park is due to slumping of these shales.

Miocene and Pliocene times were characterized by deep stream erosion through the overthrust block resulting in a "mature" topography like that found presently in the Blue Ridge of Virginia and North Carolina. This erosional activity took place over a span of several million years until the end of the Pliocene when the climate cooled and marked the advent of the Pleistocene ice age. The glaciers of the ice age cut deeper the valleys formed by stream erosion during Miocene and Pliocene times and carved the existing mountainous features of the present park relief. No glaciers existed in the park from 5,000 to 1,000 B.C. but since that period the present glaciers of the park were formed and reached a maximum during the middle 1850's. Glaciers of the park now face extinction if the climate continues to grow milder. It is interesting to note that post Pleistocene glacial events are forming vertical sided valleys with many potholes in the floor. Another post glacial event of direct import to this study is the formation of large alluvial fans which have dammed streams to form St. Mary and Lower St. Mary Lakes. These alluvial fans have been formed by Swift Current Creek. As a result of glaciation the park abounds in such glacial features as cirques, U-shaped valleys, glacial stairways, glacial scours resulting in rock-basin lakes, pater noster lakes (a string of rock-basin lakes), hanging valleys, aretes, cols or passes, horns, waterfalls, lakes held in by outwash, lakes held in by alluvial fans, morainal lakes, and moraines (Dyson 1948, 1948a).

Lower St. Mary Lake is present in regions where the main rock type is shale. Swift Current Lake is in a shale region also but does come into contact with magnesium limestones. Johns Lake, Bowman Lake, Lake McDonald and Lost Lake are in regions where argillites are prevalent. Hidden Lake is in a magnesium limestone region.

PLAN OF STUDY

Duration of Investigation

Two summers were spent in field work. During the first summer ('61) as many habitats were visited as possible and particular attention was given to algal collections and identifications. Some chemical analyses were made using the Hellige visual comparator and Hellige methods which are found in _Standard Methods for the Examination of Water and Wastewater_. The second summer ('62) was utilized in further taxonomic endeavor and in the biweekly study of the plankton from selected lakes during the period of June 20 to September 7.

The second summer operation included identification of net phytoplankton, and in a recording of lake productivity (phytoplankton counts). Limnological data collected include temperature, pH, total alkalinity, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and orthophosphate. These con - stitute factors which are regarded as critical in determining the quality and quantity of algal flora and aquatic biota in general. During this period chemical analyses were made by the Hach D R Colorimeter and Hach chemical methods which are modifications of the procedures in _Standard Methods for the Examination of Water and Wastewater_. (See Appendix)

Criteria for Selection of Lakes

The following features contributed to selection of the lakes: accessibility; altitude; whether the lake was morainal, bog, or a glacial scour; and the direction from the continental divide.

Selected were Lake McDonald, altitude 3,144 ft., west of continental divide, accessible by car, a morainal lake; Bowman Lake, altitude 4,020 ft., west of continental divide, accessible by car, a morainal lake; Johns Lake, altitude 3,300 ft., west of continental divide, accessible by 0.9 of a mile hike, with a distinctive algal flora, a bog lake; Hidden Lake, altitude 6,375 ft., accessible by a 2-mile hike, on continental divide, a glacial scour lake; Swift Current Lake, altitude 4,861 ft., east of continental divide, accessible by car, a glacial scour lake; Lost Lake, altitude 4,700 ft., accessible by car, east of continental divide, a glacial scour lake; Lower St. Mary Lake, altitude, 4,462 ft., accessible by car, east of continental divide, a flowage lake, dammed by an alluvial fan.

Collection Equipment

A two-man rubber boat was used to collect plankton and water samples. Although it was light, and easily stored for transportation, it was difficult to use for limnological work. Net tows were obtained with a No. 25 silk tow-net. All samples were preserved with Transeau's solution (six parts water to three parts 95% ethyl alcohol and one part formaldehyde). Samples for plankton counting were obtained with a 1200 ml. Kemmerer sampler.

Selection of Collecting Stations

In each lake three stations were selected. These were located as follows:

1. Lake McDonald - Station I at the east end near

inlet (McDonald Creek) stream close to the Lake McDonald Motel; Station II (west) at the Apgar picnic grounds; Station III near the outlet stream at Apgar village.

2. Johns Lake - Station I at east end of lake; Station II in the middle, Station III at the west end.
3. Bowman Lake - Station I at the northeast of ranger station; Station II at the middle of the bay in front of the Bowman Lake picnic grounds; Station III near the outlet stream (Bowman Creek). All of these stations are located at the west end of Bowman Lake.
4. Hidden Lake - Station I about 0.5 of a mile beyond the head of the outlet creek in a westerly direction; Station II near the outlet stream; and Station III about 0.5 of a mile from the outlet stream in an easterly direction; all of the stations were at the north (lower) end of the lake.
5. Lost Lake - Station I near east shore; Station II in the middle of the lake; and Station III near the west shore.
6. Swift Current Lake - Station I near the boat launching area; Station II opposite the south end of the hotel in the middle of the lake; Station III in the middle of the north sector of the lake.
7. Lower St. Mary Lake - Station I near the boat dock at the Chief Chewing Bone picnic area; Station II

near the boat dock at the Malmstrom Airforce Base Recreation Area; Station III at the west end of the lake near the inlet stream.

Criteria for Selection of Physical and Chemical Factors

Physical and chemical factors were selected on the basis of presumed importance and whether they were feasibly adaptable to field determination. Temperature was recorded by a Taylor maximum-minimum thermometer. Temperature was regarded as an important ecological factor because it acts as a controlling agent related to the range of specific tolerance for organisms. It thus can have a bearing on growth, metabolism, and time of reproduction.

The chemical factor pH was investigated. A Beckman portable pH meter was used for these determinations. This meter was found to be very reliable and tested out correctly on standardized reference pH solutions. This factor is important because of its effect, both direct and indirect, on the metabolism of organisms and because of its role in the carbon dioxide, carbonate buffering system.

A second chemical factor investigated was bicarbonate alkalinity because of its role in the carbon dioxide, carbonate buffering system. This was determined by titration to the methyl orange turning point, using standard acid. The Beckman electrode was used instead of the indicator to record this turning point.

A third chemical factor, nitrogen, was studied because of its role in the synthesis and maintenance of proteins. Tests for ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen were made.

A fourth chemical factor studied was phosphorus because it is important in the cell's energy transfer activities. The type tested for was orthophosphate because it is the form which is in solution in natural waters.

Sampling Procedure

At each station on a lake, net tows were taken by casting out the net or by towing the net behind the boat. A Kemmerer sampler was used to collect 3,600 ml. of water from a depth of 15 ft. and a like amount from the surface. Each bottle-full was strained through a No. 25 silk plankton net. Thus the concentrate obtained represented the algae in 7,200 ml. of water. Surface and a 15 foot-depth were selected because some algae are less bouyant than others and it was believed that these two levels would provide a representative collection of phytoplankton. Trial and error showed that straining of 7,200 ml. of water would provide workable results, also perusal of the literature showed that some investigators used between one and ten L. of water. This concentrate was used later for phytoplankton quantitative counts.

General Comments

Chemical determinations were made usually within one or two hours of sampling. Samples for chemical testing were taken from the same levels as the algal collections. In a first series of samplings three collections were taken from each depth, but this was reduced to one from each depth because of the increased time factor involved in analyzing such a large number of samples. At one time the samples had to be preserved and determined several days later because the analytical equipment was not available. At the end of the summer the light bulb in the apparatus failed and there was a delay before it could be replaced. Thus the phosphate and nitrogen tests were completed several weeks later. It was also found that one series of ammonia nitrogen tests could not be run because of interference from the chloroform preservative.

Counting Procedure

The enumeration procedure for estimating phytoplankton abundance was based on a membrane filter method (McNabb, 1960). No one method of counting has been found to be completely satisfactory for the enumeration of phytoplankton. Methods commonly used are the Sedgwick-Rafter and the nannoplankton counting procedures. The Sedgwick-Rafter method was rejected for use in this study because the high power objective of the microscope can not be used. Both methods depend upon various settling and or concentrating procedures which are time consuming and sometimes require complicated centrifuging equipment. Therefore, these methods were rejected. The membrane filter method was adopted because it is a rapid technique which has been substantiated statistically. No study has appeared in the literature which refutes the basic assumption of this method, that the organisms are randomly distributed on the filter. In this method an effort was made to select a quadrat size so as to have the most numerous organism occur in 80 to 90 percent of the fields enumerated. For this study the quadrat used was the entire field of a 20X ocular eyepiece. This allowed Tabellaria Sp. in Lower St. Mary Lake to fulfill such a requirement. Then the relative abundance of the phytoplankton in the other park lakes could be compared to Tabellaria Sp. in Lower St Mary Lake.

Statistical evidence for the acceptance of this technique is provided in McNabb's 1960 paper. He points out that " the validity for conversion of frequency values, (F), to theoretical density, (d), is based on the assumption that the organisms are randomly distributed on the filter."

The counting procedure used was as follows:

1. The volume of the preserved sample was increased to 50 ml. with 4% formalin solution.
2. The sample was then filtered through a 2-in.-diameter 0.85 polypore filter clamped in a Gelman membrane filter apparatus which was attached to a Buchner funnel. A vacuum was created by means of an air pump with the piston reversed in the cylinder.
3. Ceder oil was added to the filter which becomes cleared in the dark after about 7 hrs.
4. The dried filter was mounted on a microscope slide to make a bubble-free preparation when the cover slip is dropped on.

5. The occurrences of a species was counted in each of 30 microscope fields selected at random.

6. The frequency-percentage was calculated by

$$F = \frac{\text{total number of occurrences of a species}}{\text{total number of quadrats examined}}$$

7. Then F-percentage was converted to a theorectical density value (d) by entering a table which converts F-percentage to d (Fracker and Brischle (1944) in McNabb, 1960).

8. The number of species per liter was estimated by

$$\frac{(\text{d})\ (\text{area of filter})}{(\text{area of quadrate used})\ \ (\text{number of liters filtered through the plankton net})}$$

The calculation for this estimation would be as follows:

area of filter equals 2025.8 mm^2

area of 'scope field equals 0.03 mm^2

substituting in the above formula one finds that the

$$\text{species/l} = \frac{(\text{d})\ (2025.8\ mm^2)}{(0.03\ mm^2)\ (7.2\ \text{l})}$$

species/l = (d) (9378)

The advantages of this method are that the filter retains very small organisms and all the organisms are distributed randomly on the filter. High magnification can be used to identify species, but it is suggested that one first identify the organisms in a net tow because it sometimes is difficult to see the organisms clearly. Oil immersion could be used if necessary. The enumeration procedure for each slide is relatively short and these slides can be made permanent for future reference if necessary. Another advantage is that the method can be used in the field so that only a thin filter is brought home instead of gallons of water. The disadvantages are that living forms are not present and it is sometimes difficult to see the sheaths and other taxonomic features of some preserved organisms.

Taxonomy and Ecology

Table 1. provides tabulations of all forms collected. In the Park, 9 classes, 21 orders, 48 families, 96 genera, and 195 species of algae were collected. It is evident from the table that the phylum Chlorophyta predominates. The major group in this class is the Desmids collected mostly from one bog lake. Compared to some regions this total number of species would not be considered large, but considering the rigors of the habitat they represent a relatively rich flora.

A check-list of algae is found on pages 18 through 80. In this check-list will be found the dimensions of the organisms, the pertinent physical and chemical data of their environment, and the altitude at which they were collected. There are 96 new records of algae for Montana.

Table 1. Tabulation of the Algae in Glacier National Park

Phylum	Classes	Orders	Families	Genera	Species
Rhodophyta	1	1	2	2	2
Chlorophyta	2	9	21	43	113
Chrysophyta	3	6	15	24	27
Pyrrhophyta	1	1	2	2	4
Euglenophyta	1	2	2	5	8
Cyanophyta	1	2	6	20	41
Total	9	21	48	96	195

A Check-List of Algae

(New Records for Montana*)

Division CHLOROPHYTA

Class CHLOROPHYCEAE

Order VOLVOCALES

Family CHLAMYDOMONADACEAE

Chlamydomonas Sp.

Encysted spores only

Temp. 12.2° C. — NO_2-N 0.003-0.005 ppm.

pH 7.1-7.2 — NO_3-N 0.045 ppm.

Total Alk. 40-44 mg/l. — Ortho-PO_4 0.06-0.08 ppm.

NH_4-N 0.0 ppm.

Hidden Lake

Altitude 6375 ft.

Family VOLVOCACEAE

Eudorina elegans Ehrenberg

Cell diam. 8.8-11 u.

Colony diam. 50.6 u.

Temp. 14° C. — NO_2-N 0.001 ppm.

pH 7.2 — NO_3-N 0.034 ppm.

Total Alk. 74 mg/l. — Ortho-PO4 0.04 ppm.

NH_4-N 0.0 ppm.

Lower St. Mary Lake

Altitude 3489 ft.

<u>Pandorina morum</u> (Muell.) Bory.

Cell length 12.6 u.

Cell width 10.5 u.

Colony diam. 35.7 u.

Temp. 7.78-25° C. — NO_2-N 0.0-0.002 ppm.

pH 7.2-8.5 — NO_3-N 0.0-0.018 ppm.

Total Alk. 16-178 mg/l. — Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0-0.06 ppm.

Mud Lake; Bowman Lake; Lake McDonald; Johns Lake

Altitude 3144-4020 ft.

<u>Volvox aureus</u> Ehrenberg

Temp. 22.5° C. — NO_2-N 0.0 ppm.

pH 7.8 — NO_3-N 0.0 ppm.

Total Alk. 30 mg/l. — Ortho-PO_4 0.067 ppm.

NH_4-N 0.0 ppm.

Johns Lake

Altitude 3300 ft.

Order TETRASPORALES

Family PALMELLACEAE

<u>Gloeocystis ampla</u> (Kuetz.) Lagerheim

Cell length 10.5 u.

Cell width 8.4 u.

Temp. 11.5-25.56° C. — NO_2-N 0.0-0.01 ppm.

pH 6.9-7.7 — NO_3-N 0.0-0.137 ppm.

Total Alk. 16-54 mg/l. — Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0-0.195 ppm.

Lost Lake; Johns Lake

Altitude 3300-4700 ft.

Gloeocystis major Gerneck ex Lemmermann

Cell length 18.9 u.

Cell width 25.2 u.

Temp. 24^{o} C.

pH 7.8-8

Total Alk. 140-144 mg/l.

Mud Lake

Altitude 3489 ft.

Gloeocystis vesiculosa **Nageli**

Temp. 16.5-17.2^{o} C. NO_2-N 0.0-0.002 ppm.

pH 7.1-7.2 NO_3-N 0.018-0.098 ppm.

Total Alk. 56-60 mg/l. Ortho-PO_4 0.02-0.03 ppm.

Lake McDonald

Altitude 3144 ft.

Sphaerocystis Schroeteri Chodat

Cell diam. 4.2-10.5 u.

Colony diam. 31.5 u.

Temp. 9-25.56^{o} C. NO_2-N 0.0-0.027 ppm.

pH 6.9-8.5 NO_3-N 0.0-0.05 ppm.

Total Alk. 16-180 mg/l. Ortho-PO_4 0.0-0.2 ppm.

Avalanche Lake; Lubec Lake; Mud Lake; Lake McDonald; Bowman Lake; Johns Lake; St. Mary Lake; Lower St. Mary Lake; Hidden Lake; Lost Lake

Altitude 3144- 6375 ft.

Family TETRASPORACEAE

<u>Schizochlamys</u> <u>gelatinosa</u> A. Braun

Cell diam. 10.5 u.

Temp. 25^{o} C. NO_2-N 0.0-0.002 ppm.

pH 7.2 NO_3-N 0.0-0.18 ppm

Total Alk. 16-20 mg/l. Ortho-PO_4 0.02-0.05 ppm.

NH_4-N 0.05-0.06 ppm.

McGee Meadow "Moose Pond"; Johns Lake

Altitude 3300-3855 ft.

<u>Tetraspora</u> <u>gelatinosa</u> (Vauch.) Desvaux

Cell diam. 8.4 u.

pH 7.2-7.4

Total Alk. 38 mg/l.

Temporary pool below Swift Current Falls; Logan Pass; Avalanche Lake Inlet Creek

Altitude 3885-7000 ft.

<u>Tetraspora</u> <u>lacustris</u> Lemmermann*

Cell diam. 6.3-8.4 u.

Temp. 14.44-17.22^{o} C. NO_2-N 0.0-0.005 ppm.

pH 7.2-8 NO_3-N 0.0-0.038 ppm.

Total Alk. 40-52 mg/l. Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0-0.25 ppm.

Lost Lake

Altitude 4700 ft.

Family COCCOMYXACEAE

<u>Chlorosarcina</u> <u>consociata</u> (Klebs)*

Cell length 21 u.

Cell width 12.6-14.7 u.

Colony diam. 42-52 u.

Temp. 12.78-16.11° C

pH 7.4-7.7

Total Alk. 56-76 mg/l.

NH_4-N 0.0-0.01 ppm.

NO_2-N 0.0-0.004 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.02-0.2 ppm.

Bowman Lake

Altitude 4020 ft.

<u>Elakatothrix</u> <u>gelatinosa</u> Wille*

Cell length 21 u.

Cell width 4.2 u.

Temp. 16-25.56° C.

pH 6.8-7.6

Total Alk. 16-60 mg/l.

NH_4-N 0.0-0.14 ppm.

NO_2-N 0.0-0.01 ppm.

NO_3-N 0.0-0.038 ppm.

Ortho-PO_4 0.0-0.1 ppm.

Johns Lake; Lower St. Mary Lake; Lost Lake

Altitude 3300-4700 ft.

Order ULOTRICHALES

Family ULOTRICHACEAE

Ulothrix zonata (Weber & Mohr) Kuetzing

Cell length 25.2 u.

Cell width 12.6-18.9 u.

Temp. 10.5-22.5° C. | NO_2-N 0.0-0.005 ppm.
pH 7.3-8.3 | NO_3-N 0.0-0.038 ppm.
Total Alk. 16-84 mg/l. | Ortho-PO_4 0.02-0.1 ppm.
NH_4-N 0.0

Swift Current Lake; St. Mary Lake; Lower St. Mary Lake; Lubec Lake; St. Mary River; Quartz Creek; Lost Lake; Lake McDonald; McDonald Creek Inlet; Bowman Creek; Johns Lake

Altitude 3144-5300 ft.

Family MICROSPORACEAE

Microspora stagnorum (Kuetz.) Lagerheim

Cell width 8.4 u.

pH 7.2-7.4

Total Alk. 38 mg/l.

Avalanche Lake Inlet Stream

Altitude 3885 ft.

Microspora Sp.

Temp. 10.5-12.22° C. | NO_2-N 0.0 ppm.
pH 7.6-8.3 | NO_3-N 0.0 ppm.
Total Alk. 44-84 mg/l. | Ortho-PO_4 0.1 ppm.
NH_4-N 0.0-0.02 ppm.

Bowman Lake; St. Mary Lake; Swift Current Lake

Altitude 4020-4861

Family COLEOCHAETACEAE

Coleochaete pulvinata A. Braun*

Cell length 44.1 u.

Cell width 14.7-21 u.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

Order ULVALES

Family ULVACEAE

Monostroma bullosum Wittr.

Cell diam. 8.4 u.

Fish Creek

Altitude 3144

Order OEDOGONIALES

Family OEDOGONIACEAE

Bulbochaete Sp.

Temp. 10-24^{o} C. NO_2-N 0.0-0.002 ppm.

pH 7.5-8.5 NO_3-N 0.019-0.058 ppm.

Total Alk. 40-178 mg/l. Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0-0.03 ppm.

Lost Lake; Mud Lake; Swift Current Lake

Altitude 3481-4700 ft.

Oedogonium Sp.

Temp. 13-24° C. NO_2-N 0.0-0.005 ppm.

pH 7.2-8.8 NO_3-N 0.0-0.029 ppm.

Total Alk. 40-444 mg/l. Ortho-PO_4 0.0 0.15 ppm.

NH_4-N 0.0-0.25 ppm.

Swift Current Lake; Swift Current Falls; Mud Lake; Bowman Lake; Logan Pass, snow melt pool; Duck Lake; Lost Lake; McDonald Lake

Altitude 3144-7000 ft.

Order CLADOPHORALES

Family CLADOPHORACEAE

Cladophora fracta (Dillw.) Keutzing*

Cell length 21 u.

Cell width 10.5 u.

Temp. 22° C.

pH 10

Lubec Lake

Altitude 5300 ft.

Order CHLOROCOCCALES

Family DICTYOSPHAERIACEAE

Dictyosphaerium *pulchellum* Wood

Cell diam. 6.3 u.

Temp. 11.11-25° C

pH 6.9-7.9

Total Alk. 12-76 mg/l.

NH_4-N 0.0-0.046 ppm.

NO_2-N 0.0-0.008 ppm.

NO_3-N 0.0-0.046 ppm.

Ortho-PO_4 0.0-0.15 ppm.

Johns Lake; McGee Meadow "Moose Pond"; Lake McDonald;

Lower St Mary Lake

Altitude 3144-4462

Family CHARACIACEAE

Characium *falcatum* Schroeder*

Cell length 44.1 u.

Cell width 6.3 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

Characium *gracilipes* Lambert

Cell length 77.7 u.

Cell width 8.4 u.

Temp. 16.8° C.

pH 7.6-7.7

Total Alk. 44-48 mg/l.

Lost Lake

Altitude 4700 ft.

Family HYDRODICTYACEAE

<u>Pediastrum</u> <u>araneosum</u> var. <u>rugulosum</u>*
(G.S. West) G. M. Smith

Cell width 31.5 u.

Temp. 17.3-19.2^{o} C. NO_2-N 0.003-0.005 ppm.

pH 6.8-7 NO_3-N 0.027-0.035 ppm.

Total Alk. 20 mg/l. Ortho-PO_4 0.0-0.02 ppm.

Johns Lake

Altitude 3300 ft.

<u>Pediastrum</u> <u>Boryanum</u> (Turp.) Meneghini

Cell length 14.7 u.

Cell width 12.6-18.9 u.

Temp. 11.11-19.1^{o} C. NO_2-N 0.0-0.01 ppm.

pH 7.2-7.9 NO_3-N 0.0-0.032 ppm.

Total Alk. 40-52 mg/l. Ortho-PO_4 0.0-0.18 ppm.

NH_4-N 0.0-0.25 ppm.

Swift Current Lake; Duck Lake; Fishcap Lake; Lost Lake; Lake McDonald

Altitude 3144-5069 ft.

<u>Pediastrum</u> <u>Boryanum</u> var. <u>undulatum</u> Wille*

Cell length 21 u.

Cell width 18.9 u.

Colony diam. 147 u.

Temp. 12.78-17^{o} C. NO_2-N 0.002 ppm.

pH 7.4-8.8 NO_3-N 0.0-0.018 ppm.

Total Alk. 68-444 mg/l. Ortho-PO_4 0.05 ppm.

NH_4-N 0.0 ppm.

Bowman Lake; Fishcap Lake; Duck Lake

Altitude 4020-5069 ft.

<u>Pediastrum duplex</u> Meyen

Cell length 12.6 u.

Cell width 12.6 u.

Temp. 10-19.2° C.

pH 6.9-8

Total Alk. 24-84 mg/l.

NO_2-N 0.003-0.005 ppm.

NO_3-N 0.0035-0.037 ppm.

Ortho-PO_4 0.05 ppm.

Johns Lake; Bowman Lake

Altitude 3300-4020 ft.

<u>Pediastrum glanduliferum</u> Bennett*

Cell length 14.7 u.

Cell width 10.5 u.

Temp. 17.2° C.

pH 7.1-7.2

Total Alk. 60 mg/l.

NO_2-N 0.0 ppm.

NO_3-N 0.04-0.05 ppm.

Ortho-PO_4 0.02-0.03 ppm.

NH_4-N 0.08-0.15 ppm.

Lake McDonald

Altitude 3144 ft.

<u>Pediastrum integrum</u> Nageli*

Cell length 16.8-21 u.

Cell width 14.7-18.9 u.

Colony diam. 52.5 u.

Temp. 8-24° C.

pH 7.8-8.3

Total Alk. 52-180 mg/l.

Hidden Lake; Mud Lake

Altitude 3489-6375 ft.

Pediastrum obtusum Lucks*

Cell length 18.9 u.

Cell width 16.8 u.

Temp. 19.2-25^{o} C. NO_2-N 0.0-0.005 ppm.

pH 6.9-7.4 NO_3-N 0.0-0.037 ppm.

Total Alk. 16-24 mg/l. Ortho-PO_4 0.02-0.09 ppm.

NH_4-N 0.05-0.09 ppm.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

Pediastrum simplex (Meyen) Lemmermann

Cell length 27 u.

Cell width 12.6 u.

Temp. 14.44-17^{o} C. NO_2-N 0.004-0.005 ppm.

pH 7.6-8.8 NO_3-N 0.02 ppm.

Total Alk. 44-444 mg/l. Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.02-0.25 ppm.

Duck Lake; Lost Lake; Fishcap Lake

Altitude 4700-5069 ft.

Sorastrum spinulosum Nageli*

Cell length 10.5 u.

Cell width 6.3-10.5 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

Family COELASTRACEAE

Coelastrum cambricum Archer*

Cell diam. 10.5 u.

Temp. 19.2° C.

pH 6.9-7.2

Total Alk. 24 mg/l.

NH_4-N 0.0

NO_2-N 0.003-0.005 ppm.

NO_3-N 0.035-0.037 ppm.

Ortho-PO_4 0.05 ppm.

Johns Lake

Altitude 3300 ft.

Coelastrum microporum **Nageli***

Temp. 20-24° C.

pH 8.2-8.5

Total Alk. 156-178 mg/l.

Mud Lake

Altitude 3489 ft.

Family OÖCYSTACEAE

Ankistrodesmus falcatus (Corda) Ralfs.

Cell length 56.7 u.

Cell width 2.3 u.

Johns Lake

Altitude 3300 ft.

Ankistrodesmus spiralis (Turner) Lemmermann*

Temp. 22.5° C.

pH 7.8

Total Alk. 30 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.0 ppm.

NO_3-N 0.0 ppm.

Ortho-PO_4 0.067 ppm.

Johns Lake

Altitude 3300 ft.

<u>Oocystis</u> <u>Borgei</u> Snow

Cell length 16.8-21 u.

Cell width 8.4 u.

Temp. 18-20.5° C.

pH 7.7-8.1

Total Alk. 28-56 mg/l.

Lubec Lake; Lake McDonald

Altitude 3144-5300 ft.

<u>Oocystis</u> <u>gigas</u> Archer*

Cell length 57.2 u.

Cell width 30.8 u.

Colony width 77 u.

Colony length 99 u.

Temp. 15.5° C.

pH 7.5

Total Alk. 40-44 mg/l.

NH_4-N 0.02-0.03 ppm.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.02-0.058 ppm.

Ortho-PO_4 0.0 ppm.

Swift Current Lake

Altitude 4861 ft.

<u>Oocystis parva</u> West & West*

Cell length 11-18.9 u.

Cell width 6.6-10.5 u.

Colony diam. 33.6 u.

Temp. 16.11-24.44° C.

NO_2-N 0.0-0.006 ppm.

pH 6.9-8.8

NO_3-N 0.015-0.05 ppm.

Total Alk. 20-444 mg/l.

Ortho-PO_4 0.02-0.15 ppm.

NH_4-N 0.0-0.15 ppm.

Duck Lake; Johns Lake; Lake McDonald

Altitude 3144-5004 ft.

<u>Scotiella</u> Sp.

Cell length 18.9 u.

Cell width 4.2 u.

Logan Pass on snow

Altitude 7000 ft.

<u>Pectodictyon cubicum</u> Taft

Cell diam. 4.2 u.

Temp. 16.64-17.22° C.

NO_2-N 0.0-0.005 ppm.

pH 7.4-7.6

NO_3-N 0.0-0.018 ppm.

Total Alk. 44 mg/l.

Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0 ppm.

Lost Lake

Altitude 4700 ft.

Family SCENEDESMACEAE

Scenedesmus incrassatulus var. mononae G.M. Smith

Cell length 14.7 u.

Cell width 4.2 u.

Colony diam. 21 u.

Temp. 18.2-25.56° C.

pH 6.9-7.4

Total Alk. 16-20 mg/l.

NH_4-N 0.08-0.09 ppm.

NO_2-N 0.0-0.006 ppm.

NO_3-N 0.018-0.048 ppm.

Ortho-PO_4 0.02-0.09 ppm.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

Scenedesmus quadricauda (Turp.) de Brébisson

Cell length 11-12.6 u.

Cell width 2.1-4.4 u.

Colony width 14.7-22 u.

Spine length 14.7 u.

Temp. 15.5-16° C.

pH 7.2-7.4

Total Alk. 44-48 mg/l.

NH_4-N 0.0-0.05 ppm.

NO_2-N 0.003-0.005 ppm.

NO_3-N 0.0-0.015 ppm.

Ortho-PO_4 0.0-0.03 ppm.

Swift Current Lake; McGee Meadow "Moose pond"

Altitude 3855-4861 ft.

Scenedesmus quadricauda var. parvus G.M. Smith*

Cell length 4.2 u.

Cell width 14.7 u.

Colony width 42 u.

Spine length 12.6 u.

Johns Lake

Altitude 3300 ft.

Order ZYGNEMATALES

Family ZYGNEMATACEAE

<u>Moegoetia</u> Sp.

Temp. 10-24° C. | NO_2-N 0.0-0.001 ppm.

pH 7.2-8.5 | NO_3-N 0.019-0.03 ppm.

Total Alk. 20-178 mg/l. | Ortho-PO_4 0.05-0.2 ppm.

NH_4-N 0.0-0.02 ppm.

Mud Lake; Swift Current Lake; Bowman Creek; Johns Lake; Lake McDonald; Roadside pool near Avalanche Creek

Altitude 3300-4861 ft.

<u>Spirogyra varians</u> (Hass.).Kuetz.*

Cell width 31.5 u.

Spore width 35.7 u.

Temporary pool below Swift Current Falls

Altitude 4861 ft.

<u>Spirogyra</u> Sp.

Temp. 10.5-25.56° C. | NO_2-N 0.0-0.006 ppm.

pH 6.8-8.8 | NO_3-N 0.0-0.98 ppm.

Total Alk. 12-444 mg/l. | Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0-0.09 ppm.

Swift Current Lake; St. Mary Lake; Lubec Lake; Duck Lake; Logan Pass, snow melt pool; Road side spring near Avalanche Creek campground; McDonald Creek Inlet; Mud Lake; Fishcap Lake; Bowman Lake; McDonald Lake; Johns Lake

Altitude 3144-7000 ft.

<u>Spirogyra</u> <u>Weberi</u> (Kuetz.)*

Cell diam. 27.3 u.

Spore diam. 25.2 u.

Spore length 58. 8 u.

In seepage near fossil algae rock sign at the garden wall on highway 89

Altitude 3732 ft.

<u>Zygnema</u> Sp.

Temp. 10.5-24^{o} C.

pH 7.2-8.5

Total Alk. 32-178 mg/l.

Avalanche Lake Inlet Creek; Avalanche Lake; Fishcap Lake; Bowman Creek; St. Mary Lake; Swift Current Lake; McDonald Creek Inlet

Altitude 3144-5300 ft.

Family MESOTAENIACEAE

<u>Gonatozygon</u> <u>aculeatum</u> Hastings*

Cell length 33.2 u.

Cell width 10.5 u.

Temp. 12.22-15.5^{o} C.

pH 7.1-7.7

Total Alk. 32-56 mg/l.

NH_4-N 0.0-0.03 ppm.

NO_2-N 0.0-0.008 ppm.

NO_3-N 0.012-0.058 ppm.

Ortho-PO_4 0.0-0.12 ppm.

Swift Current Lake

Altitude 4861 ft.

<u>Gonatozygon monotaenium</u> De Bary*

Cell length 98.7 u.

Cell width 10.5 u.

Temp. $16.67-17.22^{o}$ C

pH 7.6-7.7

Total Alk. 44 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.0-0.018 ppm.

Ortho-PO_4 0.0-0.15 ppm.

Lost Lake

Altitude 4700 ft.

<u>Netrium Digitus</u> (Ehr.) Itzigsohn et Rothe*

Cell length 225-231 u.

Cell width 63 u.

Johns Lake; McGee Meadow "Moose Pond"

Altitude 3300-3855 ft.

Family DESMIDIACEAE

<u>Arthodesmus impar</u> (Jacobs.) Grönb.*

Cell length 21 u.

Cell width 35.7 u.

Temp. 16.8^{o} C.

pH 7.4-7.7

Total Alk. 44-48 mg/l.

NO_2-N 0.003-0.006 ppm.

NO_3-N 0.65-0.118 ppm.

Ortho-PO_4 0.0-0.02 ppm.

Lost Lake

Altitude 4700 ft.

Closterium aciculare T. West*

Temp. 14.44-15.56° C. NO_2-N 0.002 ppm.

pH 7.2-7.3 NO_3-N 0.018 ppm.

Total Alk. 44-48 mg/l. Ortho-PO_4 0.02-0.08 ppm.

Lost Lake

Altitude 4700 ft.

Closterium acutum var. *variable* (Lemm.) Krieger*

Cell length 168 u.

Cell width 8.4 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

Closterium Jenneri Ralfs.

Cell length 88 u.

Cell width 11 u..

Temp. 23° C. NO_2-N 0.0-0.004 ppm.

pH 7.2-7.4 NO_3-N 0.0 ppm.

Total Alk. 18-20 mg/l. Ortho-PO_4 0.035-0.055

NH_4-N 0.045-0.085 ppm.

Johns Lake

Altitude 3300 ft.

<u>Closterium Leibleinii</u> Kütz.

Cell length 63 u.

Cell width 12.6 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Closterium lineatum</u> Ehrenberg

Cell length 304 u.

Cell width 23.1 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

<u>Closterium moniliferam</u> (Bory.) Ehrenberg

Temp. 14.44-17.22° C — NO_2-N 0.002 ppm.

pH 7.3-8 — NO_3-N 0.018 ppm.

Total Alk. 40-52 mg/l. — Ortho-PO_4 0.02-0.08 ppm.

NH_4-N 0.0-0.05 ppm.

Lost Lake; In seepage near fossil algae rock sign at the garden wall on highway 89

Altitude 3732-4700 ft.

<u>Closterium</u> Sp.

Temp. 12.22° C. — NO_2-N 0.0 ppm.

pH 7.6 — NO_3-N 0.0 ppm.

Total Alk. 44-48 mg/l. — Ortho-PO_4 0.1 ppm.

NH_4-N 0.0-0.02 ppm.

Swift Current Lake

Altitude 4861 ft.

<u>Cosmarium binum</u> Nordstedt*

Cell length 57.2 u.

Cell width 41.8 u.

Isthmus 15.4 u.

Temp. 23.33-25.56° C.	NO_2-N 0.0 ppm.
pH 7.2-7.3	NO_3-N 0.03 ppm.
Total Alk. 16-20 mg/l.	Ortho-PO_4 0.03-0.05 ppm.
NH_4-N 0.06 ppm.	

Johns Lake

Altitude 3300 ft.

<u>Cosmarium dentatum</u> Wolle*

Cell length 132.3 u.

Cell width 94.5 u.

Isthmus 25.6 u.

Temp. 17.5-25° C.	NO_2-N 0.0-0.005 ppm.
pH 7.2	NO_3-N 0.0-0.037 ppm.
Total Alk. 16-36 mg/l.	Ortho-PO_4 0.02-0.15 ppm.
NH_4-N 0.0-0.06 ppm.	

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>difficile</u> Lütkemüller*

Cell length 48.4 u.

Cell width 17.6 u.

Isthmus 2.2 u.

Temp. 23° C. NO_2-N 0.002 ppm.

pH 7.2-7.4 NO_3-N 0.009-0.03 ppm.

Total Alk. 18-20 mg/l. Ortho-PO_4 0.02-0.09 ppm.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>margaritatum</u> (Lund.) Roy-Bissett

Cell length 90.3 u.

Cell width 65.1 u.

Isthmus 25.2 u.

Temp. 25° C. NO_2-N 0.0-0.002 ppm.

pH 7.2 NO_3-N 0.0-0.018 ppm.

Total Alk. 16-20 mg/l. Ortho-PO_4 0.02-0.05 ppm.

NH_4-N 0.05-0.06 ppm.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>moniliforme</u> (Turp.) Ralfs.*

Cell length 27.3-35.7 u.

Cell width 18.9-21 u.

Isthmus 4.2-6.3 u.

Temp. 18.25-25° C. NO_2-N 0.0-0.005 ppm.

pH 6.8-7.4 NO_3-N 0.0-0.035 ppm.

Total Alk. 16-24 mg/l. Ortho-PO_4 0.0-0.09 ppm.

NH_4-N 0.05-0.09 ppm.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>ovale</u> Ralfs*

Cell length 138.6 u.

Cell width 77 u.

Isthmus 55 u.

Temp. 17.22-17.78° C.

pH 7.5-7.7

Total Alk. 44-48 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.004 ppm.

NO_3-N 0.046 ppm.

Ortho-PO_4 0.06-0.08 ppm.

Lake McDonald

Altitude 3144 ft.

<u>Cosmarium</u> <u>pachydermum</u> Lund.

Cell length 94.5 u.

Cell width 73.5 u.

Isthmus 31.5 u.

Temp. 25° C.

pH 7.3-8.1

Total Alk. 16-24 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>phaseolus</u> var. <u>achondrum</u> Boldt*

Cell length 29.4 u.

Cell width 27.3 u.

Isthmus 6.2 u.

Mud Lake

Altitude 3489 ft.

Cosmarium portianum Archer

Cell length 37.8 u.

Cell width 27.3 u.

Isthmus 10.5 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

Cosmarium portianum var. nephroideum Wittrock*

Cell length 23.1 u.

Cell width 18.0 u.

Isthmus 6.3 u.

Temp. 25° C.

pH 7.3-8.1

Total Alk. 16-24 mg/l.

Johns Lake

Altitude 3300 ft.

Cosmarium pyramidatum var. transitorium Heimerl*

Cell length 77.7 u.

Cell width 50.4 u.

Isthmus 14.7 u.

Temp. 25° C.

pH 7.3-8.1

Total Alk. 16-24 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium portianum</u> Archer

Cell length 37.8 u.

Cell width 27.3 u.

Isthmus 10.5 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium portianum</u> var. <u>nephroideum</u> Wittrock*

Cell length 23.1 u.

Cell width 18.0 u.

Isthmus 6.3 u.

Temp. 25° C.

pH 7.3-8.1

Total Alk. 16-24 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium pyramidatum</u> var. <u>transitorium</u> Heimerl*

Cell length 77.7 u.

Cell width 50.4 u.

Isthmus 14.7 u.

Temp. 25° C.

pH 7.3-8.1

Total Alk. 16-24 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>reniforme</u> (Ralfs) Arch.*

Cell length 52.5 u.

Cell width 46.2 u.

Isthmus 10.5 u.

Temp. 19.2-25^{o} C.

pH 6.9-7.7

Total Alk. 16-24 mg/l.

NH_4-N 0.05-0.06 ppm.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.02-0.05 ppm.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>sexangulare</u> Lund.*

Cell length 22-37.4 u.

Cell width 15.4-33 u.

Isthmus 2.2-8.8 u.

Temp. 23.33-25.56^{o} C.

pH 7.2-7.3

Total Alk. 16-20 mg/l.

NH_4-N 0.0-0.03 ppm.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.0-0.03 ppm.

Ortho-PO_4 0.02-0.05 ppm.

Johns Lake

Altitude 3300 ft.

<u>Cosmarium</u> <u>speciosum</u> Lund.

Cell length 31.8 u.

Cell width 29.4 u.

Isthmus 10.5 u.

Temp. 7-8^{o} C.

pH 8.3

Total Alk. 43.1-57 mg/l.

Avalanche Lake

Altitude 3885 ft.

Cosmarium subtumidum Nordstedt*

Cell length 42 u.

Cell width 33.6 u.

Isthmus 6.3 u.

Temp. 24° C.

pH 8.5

Total Alk. 156-178 mg/l.

Mud Lake

Altitude 3489 ft.

Cosmarium Turpinii Brébisson*

Cell length 56.7 u.

Cell width 50.4 u.

Isthmus 12.6 u.

Temp. 12.22-16° C.

pH 7.1-7.6

Total Alk. 32-56 mg/l.

NH_4-N 0.0-0.05 ppm.

NO_2-N 0.0-0.008 ppm.

NO_3-N 0.0-0.032 ppm.

Ortho-PO_4 0.0-1.5 ppm.

Swift Current Lake

Altitude 4861 ft.

Cosmarium Turpinii var. *eximium* W. West*

Cell length 63 u.

Cell width 54.6 u.

Isthmus 10.5 u.

Temp. 12° C.

pH 7.8

Bullhead Lake

Altitude 5279 ft.

<u>Desmidium</u> <u>Baileyi</u> (Ralfs) Nordstedt*

Cell length 21 u.

Cell width 21 u.

Temp. 25° C.

pH 7.2

Total Alk. 16-20 mg/l.

NH_4-N 0.05-0.06 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.0-0.018 ppm.

Ortho-PO_4 0.02-0.05 ppm.

<u>Desmidium</u> <u>Swartzii</u> C. A. Agardh

Cell length 21.1 u.

Cell width 29.4 u.

Isthmus 23.1 u.

Temp. 19.2-25.56° C.

pH 6.9-7.2

Total Alk. 16-24 mg/l.

NH_4-N 0.02-0.06 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.05-0.15 ppm.

<u>Euastrum</u> <u>elegans</u> (Bréb.) Kütz.*

Cell length 31.5 u.

Cell width 23.1 u.

Isthmus 2.1 u.

Temp. 23.33-25.56° C.

pH 7.2-7.3

Total Alk. 16-20 mg/l.

NH_4-N 0.06 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.03 ppm.

Ortho-PO_4 0.03-0.05 ppm.

<u>Euastrum gemmatum</u> Brébisson*

Cell length 50.4-51.5 u.

Cell width 35.7-37.8 u.

Isthmus 8.4-10.5 u.

Johns Lake; McGee Meadow "Moose Pond"

Altitude 3300-3855 ft.

<u>Hyalotheca dissiliens</u> (Smith) Brébisson

Cell length 44.2 u.

Cell width 22 u.

Temp. 14.44-25.56° C.

pH 7.2-7.8

Total Alk. 16-60 mg/l.

NH_4-N 0.0-0.06 ppm.

NO_2-N 0.004-0.005 ppm.

NO_3-N 0.025-0.036 ppm.

Ortho-PO_4 0.08-0.12 ppm.

Johns Lake; Bowman Lake

Altitude 3300-4020 ft.

<u>Hyalotheca hians</u> Nordstedt*

Cell length 27.3 u.

Cell width 33.6 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Hyalotheca mucosa</u> (Dillw.) Ehrenberg

Temp. 12.22° C.

pH 7.1-7.7

Total Alk. 32-56 mg/l.

NH_4-N 0.0-0.02 ppm.

NO_2-N 0.0-0.008 ppm.

NO_3-N 0.0-0.032 ppm.

Ortho-PO_4 0.08-1.5 ppm.

Swift Current Lake

Altitude 4861 ft.

<u>Micrasterias</u> <u>denticulata</u> Brébisson*

Cell length 270 u.

Cell width 225 u.

Isthmus 45 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

<u>Micrasterias</u> <u>laticeps</u> Nordstedt*

Cell length 126 u.

Cell width 159.6 u.

Isthmus 21 u.

Temp. 25° C.

pH 7.2

Total Alk. 16-20 mg/l.

NH_4-N 0.0-0.06 ppm.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.02-0.05 ppm.

Johns Lake

Altitude 3300 ft.

<u>Micrasterias</u> <u>pinnatifida</u> (Kütz.) Ralfs*

Cell length 63 u.

Cell width 77.7u.

Isthmus 10.5 u.

Temp. 15-25.56° C.

pH 7.2-8.5

Total Alk. 12-178 mg/l.

NH_4-N 0.0-0.06 ppm.

NO_2-N 0.0-0.004 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.0-0.1 ppm.

Mud Lake; Johns Lake; Bowman Lake

Altitude 3300-4020 ft.

<u>Micrasterias radiata</u> Hass.*

Temp. 25° C. | NO_2-N 0.0-0.002 ppm.
pH 7.2 | NO_3-N 0.0-0.018 ppm.
Total Alk. 16-20 mg/l. | Ortho-PO_4 0.02-0.05 ppm.

NH_4-N 0.05-0.06 ppm.

Johns Lake

Altitude 3300 ft.

<u>Pleurotaenium trabecula</u> (Ehrbg.) Näg.*

Cell length 495 u.

Cell width 54 u.

Isthmus 45 u.

Lost Lake

Altitude 4700 ft.

<u>Spondylosium planum</u> (Wolle) West et G.S. West*

Cell length 12.6 u.

Cell width 12.6 u.

Isthmus 4.2 u.

Temp. 18-24.44° C. | NO_2-N 0.0-0.002 ppm.
pH 7.4 | NO_3-N 0.0-0.048 ppm.
Total Alk. 12-20 mg/l. | Ortho-PO_4 0.02-0.09 ppm.

NH_4-N 0.05-0.09 ppm.

Johns Lake

Altitude 3300 ft.

__Staurastrum arctiscon__ (Ehrenb.) Lund.

var. __glabrum__ West et West*

Cell length 108 u.

Cell width 108 u.

Isthmus 27 u.

Temp. 16.67-17.22° C.

pH 7.6-7.7

Total Alk. 44 mg/l.

NH_4-N 0.0 ppm.

Lost Lake

Altitude 4700 ft.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.0-0.018 ppm.

Ortho-PO_4 0.0-0.15 ppm.

__Staurastrum anatinum__ Cooke et Wills*

Cell length 56.7 u.

Cell width 31.8 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

__Staurastrum apiculatum__ Brébisson*

Temp. 12.22° C.

pH 7.1-7.7

Total Alk. 32-56 mg/l.

NH_4-N 0.0 ppm.

Swift Current Lake

Altitude 4861 ft.

NO_2-N 0.005-0.008 ppm.

NO_3-N 0.025-0.032 ppm.

Ortho-PO_4 0.08-1.5 ppm.

<u>Staurastrum</u> <u>brevispinum</u> Brébisson*

Cell length 31.5 u.

Cell width 31.5 u.

Isthmus 10.5 u.

Temp. 18.2° C.

pH 6.9

Total Alk. 20 mg/l.

NH_4-N 0.0 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.002-0.006 ppm.

NO_3-N 0.018-0.034 ppm.

Ortho-PO_4 0.05-0.1 ppm.

<u>Staurastrum</u> <u>cornutum</u> Arch.*

Cell length 33-35.7 u.

Cell width 35.7-39.6 u.

Isthmus 8.8-10.5 u.

Temp. 23.33-25.56° C.

pH 7.2-7.3

Total Alk. 16-20 mg/l.

NH_4-N 0.06 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.03 ppm.

Ortho-PO_4 0.05-0.1 ppm.

<u>Staurastrum</u> <u>cuspidatum</u> Brébisson*

Cell length 31.5-33.6 u.

Cell width 31.5-48.3 u.

Isthmus 8.4 u.

Temp. 17.22-25.56° C.

pH 6.9-8

Total Alk. 16-52 mg/l.

NH_4-N 0.0-0.09 ppm.

NO_2-N 0.0-0.02 ppm.

NO_3-N 0.018-0.071 ppm.

Ortho-PO_4 0.03-0.09 ppm.

Johns Lake; McGee Meadow "Moose pond"; Lost Lake

Altitude 3300-4700 ft.

Staurastrum Dickiei Ralfs.*

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

Staurastrum furcigerum Brébisson

Cell length 52.5-63 u.

Cell width 58.8-60.9 u.

Isthmus 21 u.

Temp. 12.22-25.56° C.

pH 7.4-7.6

Total Alk. 12-48 mg/l.

NH_4-N 0.0-0.09 ppm.

NO_2-N 0.0-0.002 ppm.

NO_3-N 0.0-0.048 ppm.

Ortho-PO_4 0.02-0.1 ppm.

Swift Current Lake; Johns Lake

Altitude 3300-4861 ft.

Staurastrum gracile Ralfs.

Cell length 31.5-73.5 u.

Cell width 52.5-110.1 u.

Isthmus 8.4-10.5 u.

Temp. 8.89-19.3° C.

pH 7.3-8.8

Total Alk. 40-444 mg/l.

NH_4-N 0.0-0.02 ppm.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.038 ppm.

Ortho-PO_4 0.05-0.15 ppm.

Swift Current Lake; Mud Lake; Duck Lake; Lost Lake; Lake McDonald

Altitude 3144-5004 ft.

Temp. 22.5^{o} C.

pH 7.8-7.9

Total Alk. 20-36 mg/l.

NH_4-N 0.0 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.0 ppm.

Ortho-PO_4 0.0-0.2 ppm.

<u>Staurastrum</u> <u>natator</u> West*

Cell length 31.5-37.4 u.

Cell width 66-69.3 u.

Isthmus 8.4-11 u.

Temp. 14.44-25.56^{o} C.

pH 7.1-7.9

Total Alk. 16-48 mg/l.

NH_4-N 0.0-0.25 ppm.

Johns Lake; Lost Lake

Altitude 3300-4700 ft.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.02 ppm.

Ortho-PO_4 0.0-0.15 ppm.

<u>Staurastrum</u> <u>Ophiura</u> Lund.*

Cell length 73.5 u.

Cell width 134.4 u.

Temp. 23^{o} C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

Staurastrum orbiculare var. depressum Roy et Biss.*

Cell length 25.2 u.

Cell width 25.2 u.

Isthmus 14.7 u.

Temp. 17.5° C.

pH 7.3-7.4

Total Alk. 20-32 mg/l.

NH_4-N 0.02 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.0 ppm.

Ortho-PO_4 0.0-0.08 ppm.

Staurastrum paradoxum Meyen*

Cell length 67.2 u.

Cell width 44-44.1 u.

Isthmus 10.5-12.6 u.

Temp. 12.22-25.56° C.

pH 6.8-8

Total Alk. 16-48 mg/l.

NH_4-N 0.0-0.14 ppm.

Swift Current Lake; Johns Lake; Lost Lake

Altitude 3300-4861 ft.

NO_2-N 0.0-0.01 ppm.

NO_3-N 0.0-0.07 ppm.

Ortho-PO_4 0.0-0.1 ppm.

Staurastrum tohopekaligense Wolle*

Cell length 41.8 u.

Cell width 33 u.

Temp. 23.33-25.56° C.

pH 7.2-7.3

Total Alk. 16-20 mg/l.

NH_4-N 0.06 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.03 ppm.

Ortho-PO_4 0.03-0.05 ppm.

Staurastrum teliferum Ralfs.*

Temp. 22.5° C.

pH 7.8-7.9

Total Alk. 20-36 mg/l.

NH_4-N 0.0 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.0 ppm.

Ortho-PO_4 0.0-0.2 ppm.

Staurastrum trifidium var. inflexum*

West et West

Cell length 33.6 u.

Cell width 42.u.

Isthmus 16.8 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

Staurastrum varians Raciborski*

Cell length 31.8 u.

Cell width 31.5 u.

Isthmus 14.7 u.

Temp. 6-8° C.

pH 7.9-8.3

Total Alk. 44 mg/l.

Avalanche Lake

Altitude 3885 ft.

Staurastrum dejectus (Bréb.) Teiling

Cell length 27.3 u.

Cell width 25.2 u.

Isthmus 6.3 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

Xanthidium antilopaeum Kuetz.*

Cell length 180.6 u.

Cell width 123.9-140.7 u.

Isthmus 16.8 u.

Temp. 11.2-18.2° C.

pH 6.9-7.6

Total Alk. 20-48 mg/l.

NH_4-N 0.0-0.03 ppm.

NO_2-N 0.0-0.008 ppm.

NO_3-N 0.0-0.034 ppm.

Ortho-PO_4 0.0-1 ppm.

Johns Lake; Swift Current Lake

Altitude 3300-4861 ft.

Xanthidium cristatum Brébisson

Cell length 68.2-79.8 u.

Cell width 52.5-55 u.

Isthmus 11-14.7 u.

Spine length 6.6 u.

Temp. 15-16.11° C.

pH 7.6-7.7

Total Alk. 56-60 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.003-0.004 ppm.

NO_3-N 0.026-0.037 ppm.

Ortho-PO_4 0.02-0.1 ppm.

Bowman Lake; Johns Lake

Altitude 3300-4020 ft.

Class CHAROPHYCEAE

Order CHARALES

Family CHARACEAE

Chara Sp.

Temp. 24° C.

pH 8

Total Alk. 136-155 mg/l.

Mud Lake

Altitude 3489 ft.

Division EUGLENOPHYTA

Class EUGLENOPHYCEAE

Order EUGLENALES

Family EUGLENACEAE

Euglena acus Ehrb.*

Cell length 94.5 u.

Cell width 10.5 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

Euglena charkowienses Swirenko

Cell length 70 ± u.

Cell width 14 ±

Mud Lake

Altitude 3489 ft.

Lepocinclis Sp.

Cell length 31.5 u.

Cell width 12.6 u.

Mud Lake

Altitude 3489 ft.

<u>Phacus</u> <u>caudatus</u> Hüber*

Cell length 33 u.

Cell width 19.8 u.

Mud Lake

Altitude 3489 ft.

<u>Phacus</u> <u>longicauda</u> var. <u>attenuata</u> (Pochm.) H. P.

Cell length 119.7 u.

Cell width 42 u.

Temp. 23° C.

pH 7.7

Total Alk. 20 mg/l.

Johns Lake

Altitude 3300 ft.

<u>Phacus</u> <u>suecicus</u> Lemm.*

Cell length 37.4 u.

Cell width 22 u.

Mud Lake

Altitude 3489 ft.

<u>Strombomonas</u> Sp.

Cell length 21 u.

Cell width 14.7 u.

Logan Pass

Altitude 7000 ft.

Order COLACIALES

Family COALIACEAE

Colacium arbuscula Stein*

Cell length 14.7 u.

Cell width 6.3-8.4 u.

Temp. 17° C.

pH 8.7-8.8

Total Alk. 412-44 mg/l.

Duck Lake

Altitude 5004 ft.

Division CHRYSOPHYTA

Class XANTHOPHYCEAE

Order HETEROTRICHALES

Family TRIBONEMATACEAE

Tribonema aequale Pascher

pH 7.7

Total Alk. 38 mg/l.

Mud Lake; Avalanche Lake

Altitude 3489-3885 ft.

Family VAUCHERIACEAE

Vaucheria pachydermum Walz.*

Oogonium width 12.6 u.

Avalanche Lake Inlet Stream

Altitude 3885 ft.

Class CHRYSOPHYCEAE

Order CHRYSOMONADALES

Family SYNURACEAE

Synura Adamsii G.M. Smith*

Cell length 18.9 u.

Cell width 12.6-14.7 u.

Temp. 13-16° C. NO_2-N 0.0-0.005 ppm.

pH 7.5-8.1 NO_3-N 0.0-0.015 ppm.

Total Alk. 48-76 mg/l. Ortho-PO_4 0.08-0.2 ppm.

NH_4-N 0.0 ppm.

Avalanche Lake; Swift Current Lake; Lower St. Mary Lake

Altitude 3885-4861 ft.

Family OCHROMONADACEAE

Dinobryon bavaricum Imhof.*

Cell length 46.2-73.5 u.

Cell width 10.5 u.

Temp. 10-16.7° C. NO_2-N 0.0-0.005 ppm.

pH 7.2-8.2 NO_3-N 0.0-0.038 ppm.

Total Alk. 28-84 mg/l. Ortho-PO_4 0.0-0.28 ppm.

NH_4-N 0.0-0.05 ppm.

Avalanche Lake; Bowman Lake; Lower St. Mary Lake

Altitude 3885-4700 ft.

Dinobryon divergens Imhof.*

Cell length 42 u.

Cell width 10.5 u.

Temp. 7.78-18.33° C. NO_2-N 0.0-0.005 ppm.

pH 7.1-8.4 NO_3-N 0.0-0.098 ppm.

Total Alk. 28-84 mg/l. Ortho-PO_4 0.0-0.28 ppm.

NH_4-N 0.0-0.15 ppm.

St. Mary Lake; Lubec Lake; Duck Lake; Bowman Lake; Avalanche Lake; Lower St. Mary Lake; Lake McDonald; Swift Current Lake

Altitude 3144-5300 ft.

Dinobryon sociale Ehrenberg*

Cell length 31.5 u.

Cell width 6.3-8.4 u.

Temp. 8.89-18.2^{o} C. | NO_2-N 0.0-0.006 ppm.

pH 6.9-8 | NO_3-N 0.0-0.058 ppm.

Total Alk. 20-64 mg/l. | Ortho-PO_4 0.0-0.15 ppm.

NH_4-N 0.0-0.25 ppm.

Swift Current Lake; McGee Meadow "Moose Pond";
Lower St. Mary Lake; Lost Lake; Johns Lake

Altitude 3300-4861 ft.

Order RHIZOCHRYSIDALES

Family RHIZOCHRYSIDACEAE

Lagynion Sp.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

Order CHRYSOCAPSALES

Family HYDRURACEAE

Hydrurus foetidus (Vill.) Trev.

McDonald Creek Inlet

Altitude 3144 ft.

Class BACILLARIOPHYCEAE

Order CENTRALES

Suborder COSCINODISCINEAE

Family COSCINODISCACEAE

<u>Coscinodiscus</u> Sp.

Temp. 7.78-25.56° C. NO_2-N 0.0-0.009 ppm.

pH 6.8-8 NO_3-N 0.0-0.98 ppm.

Total Alk. 12-180 mg/l. Ortho-PO_4 0.0-1.5 ppm.

NH_4 0.0-0.15 ppm.

St. Mary Lake; Mud Lake; Bowman Lake; Lost Lake; Lake McDonald; Hidden Lake; Swift Current Lake; Lower St. Mary Lake; Johns Lake

Altitude 3144-6375 ft.

<u>Cyclotella</u> Sp.

Temp. 11.11-24.44° C. NO_2-N 0.0-0.002 ppm.

pH 6-7.6 NO_3-N 0.0-0.048 ppm.

Total Alk. 20-60 mg/l. Ortho-PO_4 0.1-0.18 ppm.

NH_4-N 0.0-0.09 ppm.

Bowman Lake; Johns Lake

<u>Melosira</u> Sp.

Temp. 11.11-25.56° C. NO_2-N 0.0-0.005 ppm.

pH 6.8-8.2 NO_3-N 0.0-0.037 ppm.

Total Alk. 16-80 mg/l. Ortho-PO_4 0.0-0.18 ppm.

NH_4-N 0.0-0.14 ppm.

Avalanche Lake Inlet Stream; Swift Current Lake; Lower St. Mary Lake; Johns Lake; Bowman Lake; Lake McDonald

Altitude 3300-4861 ft.

Order PENNALES

Suborder FRAGILARINEAE

Family TABELLARIACEAE

Tabellaria Sp.

Temp. 10-25.56° C.

pH 6.9-8.2

Total Alk. 12-80 mg/l.

NH_4-N 0.0-0.25 ppm.

NO_2-N 0.0-0.01 ppm.

NO_3-N 0.0-0.098 ppm.

Ortho-PO_4 0.0-1.5 ppm.

St. Mary Lake; Swift Current Lake; Lost Lake; Johns Lake; Bowman Lake; Lake McDonald; Hidden Lake; Lower St. Mary Lake

Altitude 3144-6375 ft.

Tetracyclis Sp.

Temp. 15° C.

pH 7.5

Total Alk. 40-64 mg/l.

NH_4-N 0.0-0.03 ppm.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.058 ppm.

Ortho-PO_4 0.0-0.2 ppm.

Lower St. Mary Lake; Swift Current Lake

Altitude 4473-4861 ft.

Family FRAGILARIACEAE

Asterionella Sp.

Temp. 7.78-24° C.

pH 6.9-8.5

Total Alk. 20-178 mg/l.

NH_4-N 0.0-0.25 ppm.

NO_2-N 0.0-0.098 ppm.

NO_3-N 0.0-0.098 ppm.

Ortho-PO_4 0.0-1 ppm.

Johns Lake; St. Mary Lake; Mud Lake; Bowman Lake; Lake McDonald; Hidden Lake; Swift Current Lake; Lower St. Mary Lake; Lost Lake

Altitude 3144-6375 ft.

Fragilaria Sp.

Temp. 7.78-24° C. NO_2-N 0.0-0.008 ppm.

pH 6.9-8.4 NO_3-N 0.0-0.098 ppm.

Total Alk. 24-180 mg/l. Ortho-PO_4 0.0-1.5 ppm.

NH_4-N 0.0-0.15 ppm.

St. Mary Lake; Lubec Lake; Hidden Lake Mud Lake; Lower St. Mary Lake; Bowman Lake; Avalanche Lake; Johns Lake; Lake McDonald; Swift Current Lake; Lost Lake

Altitude 3144-6375 ft.

Synedra Sp.

Temp. 8.89-25° C. NO_2-N 0.0-0.01 ppm.

pH 6.8-8.4 NO_3-N 0.0-0.098 ppm.

Total Alk. 16-80 mg/l. Ortho-PO_4 0.0-1.5 ppm.

NH_4-N 0.0-0.25 ppm.

Avalanche Lake; St. Mary Lake; Lake McDonald; Lost Lake; Swift Current Lake; Lower St. Mary Lake; Bowman Lake; Johns Lake

Altitude 3144-4861 ft.

Family EUNOTIACEAE

Ceratoneis Sp.

Temp. 15.5° C. NO_2-N 0.0-0.002 ppm.

pH 7.5 NO_3-N 0.0-0.058 ppm.

Total Alk. 40-44 mg/l. Ortho-PO_4 0.0 ppm.

NH_4-N 0.02-0.03 ppm.

Swift Current Lake

Altitude 4861 ft.

Family ACHNANTHACEAE

Cocconeis Sp.

Temp. 12.22° C.

pH 7.1-7.7

Total Alk. 32-56 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.005-0.008 ppm.

NO_3-N 0.025-0.032 ppm.

Ortho-PO_4 0.08-1.5 ppm.

Swift Current Lake

Altitude 4861 ft.

Family NAVICULACEAE

Frustula Sp.

Temp. 18.2° C.

pH 6.9

Total Alk. 20 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.002-0.006 ppm.

NO_3-N 0.018-0.034 ppm.

Ortho-PO_4 0.05-0.1 ppm.

Johns Lake

Altitude 3300 ft.

Gyrosigma Sp.

Temp. 12.3° C.

pH 7.2

Total Alk. 10-11 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.003 ppm.

NO_3-N 0.027 ppm.

Hidden Lake

Altitude 6375 ft.

Navicula Sp.

Temp. 8.89-25.56° C.

pH 6.8-8

Total Alk. 12-80 mg/l.

NH_4-N 0.0-0.25 ppm.

NO_2-N 0.0-0.008 ppm.

NO_3-N 0.0-0.098 ppm.

Ortho-PO_4 0.0-1.5 ppm.

Lower St. Mary Lake; Swift Current Lake; Johns Lake; Bowman Lake; Lake McDonald

Altitude 3144-4861 ft.

Pinnularia Sp.

Temp. 11.11-25.56° C. NO_2-N 0.0-0.006 ppm.

pH 6.9-8 NO_3-N 0.0-0.038 ppm.

Total Alk. 12-48 mg/l. Ortho-PO_4 0.0-0.2 ppm.

NH_4-N 0.0-0.09 ppm.

Swift Current Lake; Bowman Lake; Johns Lake; Lake McDonald

Altitude 3144-4861 ft.

Family GOMPHONEMATACEAE

Gomphonema Sp.

Temp. 14.44-25.56° C. NO_2-N 0.0-0.006 ppm.

pH 6.8-8 NO_3-N 0.0-0.058 ppm.

Total Alk. 16-180 mg/l. Ortho-PO_4 0.0-0.1 ppm.

NH_4-N 0.0-0.09 ppm.

Logan Pass; Mud Lake; Hidden Lake; Swift Current Lake; Lower St. Mary Lake; Lost Lake; Johns Lake; Bowman Lake; Lake McDonald

Altitude 3144-7000 ft.

Family CYMBELLACEAE

Cymbella Sp.

Temp. 12.22-25.56° C. NO_2-N 0.0-0.01 ppm.

pH 6.9-8 NO_3-N 0.0-0.098 ppm.

Total Alk. 12-56 mg/l. Ortho-PO_4 0.0-1.5 ppm.

NH_4-N 0.0-0.14 ppm.

Swift Current Lake; Lost Lake; Johns Lake

Lake McDonald

Altitude 3144-4861 ft.

<u>*Epithemia*</u> Sp.

Temp. 11.5-13° C.
pH 7.2-7.4
Total Alk. 68-76 mg/l.
NH_4-N 0.0-0.14 ppm.
NO_2-N 0.0-0.001 ppm.
NO_3-N 0.01-0.02 ppm.
Ortho-PO_4 0.0-0.02 ppm.
Bowman Lake
Altitude 4020 ft.

<u>*Rhopalodia*</u> Sp.

Temp. 17.3-20° C.
pH 6.8-7.4
Total Alk. 16-32 mg/l.
NH_4-N 0.02-0.06 ppm.
NO_2-N 0.0-0.005 ppm.
NO_3-N 0.0-0.037 ppm.
Johns Lake
Altitude 3300 ft.

Suborder SURIRELLINEAE

Family SURIRELLA

<u>*Suririella*</u> Sp.

Temp. 15.5-25.56° C.
pH 6.9-7.5
Total Alk. 12-52 mg/l.
NH_4-N 0.0-0.09 ppm.
NO_2-N 0.0-0.002 ppm.
NO_3-N 0.0-0.058 ppm.
Ortho-PO_4 0.0-0.08 ppm.
Swift Current Lake; Lost Lake; Johns Lake
Altitude 3300-4861 ft.

Division PYRRHOPHYTA

Class DINOPHYCEAE

Order PERIDINIALES

Family PERIDINIACEAE

Peridinium bipes Stein*

Cell length 69.3 u.

Cell width 54.6 u.

Cell thickness 46.2 u.

Temp. 8.89-17.22° C.

pH 7.2-8

Total Alk. 40-52 mg/l.

NH_4-N 0.0-0.25 ppm.

NO_2-N 0.0-0.01 ppm.

NO_3-N 0.028-0.038 ppm.

Ortho-PO_4 0.12-1 ppm.

Swift Current Lake; Lost Lake

Altitude 4700-4861 ft.

Peridinium cinctum (Müller) Ehrb.

Cell length 66 u.

Cell width 66 u.

Mud Lake

Altitude 3489 ft.

Peridinium Sp.

Cell length 48.3 u.

Cell width 29.6-52.5 u.

Temp. 7.78-19.2° C.

pH 6.8-8.7

Total Alk. 20-80 mg/l.

NH_4-N 0.0-0.15 ppm.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.098 ppm.

Ortho-PO_4 0.0-0.28 ppm.

Lake McDonald; Bowman Lake; Johns Lake

Altitude 3144-4020 ft.

Family CERATIACEAE

Ceratium hirundinella (Muell.) Dujardin

Cell length 210 u.

Cell width 153.3 u.

Temp. 7-24.44° C.

pH 6.9-8.8

Total Alk. 20-444 mg/l.

NH_4-N 0.0-0.15 ppm.

NO_2-N 0.0-0.01 ppm.

NO_3-N 0.0-0.098 ppm.

Ortho-PO_4 0.0-0.2 ppm.

Hidden Lake; Lost Lake; Johns Lake; Avalanche Lake; Mud Lake; Duck Lake; Lake McDonald; Bowman Lake; Lower St. Mary Lake; St. Mary Lake; Redrock Lake; Fishcap Lake

Altitude 3144-6375 ft.

Division RHODOPHYTA

Class RHODOPHYCEAE

Subclass FLORIDEAE

Order NEMALIONALES

Family BATRACHOSPERMACEAE

Batrachospermum Sp.

McDonald Creek Inlet

Altitude 3144 ft.

Family LEMANEACEAE

Lemanea Sp.

Tuft length 1.5 cm.

Filament width 0.5 mm.

Camas Creek

Altitude 3779 ft.

Division CYANOPHYTA

Class CYANOPHYCEAE

Order CHROOCOCALES

Family CHROOCOCCACEAE

Aphanothece microspora (Menegh.) Raben.*

Cell length 6.3 u.

Cell width 2.1 u.

Temp. 25^{o} C.

pH 7.3

Total Alk. 16 mg/l.

NH_4-N 0.075 ppm.

Johns Lake

Altitude 3300 ft.

NO_2-N 0.0 ppm.

NO_3-N 0.08 ppm.

Ortho-PO_4 1 ppm.

Aphanothece stagnina (Spreng.) A. Braun

Cell length 6.3-8.4 u.

Cell width 4.2 u.

Colony length 115.5 u

Colony width 52.5-63 u.

Temp. 18.2-24.44^{o} C.

pH 6.9-7.4

Total Alk. 20 mg/l.

NH_4-N 0.08-0.09 ppm.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

NO_2-N 0.002-0.006 ppm.

NO_3-N 0.018-0.048 ppm.

Ortho-PO_4 0.02-0.1 ppm.

<u>Chroococcus dispersus</u> (Keissl.) Lemm.

Cell length 5-8.4 u.

Cell width 4.2-6.3 u.

Temp. 10-19.2° C. NO_2-N 0.003-0.005 ppm.

pH 6.8-8.8 NO_3-N 0.035-0.037 ppm.

Total Alk. 20-444 mg/l. Ortho-PO_4 0.0-0.05 ppm.

NH_4-N 0.0 ppm.

St. Mary Lake; Duck Lake; Johns Lake; Bowman Lake

Altitude 3300-5004 ft.

<u>Chroococcus limneticus</u> Lemm.*

Cell diam. 6.3 u.

Temp. 11.11-16.11° C. NO_2-N 0.0-0.005 ppm.

pH 7.3-7.7 NO_3-N 0.0-0.038 ppm.

Total Alk. 28-76 mg/l. Ortho-PO_4 0.02-0.2 ppm.

NH_4-N 0.0-0.01 ppm.

Mud Lake; Duck Lake; Bowman Lake

Altitude 3489-5004 ft.

<u>Chroococcus limneticus</u> var. <u>elegans</u>*
G.M. Smith

Cell diam. 14.7 u.

Temp. 16-18° C.

pH 7.7-8.1

Total Alk. 56-72 mg/l.

Bowman Lake

Altitude 4020 ft.

<u>Chroococcus</u> <u>minimus</u> (Keissl.) Lemm.

Temp. 13.89-25.56^o C.

pH 6.8-7.4

Total Alk. 12-60 mg/l.

NH_4-N 0.02-0.15 ppm.

NO_2-N 0.0-0.006 ppm.

NO_3-N 0.0-0.098 ppm.

Ortho-PO_4 0.0-0.15 ppm.

Lake McDonald; Johns Lake

Altitude 3144-3300 ft.

<u>Chroococcus</u> <u>minor</u> (Kuetz.) **Nageli***

Cell diam. 4.2 u.

Temp. 18.2^o C.

pH 6.9

Total Alk. 20 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.002-0.006 ppm.

NO_3-N 0.018-0.034 ppm.

Ortho-PO_4 0.05-0.1 ppm.

Johns Lake

Altitude 3300 ft.

<u>Chroococcus</u> <u>minutus</u> (Kuetz.) **Nageli***

Cell length 6.3 u.

Cell width 8.4 u.

Temp. 23-24^o C.

pH 7.7-8

Total Alk. 20-144 mg/l.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

<u>Chroococcus</u> <u>turgidus</u> (Kuetz.) **Nageli***

Cell length including sheath 23.1-25.2 u.

Cell width including sheath 14.7-21 u.

Colony diam. 31.5 u.

Temp. 11.11-19.2^{o} C.

pH 6.9-7.7

Total Alk. 20-68 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.0-0.006 ppm.

NO_3-N 0.0-0.046 ppm.

Ortho-PO_4 0.0-0.2 ppm.

Mud Lake; Bowman Lake; Johns Lake; Lake McDonald; Bowman Creek

Altitude 3144-4020 ft.

<u>Coelosphaerium</u> <u>Kuetzingianum</u> **Nageli***

Cell diam. 2.1-4.2 u.

Colony diam. 52.5 u.

Temp. 17.22-25.56^{o} C.

pH 6.9-7.8

Total Alk. 16-44 mg/l.

NH_4-N 0.0-0.09 ppm.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.048 ppm.

Ortho-PO_4 0.0-0.09 ppm.

Mud Lake; Lost Lake; Johns Lake

Altitude 3300-4700 ft.

<u>Coelosphaerium</u> <u>pallidum</u> Lemm.

Cell daim. 2.1 u.

Temp. 17^{o} C.

pH 8.7-8.8

Total Alk. 412-444 mg/l.

Duck Lake

Altitude 5004 ft.

<u>Dactylococopsis fascicularis</u> Lemm.

Temp. 19.2-25.56° C. | NO_2-N 0.0-0.005 ppm.

pH 6.9-7.4 | NO_3-N 0.0-0.037 ppm.

Total Alk. 16-24 mg/l. | Ortho-PO_4 0.02-0.09 ppm.

NH_4-N 0.05-0.09 ppm.

Johns Lake

Altitude 3300 ft.

<u>Gomphosphaeria aponina</u> var. <u>multiplex</u> Nyg.*

Temp. 24-25.56° C. | NO_2-N 0.0-0.002 ppm.

pH 7.2-8.5 | NO_3-N 0.0-0.03 ppm.

Total Alk. 16-178 mg/l. | Ortho-PO_4 0.02-0.05 ppm.

NH_4-N 0.05-0.06 ppm.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

<u>Gomphosphaeria lacustris</u> Chodat

Cell diam. 2.1-3 u.

Temp. 15.5-25.56° C. | NO_2-N 0.0-0.006 ppm.

pH 6.9-8.5 | NO_3-N 0.0-0.046 ppm.

Total Alk. 16-178 mg/l. | Ortho-PO_4 0.0-0.08 ppm.

NH_4-N 0.0-0.06 ppm.

Lubec Lake; Johns Lake; Mud Lake; Swift Current Lake; Lake McDonald

Altitude 3144-5300 ft.

Merismopedia tenuissima Lemm.*

Cell length 1.05 u.

Cell width 2.1 u.

Colony length 18.9 u.

Temp. 23.33-25.56^{o} C.

pH 7.2-7.3

Total Alk. 16-20 mg/l.

NH_4-N 0.06 ppm.

NO_2-N 0.0 ppm.

NO_3-N 0.03 ppm.

Ortho-PO_4 0.03-0.05 ppm.

Johns Lake

Altitude 3300 ft.

Microcystis flos-aque (Wittr.) Kirch.

Cell diam. 6.3 u.

Temp. 23-24^{o} C.

pH 7.7-8

Total Alk. 20-180 mg/l.

Mud Lake; Johns Lake; Lubec Lake

Altitude 3300-5300 ft.

Rhabdoderma Gorskii Woloszynska

Cell length 10.5 u.

Cell width 2.1 u.

Johns Lake

Altitude 3300 ft.

Order OSCILLATORIALES

Suborder OSCILLATORINAE

Family OSCILLATORIACEAE

Oscillatoria Agardhii Gomont*

Cell length 4.2 u.

Cell width 6.3 u.

Logan Pass

Altitude 7000 ft.

Oscillatoria Bornetii Zukal.*

Cell length 4.2-6.3 u.

Cell width 10.5 u.

Temp. 17.5-25.56° C.

pH 6.8-7.9

Total Alk. 12-36 mg/l.

NH_4-N 0.0-0.09 ppm.

NO_2-N 0.0-0.006 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.0-0.2 ppm.

Johns Lake

Altitude 3300 ft.

Oscillatoria chlorina Kuetz.*

Cell length 2.1 u.

Cell width 6.3 u.

Bear Creek

Altitude 4912 ft.

Oscillatoria limnetica Lemm.

Filament width 4.2 u.

Trichome width 2.1 u.

Temp. 20-24° C.

pH 8.2-8.5

Total Alk. 156-178 mg/l.

Mud Lake

Altitude 3489 ft.

Oscillatoria nigra Vaucher

Trichome width 6.6 u.

Temp. 15-25.56° C.

pH 6.9-7.7

Total Alk. 12-60 mg/l.

NH_4-N 0.0-0.06 ppm.

NO_2-N 0.0-0.005 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.02-0.1 ppm.

Bowman Lake; Johns Lake; "Dripping Springs" Avalanche Creek Campground Nature Trail

Altitude 3300-4020 ft.

Oscillatoria tenuis C.A. Agardh

Cell width 8.4 u.

Temp. 7-23° C.

pH 7.7-7.9

Total Alk. 20-57 mg/l.

Johns Lake; Avalanche Lake

Altitude 3300-3885 ft.

Lyngbya aerugineo-caerulea (Kuetz.) Gomont

Cell width 2.1-4.2 u.

Filament width 6.3-8.4 u.

Mud Lake; Johns Lake

Altitude 3300-3489 ft.

Lyngbya Martensiana Meneghini*

Cell length 2.1 u.

Cell width 4.2 u.

Filament width 6.3 u.

Temp. 17.5-25.56° C.

pH 6.9-7.4

Total Alk. 16-72 mg/l.

NH_4-N 0.02-0.09 ppm.

NO_2-N 0.0-0.006 ppm.

NO_3-N 0.0-0.037 ppm.

Ortho-PO_4 0.0-0.15 ppm.

Johns Lake

Altitude 3300 ft.

Lyngbya Sp.

Temp. 18.2° C.

pH 6.9

Total Alk. 20 mg/l.

NH_4-N 0.0 ppm.

NO_2-N 0.002-0.006 ppm.

NO_3-N 0.018-0.034 ppm.

Ortho-PO_4 0.05-0.1 ppm.

Johns Lake

Altitude 3300 ft.

Family NOSTOCACEAE

<u>Aphanizomenon flos-aquae</u> (l.) Ralfs.*

Cell length 13.2 u.

Cell diam. 6.6 u.

Heterocyst length 1-15.4 u.

Heterocyst diam 8.8 u.

Temp. 22° C.

pH 10

Lubec Lake

Altitude 5300 ft.

<u>Nostoc commune</u> Vaucher

Cell length 6.6 u.

Cell diam. 6 u.

Heterocyst length 8.8 u.

Heterocyst diam. 8.8 u.

Logan Pass

Altitude 7000 ft.

<u>Nostoc paludosum</u> Kuetz.*

Cell length 4.2-6.3 u.

Cell width 4.2 u.

Gonidia length 8.4-10.5 u.

Gonidia width 6.3 u.

Heterocyst length 4.2 u.

Heterocyst width 4.2 u.

Colony diam. 52.5-423 u.

Temp. 23.33-25.56° C. NO_2-N 0.0 ppm.

pH 7.2-8.5 NO_3-N 0.0 ppm.

Total Alk. 16-178 mg/l. Ortho-PO_4 0.02-0.05 ppm.

NH_4-N 0.06 ppm.

St. Mary Lake; Lubec Lake; Johns Lake; Mud Lake; McDonald Creek Inlet

Altitude 3244-5300 ft.

<u>*Anabaena flos-aquae*</u> **(Lyngb.) Brebisson**

Cell length 6.3-8.4 u.

Cell width 4.2-6.3 u.

Heterocyst length 8.4-10.5 u.

Heterocyst width 8.4 u.

Gonidia length 10.5-23.1 u.

Gonidia width 6.3-10.5 u.

Temp. 10-24^{o} C.

pH 7.8-8.8

Total Alk. 80-444 mg/l.

Mud Lake; Duck Lake; Bowman Lake

<u>Anabaena</u> Sp.

Temp. 10.5-25.56^{o} C.

pH 6.8-8.8

Total Alk. 16-444 mg/l.

NH_4-N 0.0-0.25 ppm.

NO_2-N 0.0-0.01 ppm.

NO_3-N 0.015-0.071 ppm.

Ortho-PO_4 0.0-0.28 ppm.

Lubec Lake; St. Mary Lake; Bedrock Lake; Mud Lake; Bowman Lake; Duck Lake; Lost Lake; Johns Lake

Altitude 3300-5300 ft.

Family SCYTONEMATACEAE

<u>Scytonema</u> Sp.

Cell width 10.5 u.

Logan Pass

Altitude 7000 ft.

<u>Tolypothrix tenuis</u> Keutz.

Cell width 6.3-4.2 u.

Filament width 10.5 u.

Heterocyst length 10.5 u.

Heterocyst width 7.4 u.

McGee Meadow "Moose Pond"; Lost Lake

Altitude 3855-4700 ft.

Family STIGONEMATACEAE

Stigonema mamillosum (Lyngb.) C.A. Agardh*

Filament width 52.5 u.

Temp. 24° C.

pH 8.5

Total Alk. 156 mg/l.

Mud Lake

Altitude 3489 ft.

Stigonema oscellatum (Dillw.) Thuret*

Cell width 12.6 u.

Filament width 25.2 u.

McGee Meadow "Moose Pond"

Altitude 3855 ft.

Family RIVULARIACEAE

Amphithrix janthina (Gomont) Born. & Flah.*

Trichome width 2.5 u.

Temp. 12-13° C.

pH 8.1-8.2

Total Alk. 66.76 mg/l.

Swift Current Lake

Altitude 4861 ft.

Calothrix adscendens (Nag.) Born. & Flah.*

Cell width at base of filament 6.3 u.

Filament width at base 19.5 u.

Heterocyst width 6.3 u.

Johns Lake

Altitude 3300 ft.

Calothrix Sp.

Temp. 12.3° C.

pH 7.2

Total Alk. 10 mg/l.

Ortho-PO_4 0.06 ppm.

Hidden Lake

Altitude 6375 ft.

Dichothrix gypsophila (Kuetz.) Born. & Flah.*

Cell length 4.2 u.±

Cell width 6.3 u.

Filament width 31.5 u.

Bowman Creek

Altitude 4020 ft.

Gleoetrichia pisum (C.A. Ag.) Thuret

Cell width 6.3 u. ±

Colony diam. 2mm. ±

Temp. 24° C.

pH 8

Total Alk. 144 mg/l.

Mud Lake

Altitude 3489 ft.

Lower St. Mary Lake

Description of Lake

Lower St. Mary Lake is located about 0.8 of a mile east of the park boundary along state highway 89 in the Black Feet Indian reservation. The lake, 0.9 mi. wide by 6 mi. long, is formed by an alluvial fan at the lower end which acts as a dam to back up the present water of the lake. Bottom vegetation is abundant near the rocky shores and the lake bottom is composed of sand and silt. The west (upper) sector of the lake is very shallow, choked with weeds at the end of the summer, and posseses a sand bottom. The east (lower) sector of the lake is deeper and has more silt on the bottom. St. Marys river enters the lake at the west and flows eastward as the outlet.

Location of Stations

Station I was located near the west end of the lake opposite the inlet stream which flows from upper St. Mary within the park boundaries. The depth of water at this station was 3 ft. Station II was located at the Malmstrom Airforce Base Recreation Center near the middle of the lake where the depth was about 23 ft. Station III was located at the Chief Chewing Bone Campground near the East end of the lake. Depth at this station was about 23 ft.

Taxonomy and Species Abundance

Table 2 provides an analysis of the classification for the plankton algae collected, showing that the Chlorophyta and Chrysophyta are the prominent groups in Lower St. Mary Lake.

Table 2. An Analysis of the Classification for Phytoplankton Collected in Lower St. Mary Lake

Phylum	Classes	Orders	Families	Genera	Species
Chlorophyta	1	5	9	9	9
Chrysophyta	2	3	7	11	13
Pyrrhophyta	1	1	1	1	1
Totals	4	9	17	21	23

Table 3 lists the plankton forms collected during the summer of 1962, at each station and their date of collection. If one considers the totals for each station it can be seen that the numbers of species at all three stations rise from a low early in July and remain relatively the same from the middle of July to the final collections made during the first week in September. *Synedra* Sp., *Tabellaria* Sp., and *Fragilaria* Sp., represent Bacillariophyceae collected at each station throughout the summer. *Dinobryon divergens* (Chrysophyceae) was collected four times out of a possible five sampling periods at each station. Another frequently-occurring form was *Ceratium hirundinella* (Dinophyceae).

Table 3. Plankton Forms Collected at Each Station on Lower Saint Mary Lake

Station I

Plankton	7/5	7/19	7/31	8/18	9/3
Coscinodiscus Sp.	X	X		X	
Asterionella Sp.	X	X	X	X	
Tabellaria Sp.	X	X	X	X	X
Navicula Sp.		X		X	
Synedra Sp.	X	X	X	X	X
Fragilaria Sp.	X	X	X	X	X
Gomphonema Sp.			X		
Tetracyclis Sp.		X			
Melosira Sp.			X		X
Pediastrum Boryanum					X
Sphaerocystis Schroeteri		X	X		X
Dinobryon bavaricum				X	X
Dinobryon divergens		X	X	X	X
Dinobryon sociale			X	X	X
Synura Adamsii		X			
Ceratium hirundinella	X	X	X	X	X
Total	6	11	10	10	10

Station II

Plankton	7/5	7/19	7/31	8/18	9/3
Coscinodiscus Sp.		X	X	X	X
Asterionella Sp.	X	X	X	X	X
Tabellaria Sp.	X	X	X	X	X
Navicula Sp.		X			X

Plankton	7/5	7/19	7/31	8/18	9/3
Synedra Sp.	X	X	X	X	X
Fragilaria Sp.	X	X	X	X	X
Melosira Sp.	X	X	X	X	X
Sphaerocystis Schroeteri	X	X			X
Elakatothrix gelatinosa			X		
Ulothrix zonata		X			
Eudorina elegans					X
Dictyosphaerium pulchellum	X	X	X		
Scenedesmus quadricauda			X		
Dinobryon divergens		X	X	X	X
Dinobryon bavaricum	X	X	X		
Dinobryon sociale			X	X	X
Ceratium hirundinella		X	X	X	X
Total	8	13	12	11	12

Station III

Coscinodiscus Sp		X	X	X	X
Asterionella Sp	X	X	X	X	X
Tabellaria Sp.	X	X	X	X	X
Navicula Sp.				X	
Synedra Sp.	X	X	X	X	X
Fragilaria Sp.	X	X	X	X	X
Melosira	X		X	X	X
Sphaerocystis Schroeteri		X	X		X
Ulothrix zonata				X	
Dictyosphaerium pulchellum	X	X	X		

Plankton	7/5	7/19	7/31	8/18	9/3
Mougeotia Sp.					X
Dinobryon divergens		X	X	X	X
Dinobryon bavaricum		X	X		
Dinobryon sociale			X	X	X
Ceratium hirundinella			X	X	X
Total	6	9	12	11	11

Phytoplankton Abundance

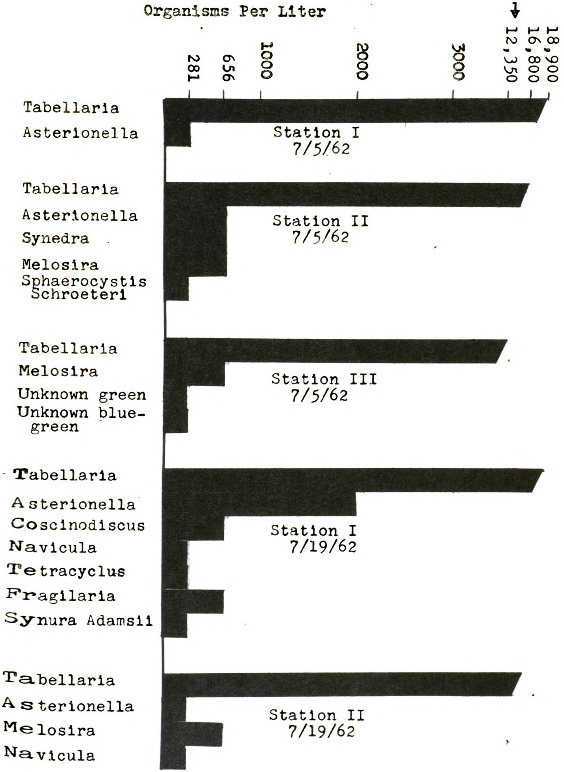
Graphs 1. through 3. show the phytoplankton count estimates for each species at the various stations during the summer of 1962. One should note that Tabellaria is in bloom condition at all three stations throughout the summer collecting period. The total number of estimated organisms per liter at all three stations at each collection date are as follows:

7/5/62-Station	I,	19,181;	II,	19,049;	III,	13,568
7/19/62-Station	I,	23,000;	II,	18,018;	III,	19,611
7/31/62-Station	I,	24,039;	II,	21,065;	III,	35,837
8/18/62-Station	I,	21,065;	II,	13,203;	III,	36,608
9/3/62-Station	I,	28,306;	II,	34,271;	III,	48,107
Station total		115,591		105,606		153,731

Physical and Chemical Factors

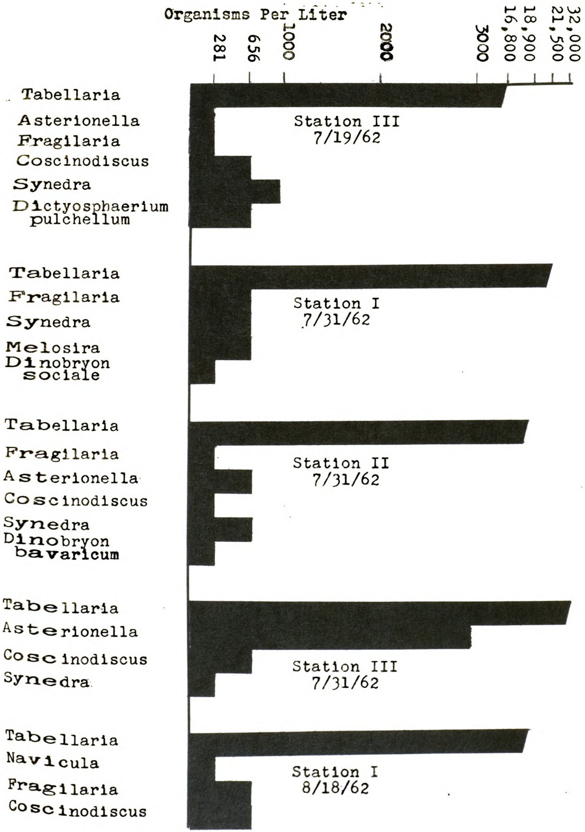
The results of the analyses for physical and chemical factors are given in graphs 4. through 7. In some instances a multiplier for the Y axis value is given along with the variable on the X axis.

Graph 1. LOWER ST. MARY LAKE

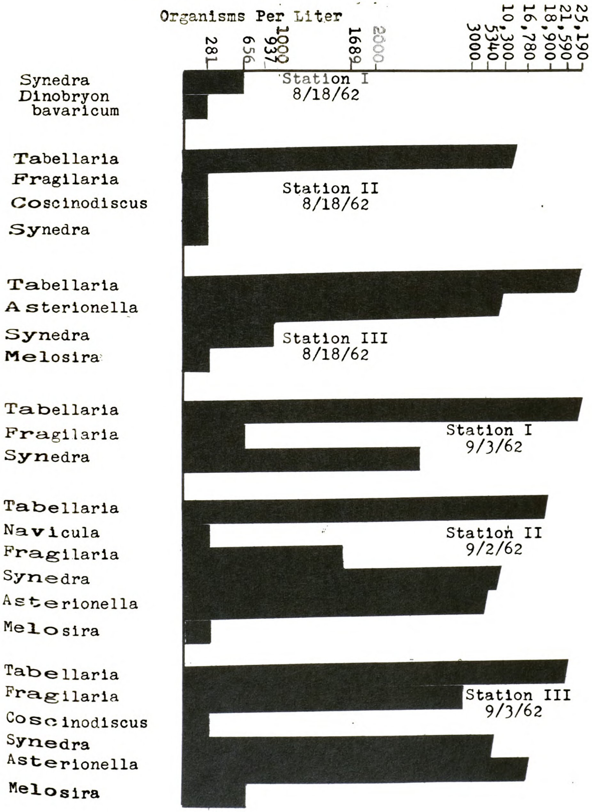


1. See explanation of scale on page xvi.

Graph 2. LOWER ST. MARY LAKE

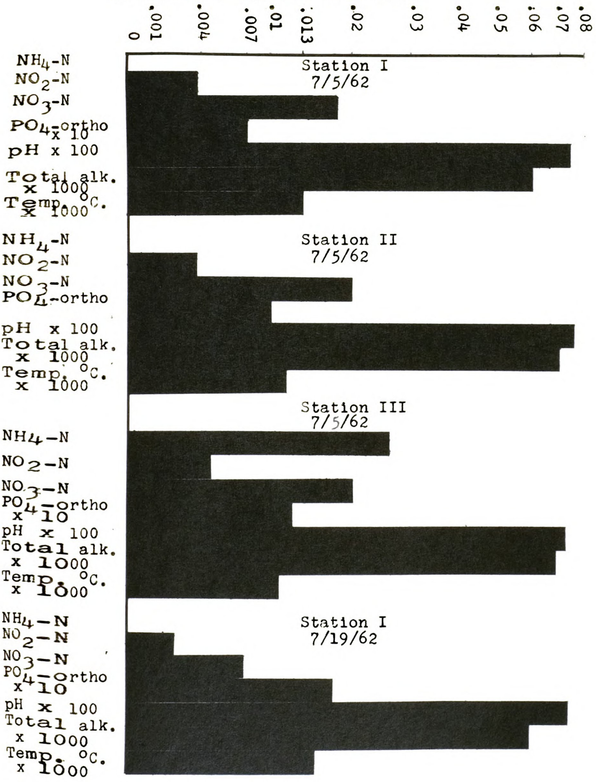


Graph 3. LOWER ST. MARY LAKE



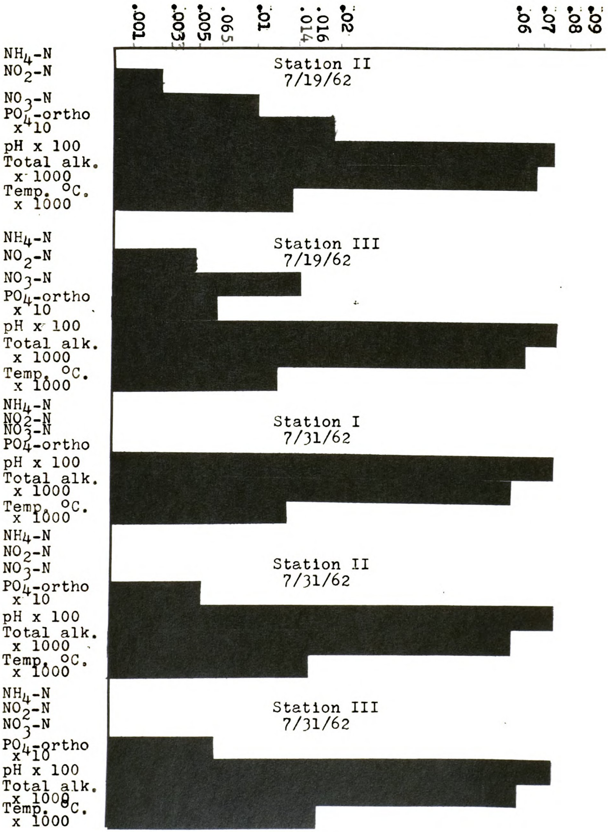
Graph 4. LOWER ST. MARY LAKE

Chemical and Physical Conditions



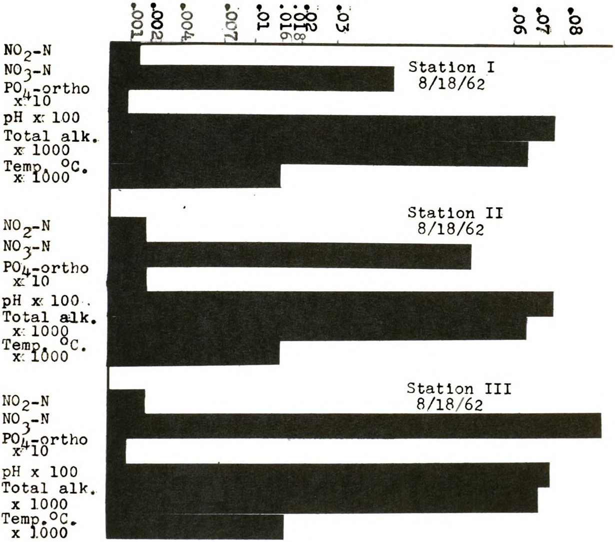
Graph 5. LOWER ST. MARY LAKE

Chemical and Physical Conditions



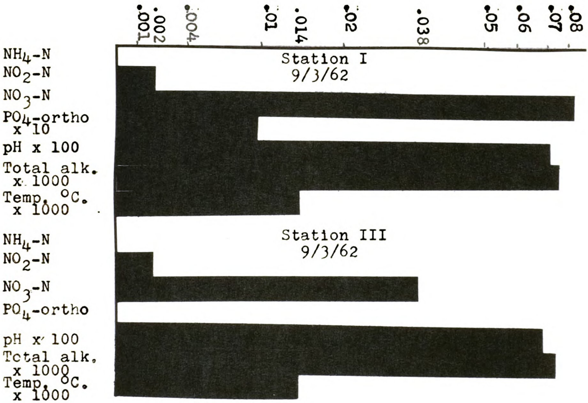
Graph 6.. LOWER ST. MARY LAKE

Chemical and Physical Conditions



Graph 7. LOWER ST. MARY LAKE

Chemical and Physical Conditions



Generalizations

When the physical and chemical factors are graphed and these graphs compared, the following relationships are found to exist between them and the organisms per liter. Many of the implications of such generalizations are discussed at the end of the chapter. These relationships for Station I are:

1. Nitrite nitrogen and organisms per liter are inversely related for the first half of the summer and then become directly related the last part of the summer (Figs. 1 and 2).
2. Nitrate nitrogen and organisms per liter are related the same as in one above (Figs. 1 and 3).
3. Orthophosphate and organisms per liter appear to be directly related but it will be noticed that the low point for phosphorus occurs before the low point for organisms per liter. Thus the build-up in phytoplankton numbers the second half of the summer lags behind the increase in phosphorus the second half of the summer (Figs. 1 and 4).
4. No apparent relationship exists between the pH curve and the organisms per liter curve (Figs. 1 and 5).
5. Total alkalinity and organisms per liter seem to be inversely related the first half of the summer. The increase in total alkalinity occurs before the increase in organisms per liter (Figs. 1 and 6).
6. The only relationship noted for the temperature curve and the organisms per liter curve is that

the lowest count occurs at the time of lowest temperature.(Figs. 1 and 7).

Relationships for Station II are:

1. In general an inverse relationship with the low point for both nitrite and nitrate nitrogen occurring before the lowest phytoplankton count. In general the organism growth lags behind the increases and decreases of these two chemical factors (Figs. 8, 9 and 10).
2. Orthophosphate and organisms per liter are directly related with the organism growth curve lagging behind the phosphorus curve. In this case the two low points of the curves coincide (Figs. 8 and 11).
3. No relationship between organisms per liter and pH (Figs. 8 and 12).
4. The organisms per liter seem to lag behind the total alkalinity, but no clear relationship exists in these data (Figs. 8 and 13).
5. No relationship to temperature except that the highest temperatures are followed by a burst in plankton numbers (Figs. 8 and 14).

Station III shows the following relationships:

1. Nitrite and organisms per liter are inversely related the first half of the summer (Figs.15 and 16).

2. An inverse relationship occurs between organisms per liter and Nitrate nitrogen from July 5th-July 31 (Figs 15 and 17).
3. Inverse relationship occurs between phosphorus and organisms per liter. As the organism count increases the phosphorus curve decreases (Figs. 15 and 18).
4. No relationship of organisms per liter to pH (Figs. 15 and 19).
5. No relationship of organisms per liter to total alkalinity (Figs. 15 and 20).
6. Direct relationship of temperature for the first four collecting periods to number of organisms per liter (Figs. 15 and 21).

Lower St. Mary Lake-July 5, 19, 31,
Aug. 18, Sept. 3

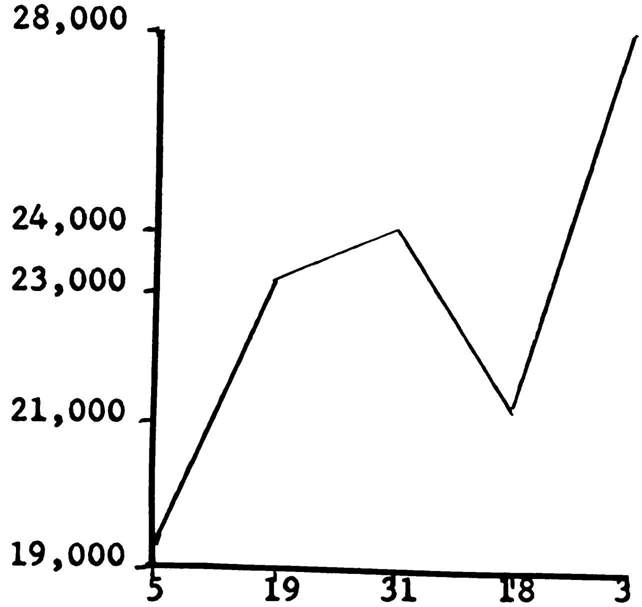


Fig. 1. Station I
Organisms per liter

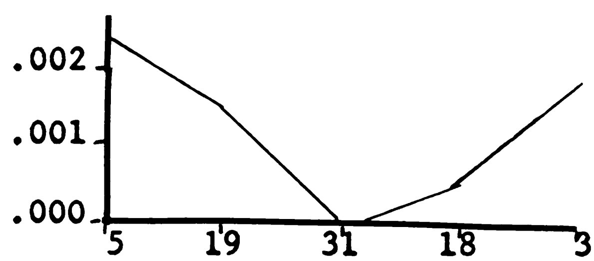


Fig. 2. Station I
Nitrite nitrogen ppm.

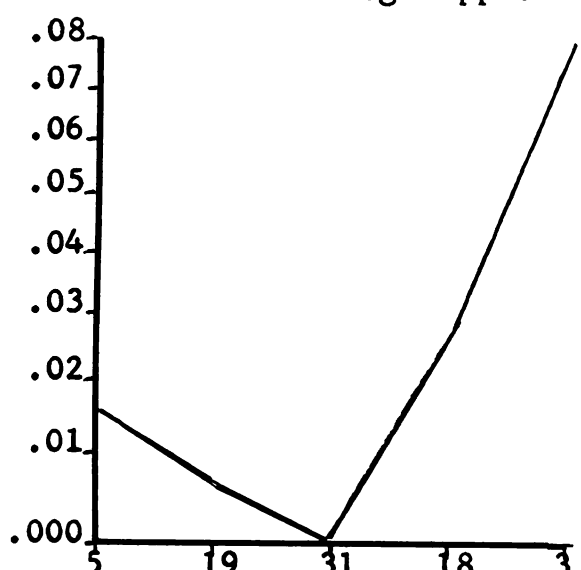


Fig. 3. Station I
Nitrate nitrogen ppm.

Lower St. Mary Lake-July 5, 19, 31,

Aug. 18, Sept. 3

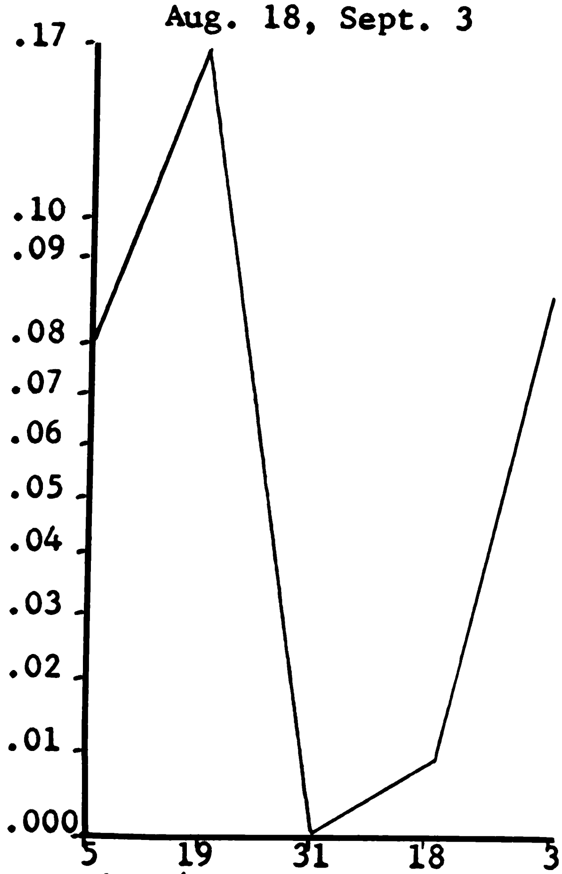


Fig. 4. Station I
Ortho-phosphate ppm.

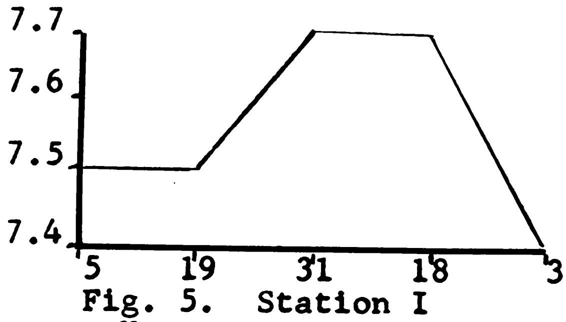


Fig. 5. Station I
pH

Lower St. Mary Lake-July 5, 19, 31,
Aug. 18, Sept. 3

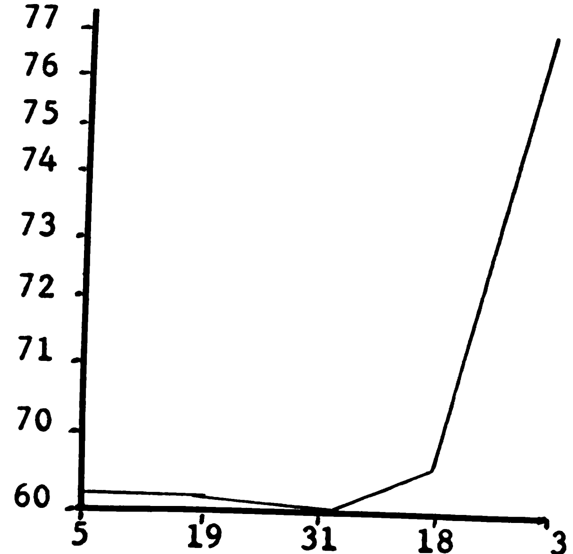


Fig. 6. Station I
Total alkalinity mg/l

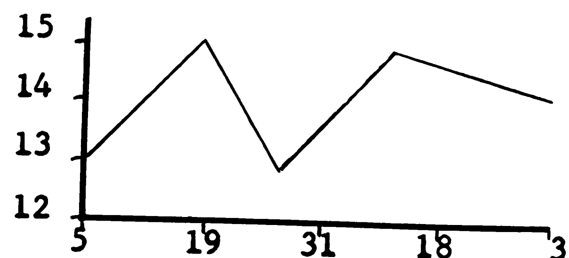


Fig. 7. Station I
Temperature °C

Lower St. Mary Lake-July 5, 19, 31, Aug. 18, Sept. 3

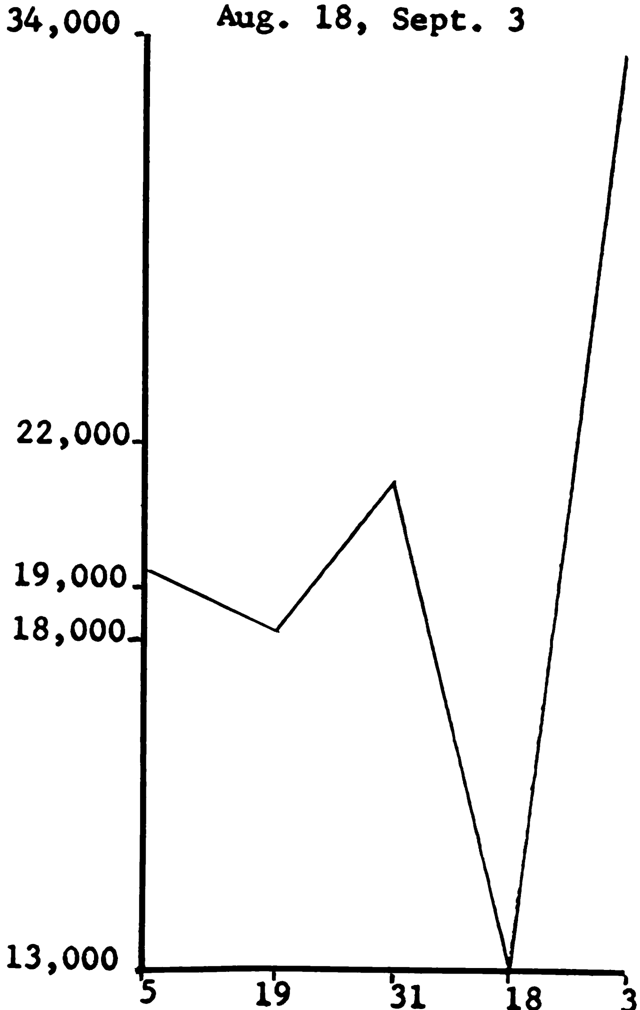


Fig. 8. Station II
Organisms per liter

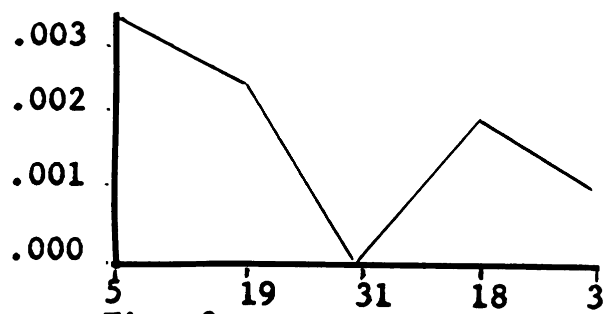


Fig. 9. Station II
Nitrite nitrogen ppm.

Lower St. Mary Lake-July 5, 19, 31,

Aug. 18, Sept. 3

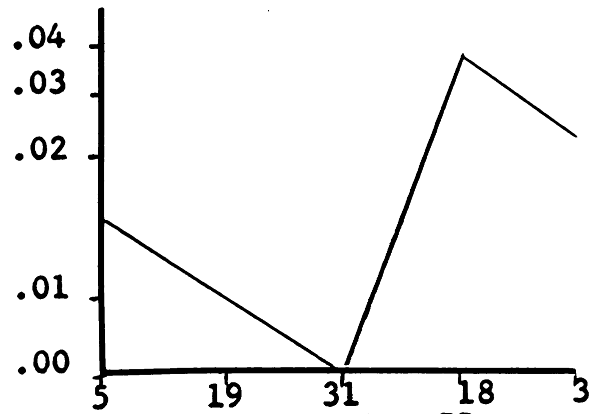


Fig. 10. Station II
Nitrate nitrogen ppm.

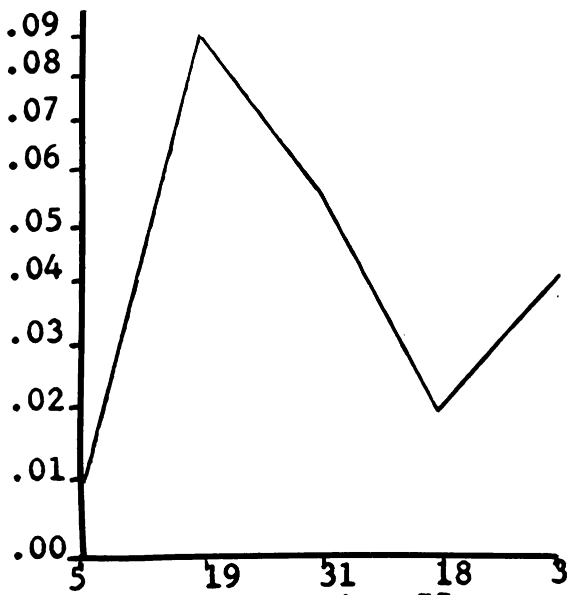


Fig. 11. Station II
Orthophosphate ppm.

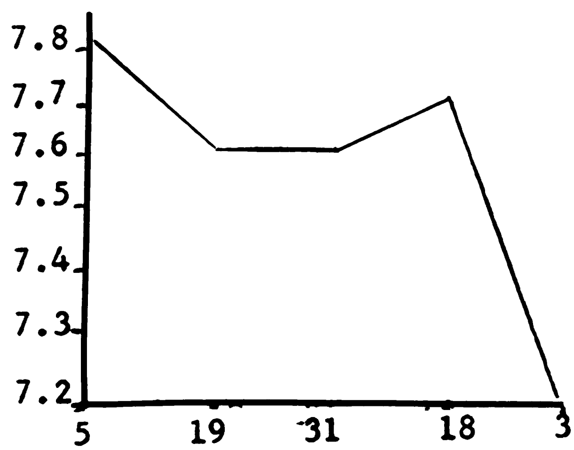


Fig. 12. Station II
pH

Lower St. Mary Lake-July 5, 19, 31,

Aug. 18, Sept. 3

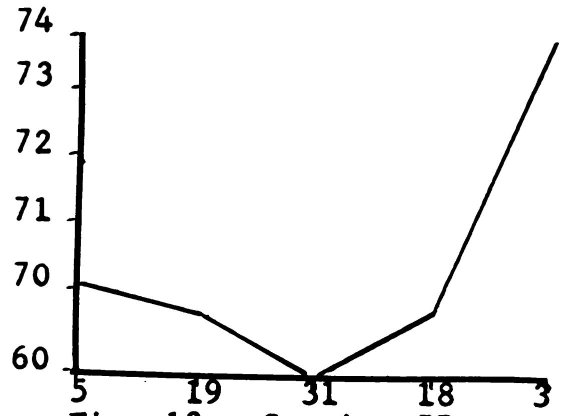


Fig. 13. Station II
Total alkalinity mg/1

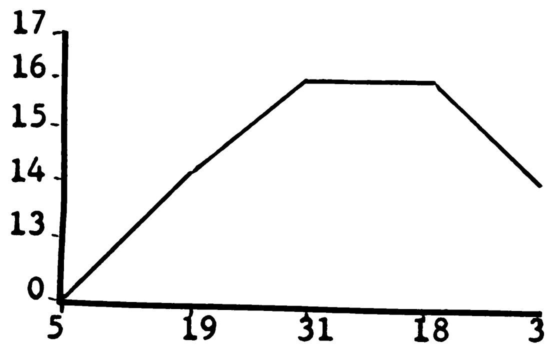


Fig. 14. Station II
Temperature °C

Lower St. Mary Lake-July 5, 19, 31,
Aug. 18, Sept. 3

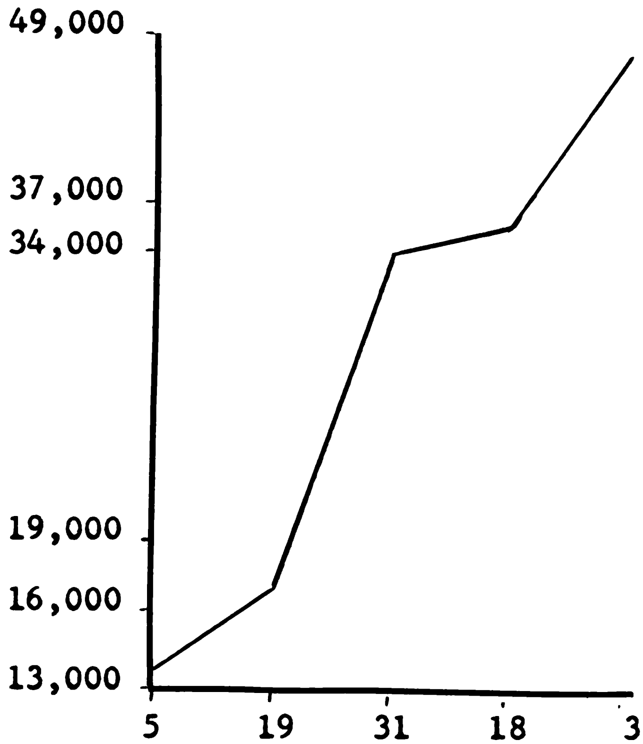


Fig. 15. Station III
Organisms per liter

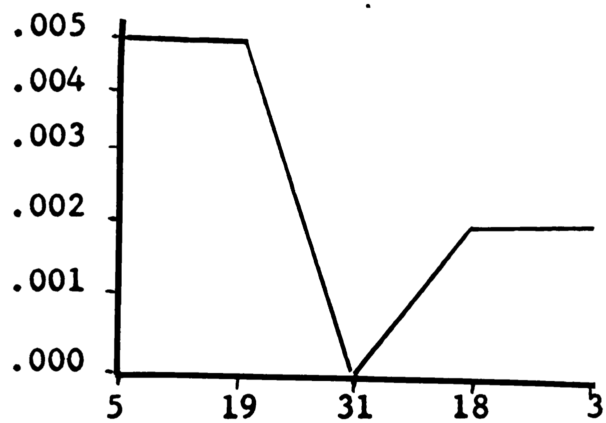


Fig. 16. Station III
Nitrite nitrogen ppm.

Lower St. Mary Lake-July 5, 19, 31,

Aug. 18, Sept. 3

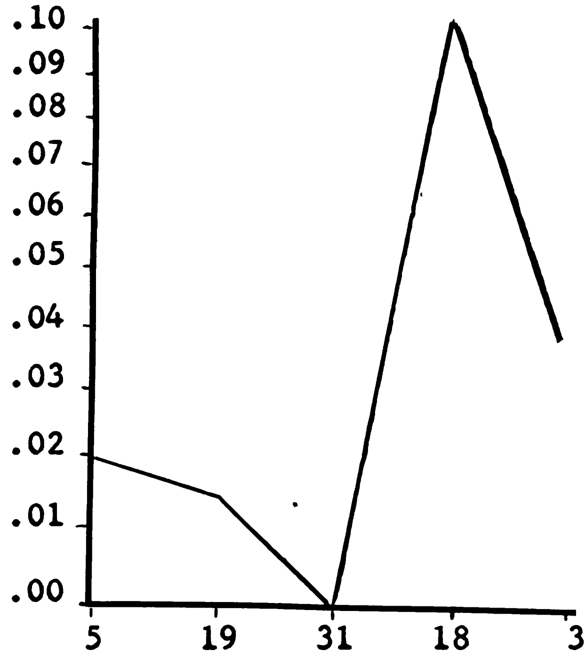


Fig. 17. Station III
Nitrate nitrogen ppm.

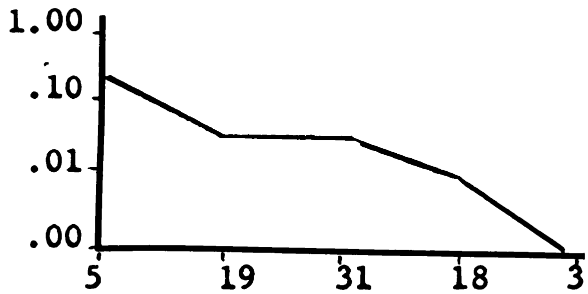


Fig. 18. Station III
Orthophosphate ppm.

Lower St. Mary Lake-July 5, 19, 31, Aug. 18, Sept. 3

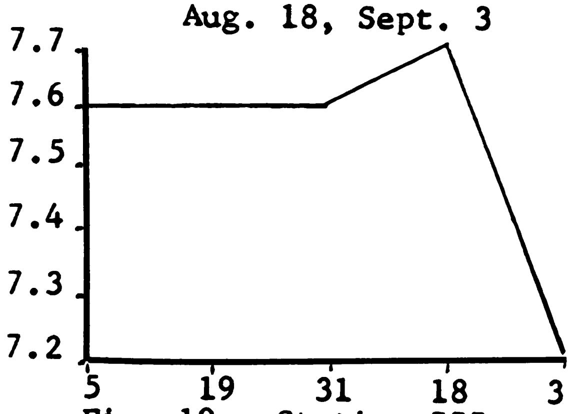


Fig. 19. Station III
pH

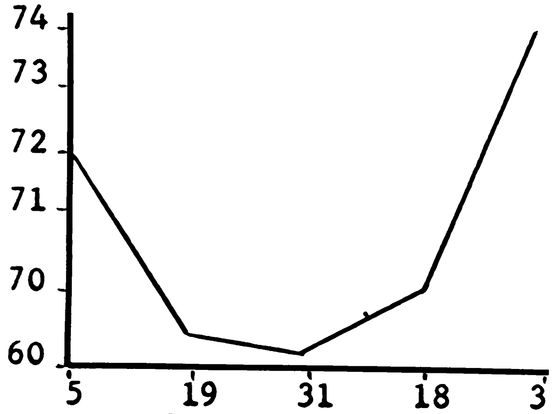


Fig. 20. Station III
Total alkalinity mg/1

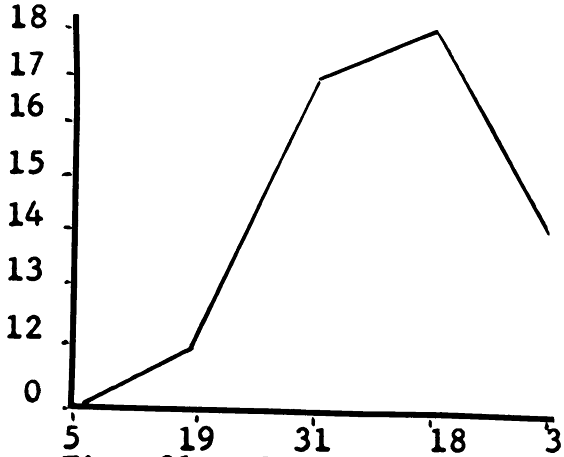


Fig. 21. Station III
Temperature °C

Discussion

Representatives of the phyla Chlorophyta and Chrysophyta were the abundant forms in Lower St. Mary Lake. Frequently occurring organisms in the qualitative net tows were *Synedra* Sp. *Tabellaria* Sp., *Fragilaria* Sp., *Dinobryon divergens*, and *Ceratium hirundinella*. The number of different kinds collected on each date remained relatively constant for the sampling period. Phytoplankton abundance measured as total organisms per liter was higher in this lake than in any other Glacier National Park Lake studied. Since phytoplankton abundance is considered to be an indicator of productivity, it would follow that Lower St. Mary Lake was the most productive lake of those studied. *Tabellaria* Sp. was the principal form contributing to phytoplankton abundance. The chemical and physical factors were uniform at all three stations on 7/5/62. This uniformity was also found on 7/19/62, except for Station III which was lower in its phosphate content. On 7/31/62 Stations II and III were uniform as to their chemical and physical factors but Station I was erratic because of the absence of ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. All three stations were again uniform on 8/18/62 and 9/3/62, except for the absence of orthophosphate at Station III on the later date. It is of interest to note that ammonia nitrogen was absent on all collection dates, and thus did not enter into the nitrogen cycle in this lake. The fact that as the organisms per liter increased and the nitrite and nitrate nitrogen decreased probably shows that these are being used as nutrients

for the phytoplankton bloom. At the end of the sampling period these three variables-organisms per liter, nitrite nitrogen, and nitrate nitrogen-increased together. I suspect that decay of plankton organisms and higher water plants was permitting the return of these nutrients to the lake water. No explanation can be offered for the mutual increase of orthophosphate and organisms per liter. My values for orthophosphate rose to 0.17 ppm. and were generally unusually high as compared to orthophosphate in other similar habitats. For example orthophosphate was not above 0.07 ppm. in Convict Creek Basin, Mono County, California (Reimers and Maciolek); between 0.0065-0.0095 ppm. in three lakes of the Alaskan peninsula (Goldman, 1960); never above 0.002 ppm. for lakes on Afugnak Island, Alaska (Dugdale and Dugdale); 0.000-0.46 ppm. was recorded by Ruttner in lakes of the Austrian Alps region (in Reid, 1961); 0.002 to 0.162 ppm. in lakes of the Swedish Upland (by Lohammar in Reid, 1961). But these high values of phosphorus and nitrogen for Lower St. Mary Lake would not be unusually high if one considers the opportunity for fertilization which this lake has from the activities of humans and from "nature." In general the greatest abundance of total organisms per liter was the highest at the end of the summer when temperature had decreased, even so the organism count was relatively high during warmer temperatures. At the beginning of the summer the organisms per liter were more abundant with warming of the lake water. The following tabulation summarizes the conditions for Lower St. Mary Lake.

Lake type: flowage

Lake size: large

Benthic vegetation: abundant

Species abundance: 23

Total organism count range: 13,203-48,107

Ammonia nitrogen range: 0.00-0.05 ppm.

Nitrite nitrogen range: 0.000-0.005 ppm.

Nitrate nitrogen range: 0.00-0.104 ppm.

*Orthophosphate range: 0.000-0.17 ppm.

Range of pH: 7.2-7.8

Total alkalinity range: 60-78 mg/1

Temperature range: 13-18° C.

*Values suspect

LOST LAKE

Description of Lake

This lake is a small, nearly circular lake on the east side of the park lying in a rocky ledge above St. Mary Lake and near Going to-the-Sun Chalet. Its altitude is 4,700 ft. and its approximate diameter is 0.07 miles. It was probably formed by a glacial scour; there being no inlet or outlet. Attached vegetation is negligible. The nature of the bottom deposits is not known.

Location of Stations

Station I was located near the east shore where the water depth was 3 ft. Station II was located at the middle of the lake at a depth in excess of 18 ft. Station III was located near the west shore at a water depth of 18 ft.

Taxonomy and Species Abundance

Table 4 shows the analysis of algal flora in Lost Lake. There are 6 classes, 12 orders, 24 families, 35 genera, and 46 species represented. Table 5 lists the organisms and their dates of collection. Asterionella Sp., Tabellaria Sp. Ceratium hirundinella, Gloeocystis ampla, Staurastrum paradoxum, and Anabaena Sp. were the main forms collected. Species totals at each station indicate that July and August showed the largest numbers of species.

Table 4. An Analysis of the Classification for Phytoplankton Collected in Lost Lake

Phylum	Classes	Orders	Families	Genera	Species
Chlorophyta	1	6	11	15	25
Chrysophyta	2	3	8	11	12
Pyrrhophyta	1	1	2	2	3
Cyanophyta	1	1	2	4	5
Euglenophyta	1	1	1	1	1
Totals	6	12	24	35	46

Table 5. Plankton Forms Collected at Each Station on Lost Lake

Station I

Plankton	7/3	7/16	8/2	8/18	9/3
Coscinodiscus Sp.	X				X
Asterionella Sp.		X	X	X	X
Tabellaria Sp.		X		X	X
Navicula Sp.	X	X		X	
Synedra Sp.	X	X	X		X
Fragilaria Sp.	X	X	X	X	
Melosira Sp.					X
Surirella Sp.		X			
Cymbella Sp.			X		
Closterium moniliferum		X		X	
Closterium aciculare	X				

Plankton	7/3	7/16	8/2	8/18	9/3
Staurastrum cuspidatum		X		X	
Staurastrum furcigerum				X	
Staurastrum paradoxum			X	X	
Staurastrum natator		X			
Staurastrum gracile		X			
Arthrodesmus impar				X	
Sphaerocystis Schroeteri	X		X	X	
Dictyosphaerium pulchellum		X	X	X	
Pediastrum Sp.	X				
Pediastrum Boryanum				X	
Tetraspora lacustris		X			
Elakatothrix gelatinosa			X	X	X
Gloeocystis ampla			X	X	X
Ulothrix zonata		X			
Geminella interrupta				X	
Dinobryon bavaricum	X			X	X
Dinobryon sociale	X	X			
Peridinium Sp.				X	
Peridinium bipes		X			
Ceratium hirundinella	X	X	X	X	X
Gomphosphaeria lacustris					X
Anabaena Sp.			X	X	X
Totals	10	16	11	19	11

Station II

Plankton	7/3	7/16	8/2	8/18	9/3
Coscinodiscus Sp.			X		X
Asterionella Sp.	X	X	X	X	X
Tabellaria Sp.	X	X	X	X	X
Navicula Sp.	X	X			
Synedra Sp.	X	X		X	
Fragilaria Sp.	X	X		X	
Cymbella Sp.		X			
Gonatozygon monotaenium		X			
Staurastrum cuspidatum			X	X	X
Staurastrum furcigerum				X	
Staurastrum paradoxum			X	X	X
Staurastrum natator	X	X			
Staurastrum gracile		X		X	
Staurastrum arctiscon		X			X
Staurastrum Sp.			X		
Cosmarium Sp.			X		
Sphaerocystis Schroeteri		X	X	X	
Dictyosphaerium pulchellum	X	X		X	
Characium gracilipes				X	
Pediastrum Boryanum	X	X	X		
Pediastrum simplex	X				
Mougeotia Sp.				X	
Tetraspora lacustris		X			
Elakatothrix gelatinosa			X	X	

Plankton	7/3	7/16	8/2	8/18	9/3
Gloeocystis ampla		X	X	X	X
Coelosphaerium Kuetzingianum		X			
Oedogonium Sp.	X				
Pectodictyon cubicum		X			
Geminella interrupta				X	
Dinobryon bavaricum				X	X
Dinobryon sociale	X	X		X	X
Ceratium hirundinella		X	X	X	X
Anabaena Sp.	X		X	X	X
Totals	12	19	13	18	10

Station III

Coscinodiscus Sp.	X	X		X	X
Asterionella Sp.	X	X	X	X	X
Tabellaria Sp.				X	X
Navicula Sp.	X	X		X	
Synedra Sp.	X	X			X
Fragilaria Sp.	X	X		X	
Pinnularia Sp.				X	
Gomphonema Sp.		X		X	
Staurastrum Sp.					X
Staurastrum paradoxum	X	X	X	X	
Staurastrum natator		X			
Staurastrum cuspidatum		X			
Staurastrum gracile		X			

Plankton	7/3	7/16	8/2	8/18	9/3
Arthrodesmus impar				X	
Dictyosphaerium pulchellum		X			
Elakatothrix gelatinosa			X	X	
Gloeocystis ampla		X	X	X	X
Pediastrum Boryanum	X		X		
Mougeotia Sp.				X	
Oedogonium Sp.	X				
Pectodictyon cubicum		X			
Dinobryon bavaricum	X			X	X
Dinobryon sociale		X			
Ceratium hirundinella			X	X	X
Peridinium bipes	X				
Chroococcus minor				X	
Anabaena Sp.		X	X	X	X
Anabaena circinalis				X	
Totals	10	15	7	17	9

Phytoplankton Abundance

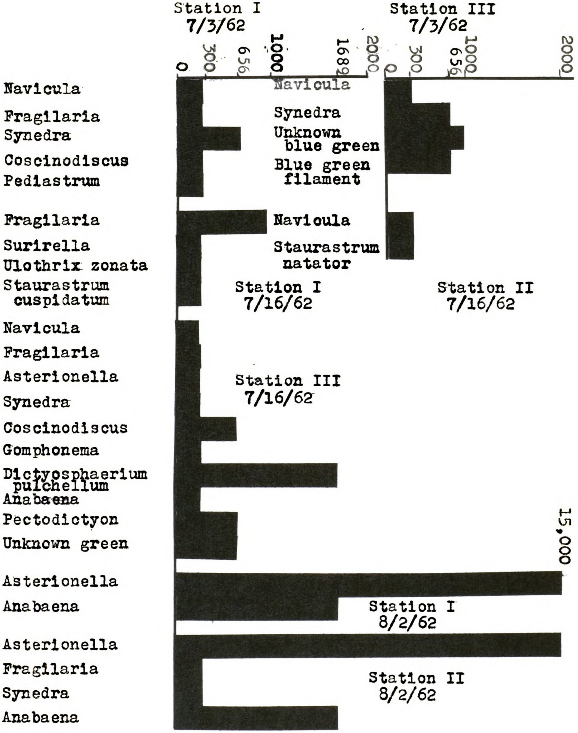
Graphs 8 through 10. give the estimated phytoplankton counts for each species at various stations during the summer of 1962. The total organisms per liter, which are used here to indicate productivity, at the three stations and their dates of collection are as follows:

7/3/62-Station	I,	1,780;	II,	no data;	III,	2,530
7/16/62-Station	I,	1,499;	II,	562;	III,	6,092
8/2/62-Station	I,	16,689;	II,	17,251;	III,	13,638
8/18/62-Station	I,	14,616;	II,	9,086;	III	25,424
9/3/62-Station	I,	13,054;	II,	6,400;	III	5,254
Station total		47,638		17,299		52,848

Physical and Chemical Factors

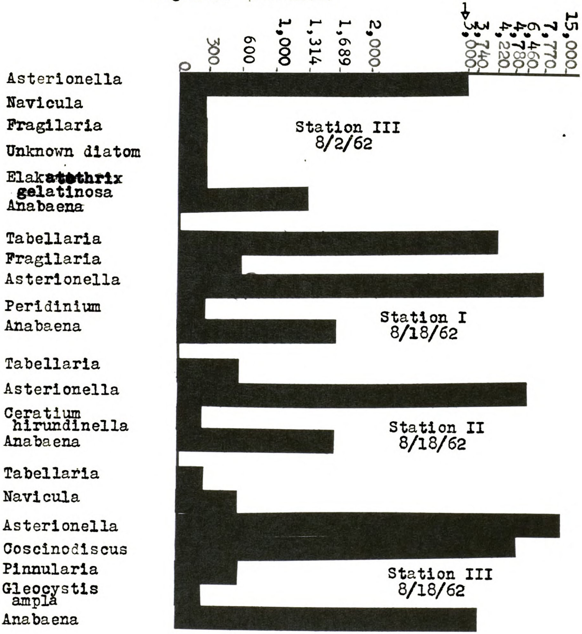
The results of the analyses for physical and chemical factors are given in graphs 11 through 15. In some instances a multiplier for the Y axis value is given along with the variable on the X axis.

Graph 8. LOST LAKE
Organisms Per Liter



Graph 9 . LOST LAKE

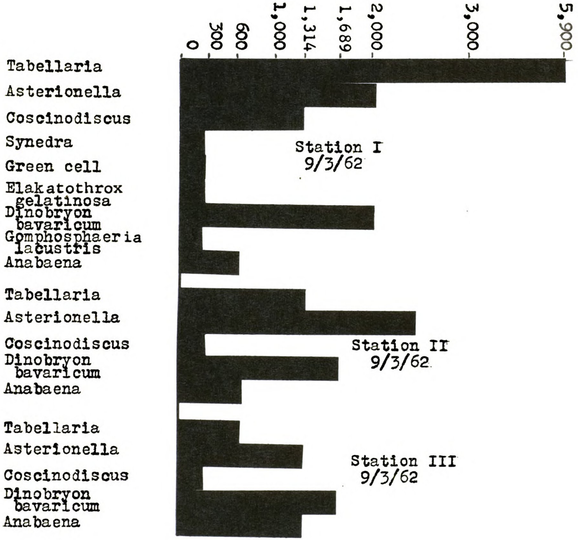
Organisms Per Liter



1. Values above 3,000 modified to fit on scale.

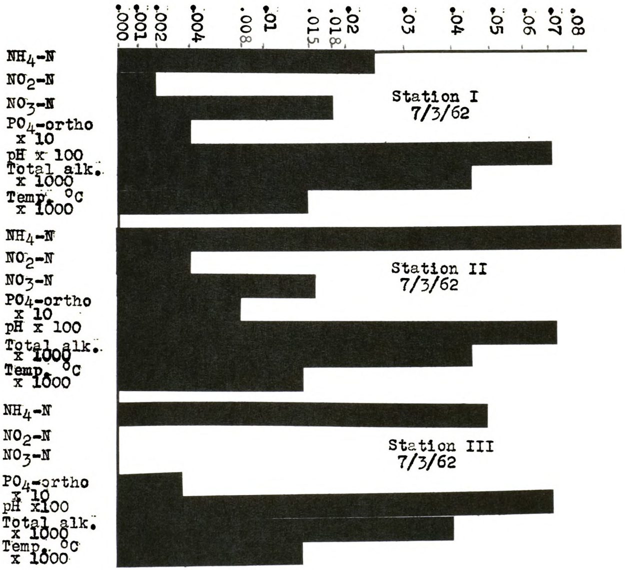
Graph 10. LOST LAKE

Organisms Per Liter

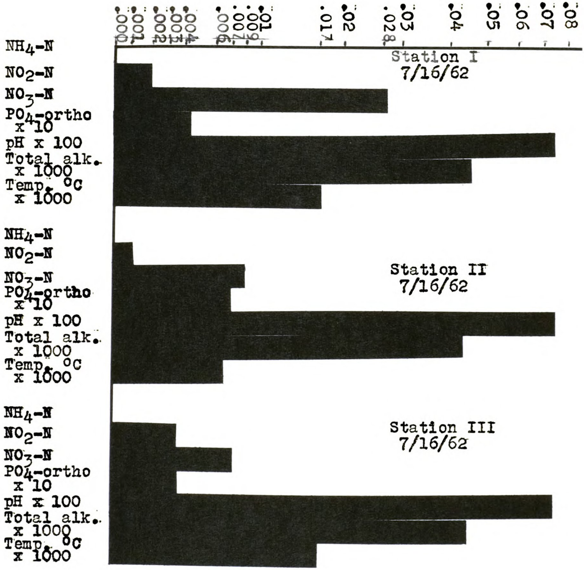


Graph 11. LOST LAKE

Chemical and Physical Conditions

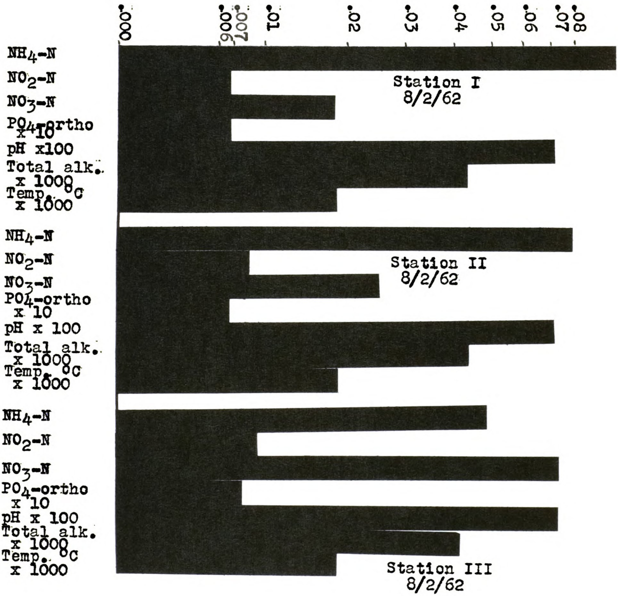


Graph 12. LOST LAKE
Chemical and Physical Conditions



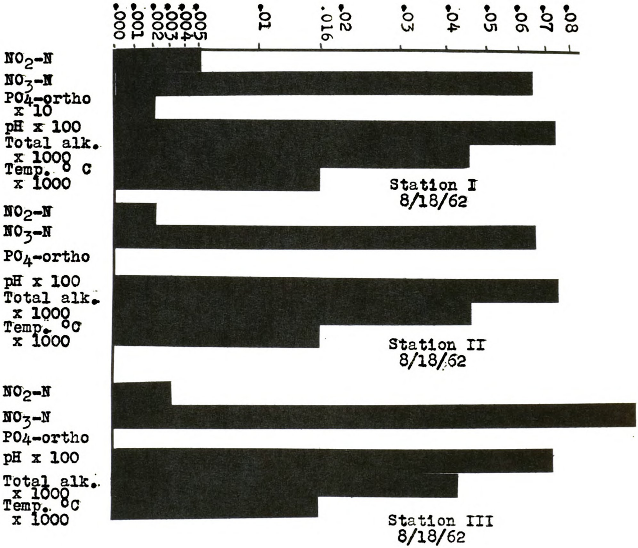
Graph 13. LOST LAKE

Chemical and Physical Conditions



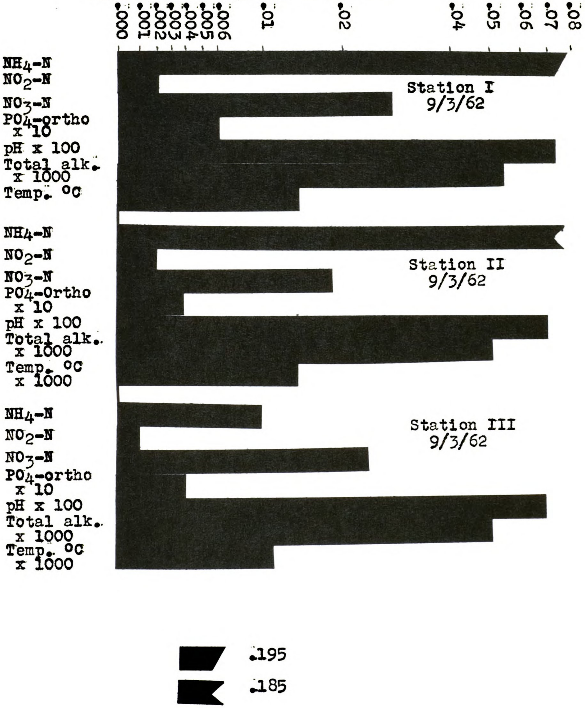
Graph 14. LOST LAKE

Chemical and Physical Conditions



Graph 15. LOST LAKE

Chemical and Physical Conditions



Generalizations

In studying the figures for Station I, the following relationships appear when the graph of organisms per liter is compared to each ecological factor:

1. Ammonia nitrogen and organisms per liter are directly related for the first three weeks of the collecting period. But at the last sampling, ammonia nitrogen is relatively high whereas the organism count begins to decrease slightly. See Figs. 22 and 23.
2. A direct relationship occurs between organisms per liter and nitrite nitrogen. See Figs. 22 and 24.
3. The organisms per liter and nitrate nitrogen show an inverse relationship until the last two sampling periods, then both factors decrease. Note that the peak for organisms per liter is reached two weeks before the peak for nitrate nitrogen. See Figs. 22 and 25.
4. Figs. 22 and 26 show a direct relationship between organisms per liter and orthophosphate for the first four weeks of the summer with the last sampling period represented by a decrease in estimated organism count and a rise again in phosphorus.
5. No relationship is seen between organisms per liter and pH. See Figs. 22 and 27.
6. No relationship exists between organisms per liter and total alkalinity. See Figs. 22 and 28.

7. Organisms per liter and temperature are approximately directly related. See Figs. 22 and 29.

Figures 30 through 37 describe the situation for Station II. The following relationships appear in these data.

1. Ammonia nitrogen and organisms per liter are related the same as at Station I (Figs. 30 and 31).
2. Nitrite nitrogen and organisms per liter show no relationship (Figs. 30 and 32).
3. Nitrate nitrogen and organisms per liter show the same relationships as at Station I (Figs. 30 and 33).
4. Orthophosphate and organisms per liter behave slightly different at Station II than at Station I (Figs. 26 and 34). The peak for orthophosphate is at the first sampling period instead of at the third sampling period as in Station I. However, if one compares dates 2, 18, and 3 at Station I with 2, 18, and 3 of Station II (Figs. 26 and 34) the same graph shapes occur. Notice that the peak for organism count is reached at the same time that a relatively high orthophosphate count is maintained and that the count and phosphorus decrease together. It will be noted also that phosphorus has begun a slight increase from dates 18, to 3 but that the decrease in counts contines (Figs. 30 and 34).
5. No relationship occurs between pH and total alkalinity and organisms per liter (Figs. 30, 35 and 36).
6. Organisms per liter and temperature are directly related (Figs. 30 and 37).

At Station III the following relationships are noted;

1. In general there is a direct relationship between ammonia nitrogen and organisms per liter except for the first two collecting periods (Figs. 38 and 39).
2. No relationship exists between nitrite nitrogen and organisms per liter (Figs. 38 and 40).
3. A direct relationship exists between nitrate nitrogen and organisms per liter (Figs. 38 and 41).
4. Orthophosphate seems to be directly related to the organisms per liter for the first three sampling periods. It is of interest to note that phosphorus declines sharply from August 2nd to August 18th, whereas the organisms per liter continue to increase until August 18th before beginning a sharp decline (Figs. 38 and 42).
5. There appears to be a direct relationship between organisms per liter and pH from August 2nd to September 3rd. Note that the peaks for both factors occur on August 18th (Figs. 38 and 43).
6. No relationship exists between total alkalinity and organisms per liter (Figs. 38 and 44).
7. Organisms per liter and temperature seem to be directly related except that the temperature peak is reached two weeks before the organisms per liter peak. Note that the temperature decreases before the organisms per liter declines (Figs. 38 and 45).

Lost Lake-July 3, 16

Aug. 2, 18, Sept. 3

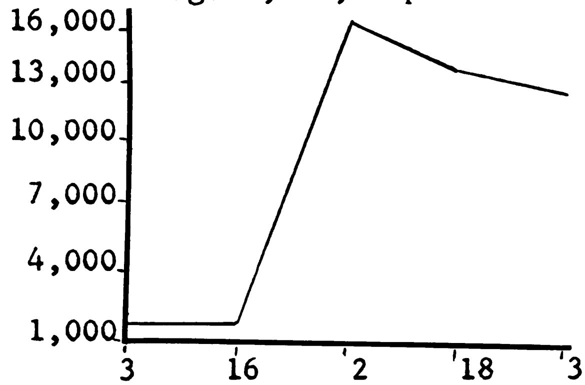


Fig. 22. Station I
Organisms per liter

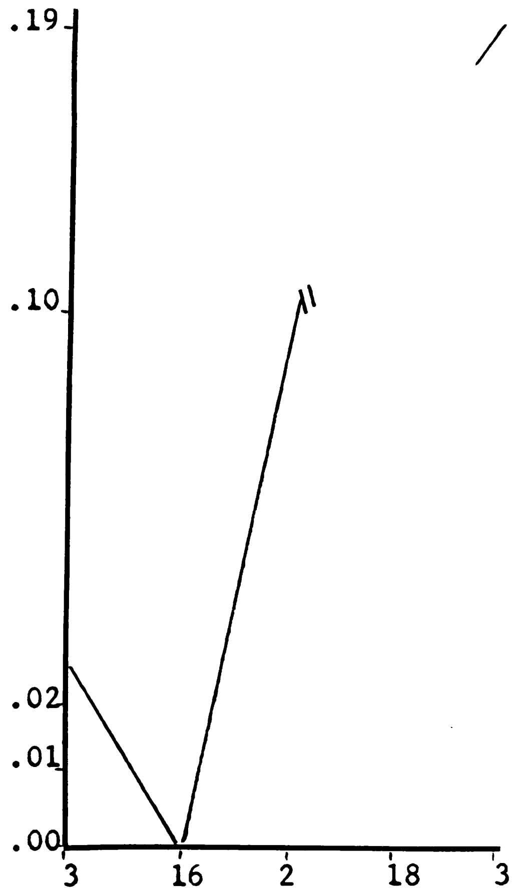


Fig. 23. Station I
Ammonia nitrogen ppm.

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

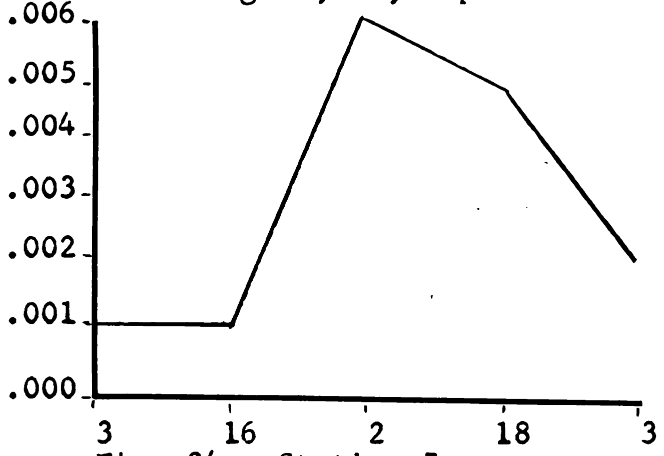


Fig. 24. Station I
Nitrite nitrogen ppm.

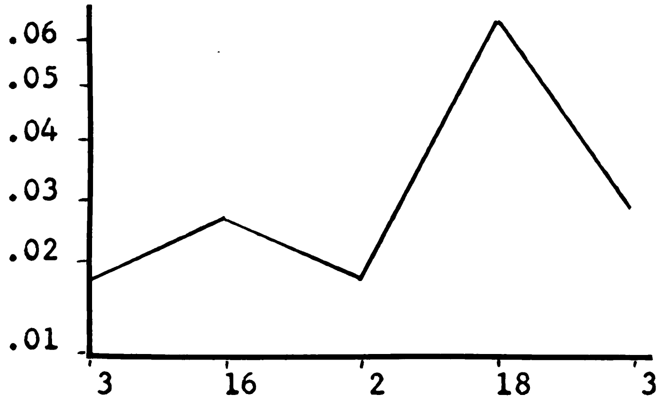


Fig. 25. Station I
Nitrate nitrogen ppm.

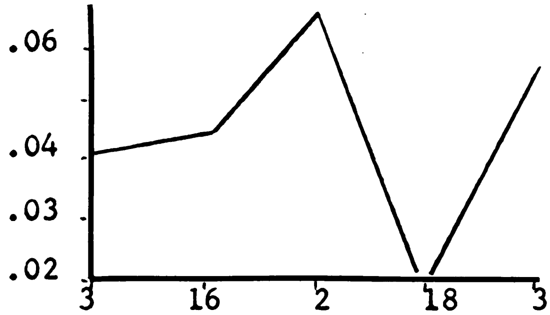


Fig. 26. Station I
Orthophosphate ppm.

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

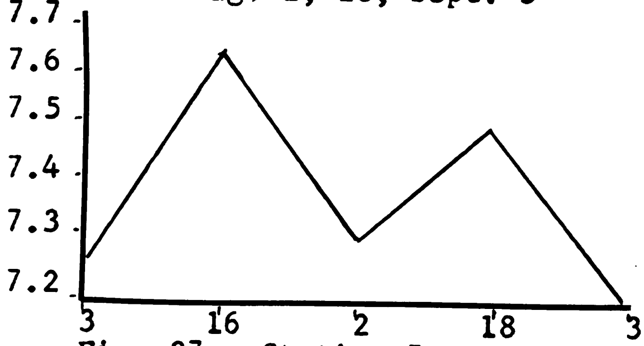


Fig. 27. Station I
pH

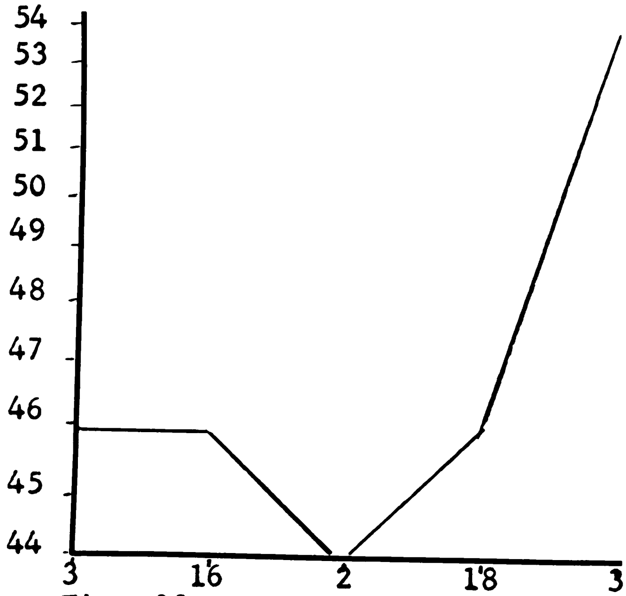


Fig. 28. Station I
Total alkalinity mg/1

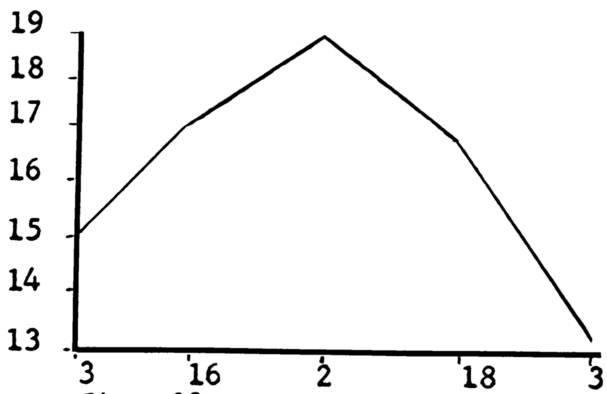


Fig. 29. Station I
Temperature °C

Lost Lake-July 3, 16,
Aug. 2, 18, Sept. 3

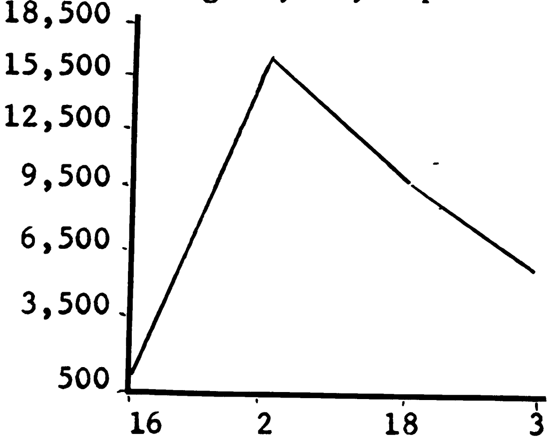


Fig. 30. Station II
Organisms per liter

Fig. 31. Station II
Ammonia nitrogen ppm.

Lost Lake-July 3, 16,
Aug. 2, 18, Sept. 3

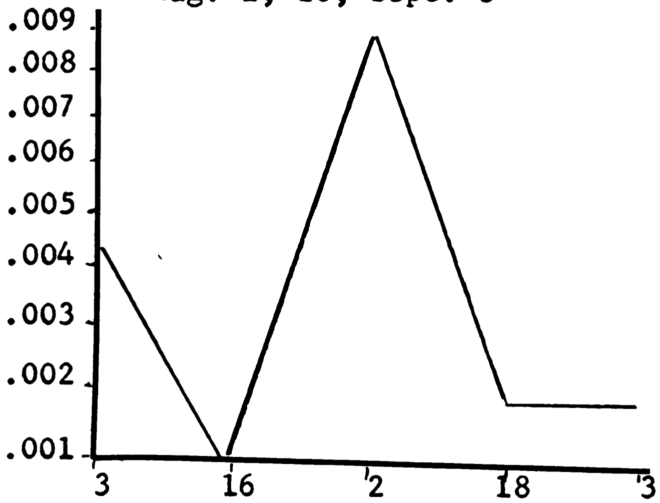


Fig. 32. Station II
Nitrite nitrogen ppm.

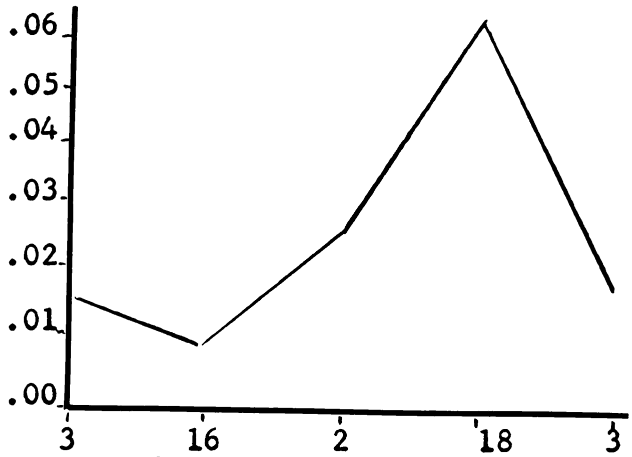


Fig. 33. Station II
Nitrate nitrogen ppm.

Lost lake-July 3, 16,

Aug. 2, 18, Sept. 3

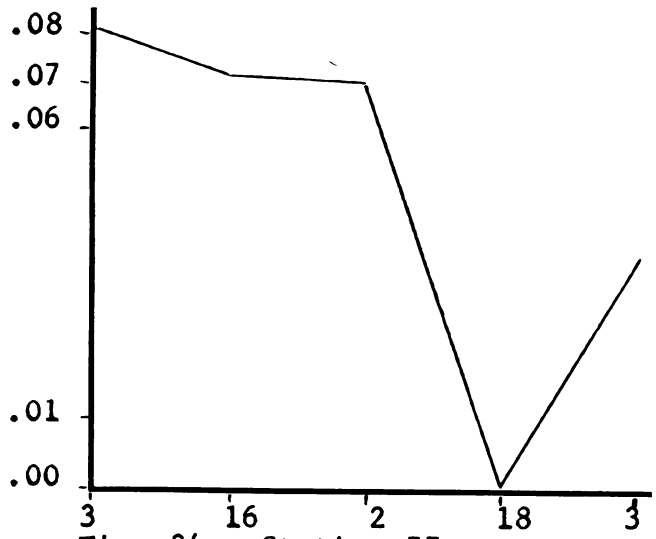


Fig. 34. Station II
Orthophosphate ppm.

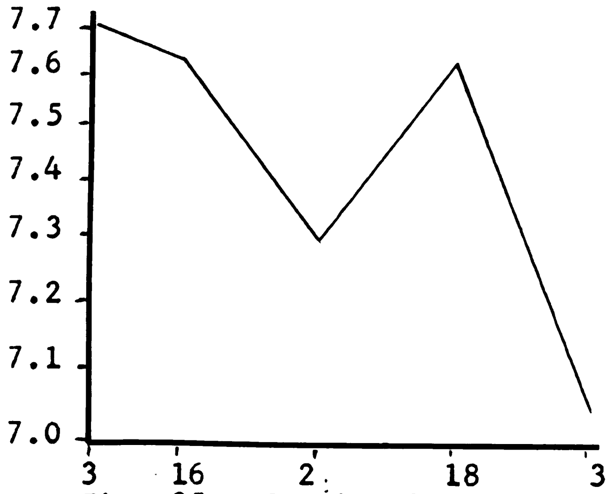


Fig. 35. Station II
pH

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

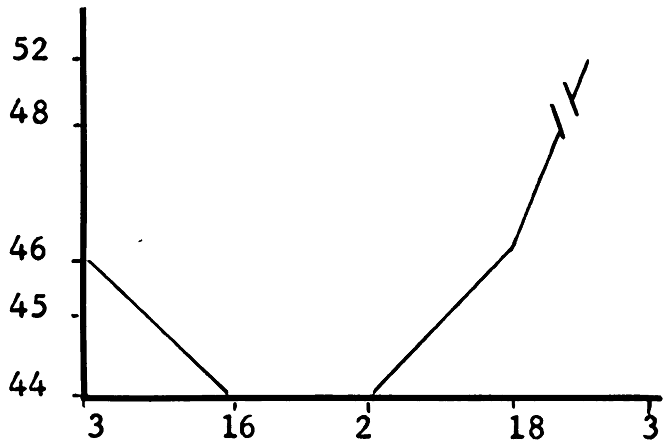


Fig. 36. Station II
Total alkalinity mg/l

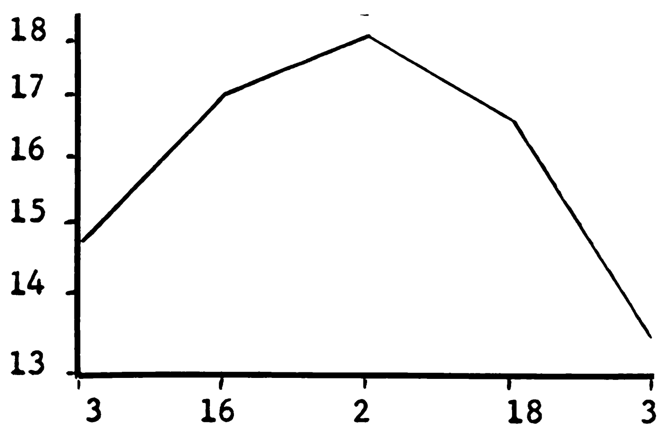


Fig. 37. Station II
Temperature °C

Lost Lake-July 3, 16,
Aug. 2, 18, Sept. 3

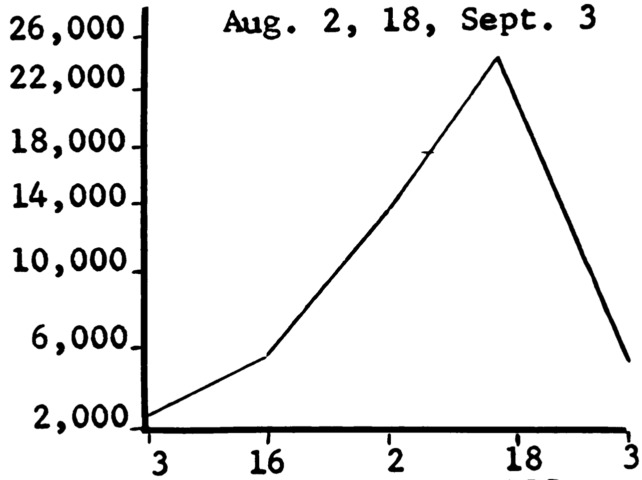


Fig. 38. Station III
Organisms per liter

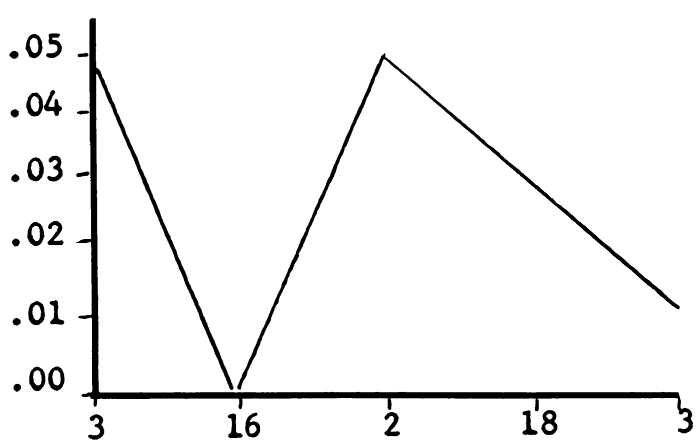


Fig. 39. Station II
Ammonia nitrogen ppm.

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

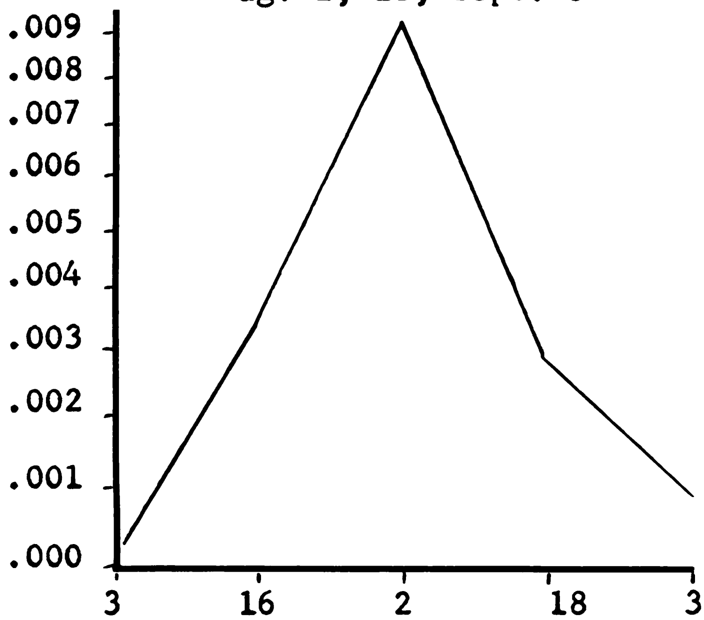


Fig. 40. Station II
Nitrite nitrogen ppm.

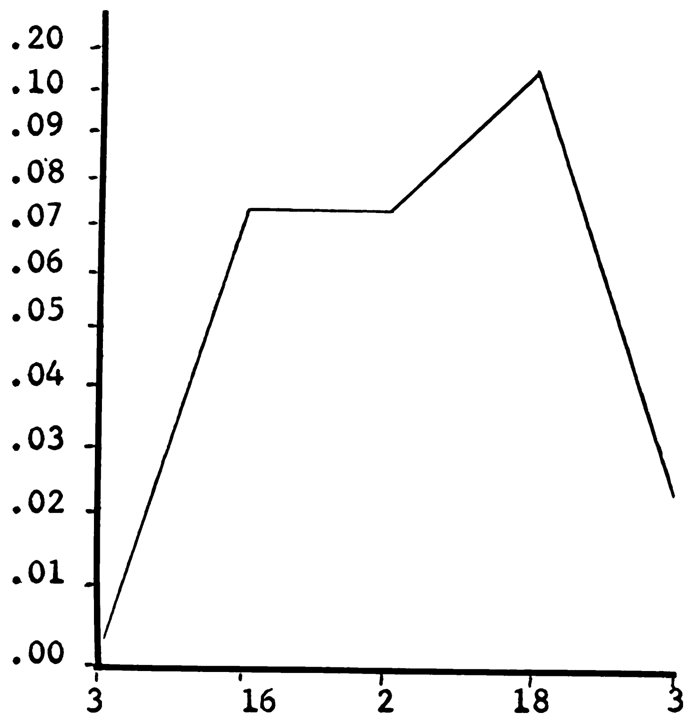


Fig. 41. Station III
Nitrate nitrogen ppm.

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

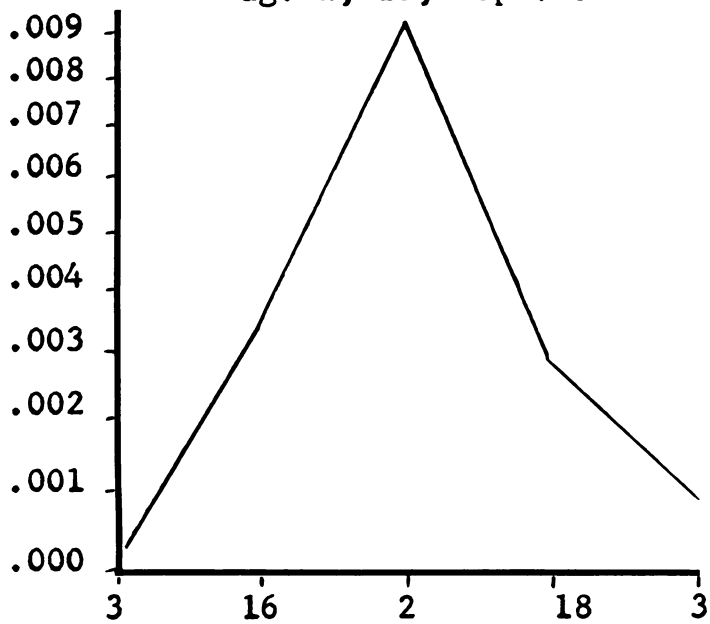


Fig. 40. Station II
Nitrite nitrogen ppm.

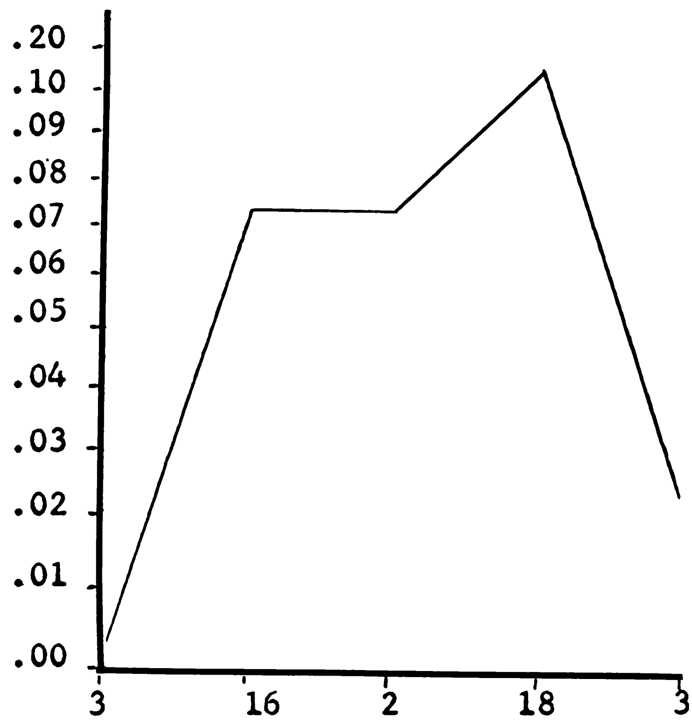


Fig. 41. Station III
Nitrate nitrogen ppm.

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

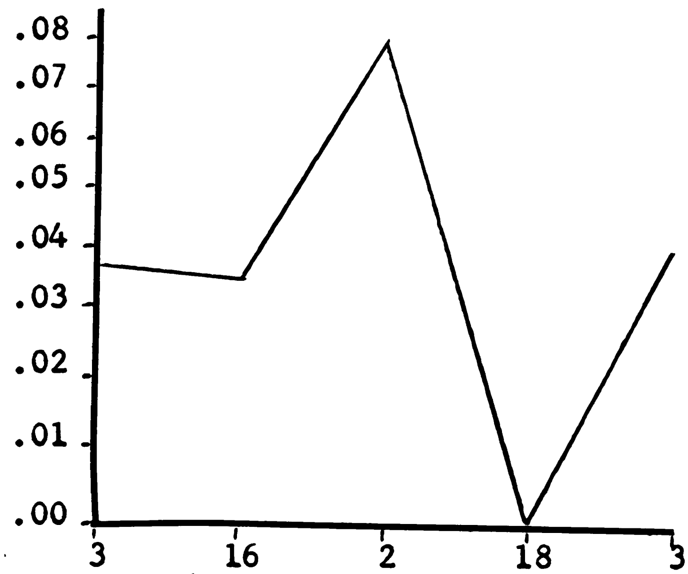


Fig. 42. Station III
Orthophosphate ppm.

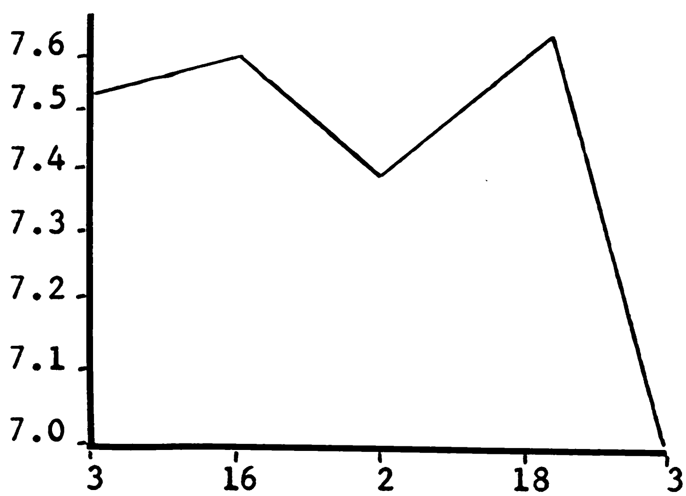


Fig. 43. Station III
pH

Lost Lake-July 3, 16,

Aug. 2, 18, Sept. 3

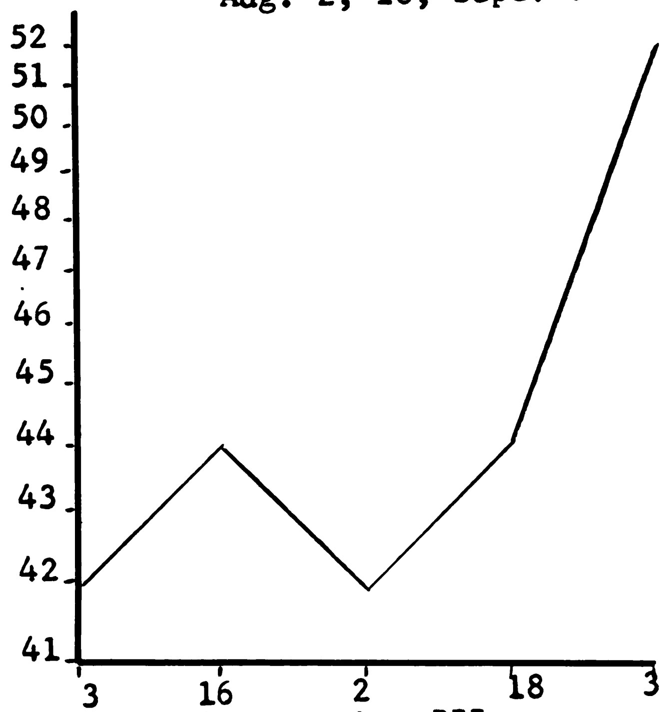


Fig. 44. Station III
Total alkalinity mg/1

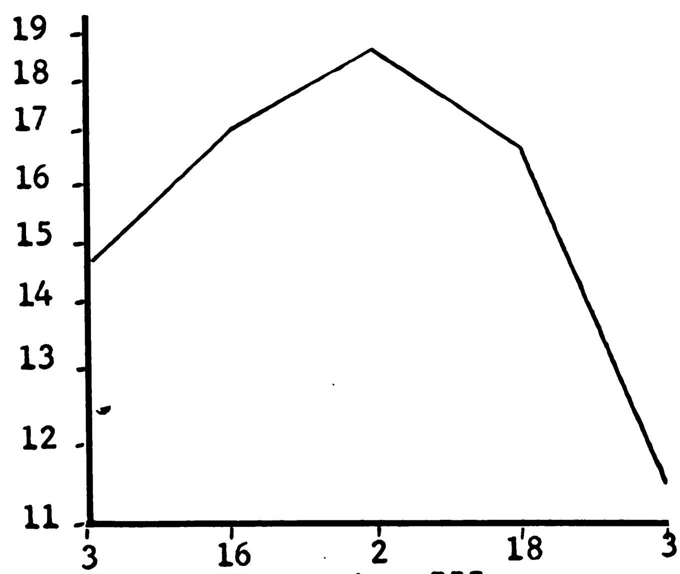


Fig. 45. Station III
Temperature °C

Discussion

Representatives of the phyla Chlorophyta and Chrysophyta were the abundant forms in Lost Lake. Frequently occurring net phytoplankton were Asterionella Sp., Tabellaria Sp., Ceratium hirundinella, Gloeocystis ampla, Staurastrum paradoxum and Anabaena Sp. The largest numbers of different kinds of species were in July and August which were also the warmest months. In terms of productivity this was the second most abundant lake. At all three stations Asterionella became very abundant between July 16th and August 2nd, and persisted for about two collecting dates. Anabaena Sp. also increased in abundance during August, as compared to the other organisms. This increase in numbers of a blue-green was noted only in one other lake studied, Johns Lake. This is of interest because Lower St. Mary Lake which appeared to be an ideal blue-green algal habitat, i.e., high temperatures, and plentiful nitrate and nitrite nitrogen, did not have any blue-green algae in it. The water chemistry is not completely uniform between stations at each sampling date. However, Station I and III were located near shore, while Station II was at the middle of the lake. This lake was also a favorite fishing, boating, and swimming site, and I think that the water was more disturbed, particulary at Station I where vacationers could wade far out and thus stir up bottom detritus. Another factor contributing to erratic water chemistry was that this lake was frequently disturbed by mountain rain storms and very high winds. No clear relationship exists between the

chemical factors and organisms per liter. By September nitrite and nitrate nitrogen had become low in content while ammonia nitrogen had increased in quantity. Total alkalinity is very low at the time of high organism abundance, but by September the reverse of this is true. The best correlation for this lake would be between temperature and organism counts because both increase and decrease together. It may be postulated that the decrease in temperature would be accompanied by more carbon dioxide which would then cause the pH to decrease which should bring about a build-up of bicarbonate alkalinity. This is supported by my data for these variables. It is the author's belief that in this small subalpine lake temperature is the key factor which controls or influences the behavior of other variables. Orthophosphate is fairly high but not to the extent that it is in some of the other lakes. But still it is high in relation to studies made on European lakes already mentioned in the discussion of Lower St. Mary Lake. One might predict that the orthophosphate would be on the order of 10^{-3} ppm., but for this lake it is in the range of 10^{-2} ppm. There are at least two explanations for this relationship. The first is that there was a possible contamination in the handling of the sample. Tests made on the equipment seem to refute this but the phosphate test is easily contaminated and this well may have occurred here. The second is that the lake is disturbed by humans and mountain storms, and these could have brought more orthophosphate into solution. This question will be settled only by future investigations. The conditions for Lost Lake are summarized on the next page.

Lake type: seepage

Lake size: small (0.07 mi. in diameter)

Benthic vegetation : negligible

Species abundance: 46

Total organism count range: 562-25,424

Ammonia nitrogen range: 0.00-0.185 ppm.

Nitrite nitrogen range: 0.001-0.0095 ppm.

Nitrate nitrogen range: 0.009-0.075 ppm.

*Orthophosphate range: 0.00-0.082 ppm

Range of pH: 7.05-7.75

Total alkalinity range: 42-52 mg/1.

Temperature range: 11.5-19.2°C.

*Values suspect.

Swift Current Lake

Description of Lake

Swift Current Lake is located on the east side of the park near Many Glaciers Hotel. Its altitude is 4,861 ft. and its approximate dimensions are 0.3 mi. wide by 0.9 mi. long. It is a glacial scour lake and is part of a pater noster lake system. There are two main inlet streams and one outlet stream which forms Swift Current Falls. Benthic vegetation is abundant in August and probably covers the entire bottom of the lake.

Location of Stations

Station I was located near the north end of the lake in front of the boat launching site. Water depth was 30 ft. Station II was located near the west side of the lake opposite the south end of the hotel. Station III was located in the middle of the lake at the narrows. Water depth was 24 ft. at both stations.

Taxonomy and Species Abundance

Table 6 provides an analysis of classification for the plankton algae collected. It is shown that the Chlorophyta and the Chrysophyta were the prominent groups in Swift Current Lake. Table 7 lists the plankton forms collected at each station and their dates of collection. If one considers the totals at the bottom of these tables, it can be seen that the numbers of species is at a high point on July 18th and July 31st. Forms collected at all

stations were Coscinodiscus Sp., Navicula Sp., Tabellaria Sp., Synedra Sp., Fragilaria Sp., Gomphonema Sp., and Dinobryon sociale.

Table 6. An Analysis of the Classification for Phytoplankton Collected in Swift Current Lake

Phylum	Classes	Orders	Families	Genera	Species
Chlorophyta	1	4	7	13	17
Chrysophyta	1	3	10	15	15
Pyrrhophyta	1	1	2	2	3
Cyanophyta	1	1	1	1	1
Totals	4	9	20	31	36

Table 7. Plankton Forms Collected at Each Station on Swift Current Lake

Station I

Plankton	7/4	7/18	7/31	8/18	9/3
Coscinodiscus Sp.	X	X	X		
Asterionella Sp.	X	X			X
Tabellaria Sp.	X	X	X		
Navicula Sp.		X	X		
Synedra Sp.		X			
Fragilaria Sp.	X	X	X	X	X
Gomphonema Sp.			X	X	X
Pinnularia Sp.			X		
Cymbella Sp.		X	X		X
Melosira Sp.			X		X

Plankton	7/4	7/18	7/31	8/18	9/3
Cocconeis Sp.		X			
Epithemia Sp.					X
Staurastrum apiculatum		X			
Staurastrum paradoxum				X	
Hyalotheca mucosa		X			
Cosmarium Turpinii		X	X		
Mougeotia Sp.	X				
Bulbochaete Sp.	X				
Scenedesmus quadricauda			X		
Dinobryon sociale	X			X	
Ceratium hirudinella				X	X
Peridinium Sp.				X	
Gomphosphaeria lacustris			X		
Totals	7	11	11	6	6

Station II

Asterionella Sp.	X	X	X		
Tabellaria Sp.			X	X	
Navicula Sp.	X	X	X	X	
Synedra Sp.	X	X			
Fragilaria Sp.	X	X	X	X	
Gomphonema Sp.			X	X	X
Cynbella Sp.		X	X	X	X
Epithemia Sp.					X
Gonatozygon aculeatum		X			
Staurastrum avicula				X	

Plankton	7/4	7/18	7/31	8/18	9/3
Staurastrum paradoxum		X		X	
Staurastrum gracile	X				
Xanthidium antilopaeum		X	X		
Cosmarium Turpinii			X		
Pediastrum Boryanum		X		X	
Dinobryon sociale	X		X		
Dinobryon divergens			X		
Ceratium hirundinella				X	X
Peridinium bipes	X			X	
Totals	7	9	10	10	39
Station III					
Coscinodiscus Sp.		X			
Asterionella Sp.	X	X			
Tabellaria Sp.		X	X		X
Navicula Sp.		X	X	X	
Synedra Sp.		X	X	X	
Fragilaria Sp.		X	X	X	
Gomphonema Sp.			X		
Surirella Sp.			X		
Ceratoneis Sp.			X		
Tetracyclis Sp.			X		
Gonatozygon aculeatum		X	X		
Staurastrum paradoxum		X			
Staurastrum furcigerum		X			

Plankton	7/4	7/18	7/31	8/18	9/3
Staurastrum gracile		X			
Hyalotheca mucosa		X			
Closterium Sp.		X			
Xanthidium antilopaeum			X		
Spirogyra Sp.		X	X		
Oedogonium Sp.				X	
Microspora Sp.		X			
Oocystis gigas			X		
Bulbochaete Sp.			X	X	
Dinobryon sociale	X	X	X		
Ceratium hirundinella				X	
Totals	2	15	14	6	1

Phytoplankton Abundance

The estimated phytoplankton counts for each species at the various stations during the summer of 1962 are given in graphs 16 and 17. The productivity in terms of standing crop is indicated by the total number of organisms per liter at all three stations on each collection date are as follows:

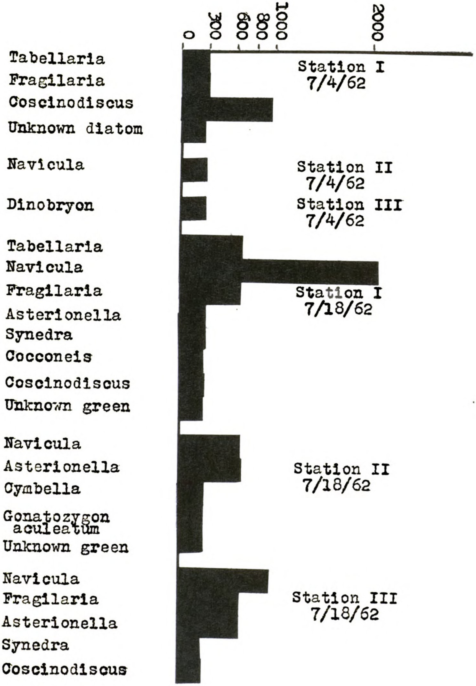
7/4/62-Station I,	1,782;	II,	281;	III,	281
7/18/62-Station I,	4,777;	II,	2,155;	III,	2,811
7/31/62-Station I,	3,375;	II,	4,129;	III,	3,654
8/18/62-Station I,	562;	II,	1,218;	III,	281
9/3/62-Station I,	281;	II,	281;	III,	281
Station total	10,777		8,084		7,308

Physical and Chemical Factors

The results of the analyses for physical and chemical factors are given in graphs 18. through 22. In some instances a multiplier for the Y axis value is given along with the variable on the X axis.

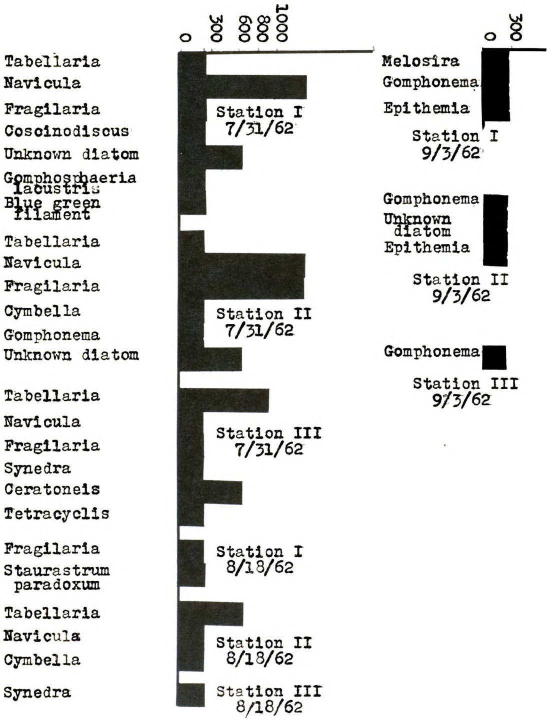
Graph 16. SWIFT CURRENT LAKE

Organisms Per Liter



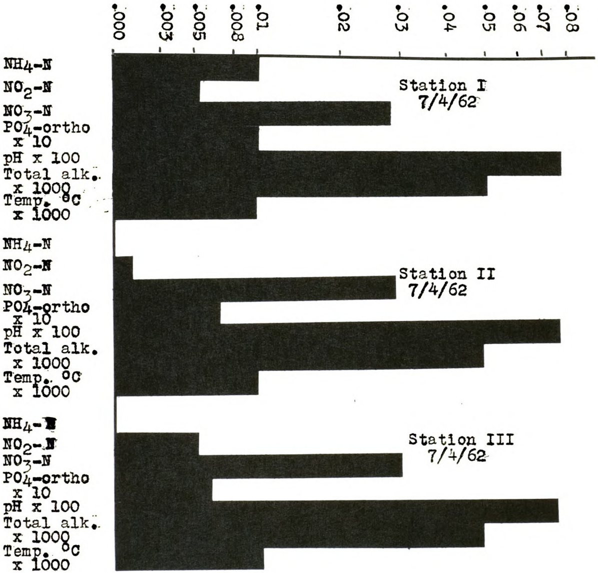
Graph 17. SWIFT CURRENT LAKE

Organisms Per Liter



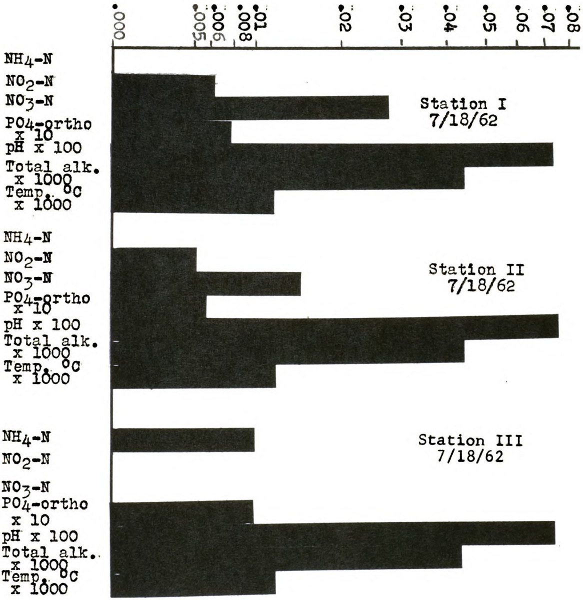
Graph 18. SWIFT CURRENT LAKE

Chemical and Physical Conditions



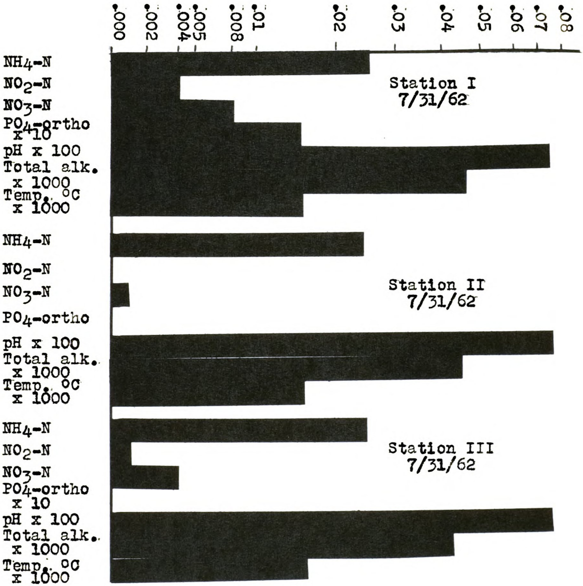
Graph 19 . SWIFT CURRENT LAKE

Chemical and Physical Conditions



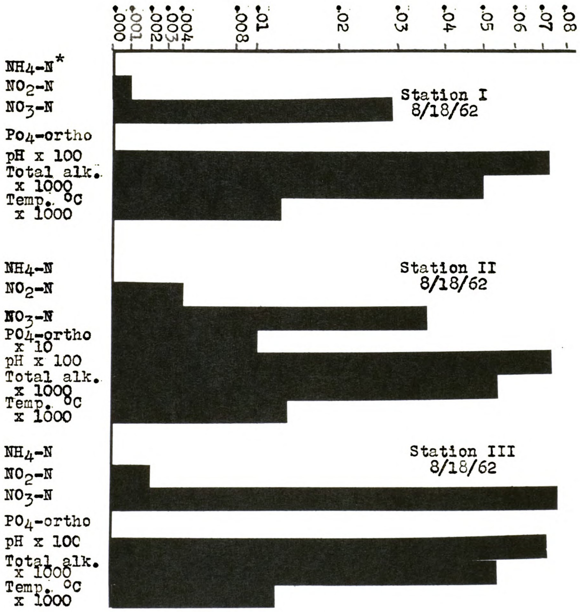
Graph 20. SWIFT CURRENT LAKE

Chemical and Physical Conditions



Graph 21. SWIFT CURRENT LAKE

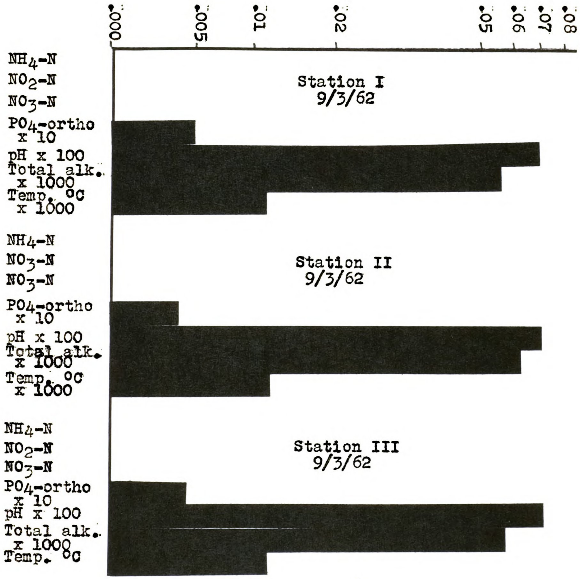
Chemical and Physical Conditions



* No data

Graph 22. SWIFT CURRENT LAKE

Chemical and Physical Conditions



Generalizations

At Station I the following relationships exist between organisms per liter and the chemical and physical conditions.

1. No relationship is discernible between ammonia nitrogen and number of organisms per liter. However, readings for both conditions are very low for the last two collecting periods. On 7/31 both are relatively high (Figs. 46 and 47).
2. Nitrite nitrogen and number of organisms per liter are directly related (Figs. 46 and 48).
3. Nitrate nitrogen and number of organisms per liter show no relationship (Figs. 46 and 49).
4. Orthophosphate and number of organisms per liter are directly related (Figs. 46 and 50).
5. The pH and number of organisms per liter show no definite relationship except that both conditions show a general decrease from 7/18 to 9/3 (Figs. 46 and 51).
6. Total alkalinity and number of organisms per liter are inversely related (Figs. 46 and 52).
7. Temperature and number of organisms per liter show no relationship. In general the organism count is low at the periods of low temperature (Figs. 46 and 53).

At Station II the relationships are:

1. No relationship between ammonia nitrogen and number of organisms per liter (Figs. 54 and 55).
2. No relationship between nitrite nitrogen and number or organisms per liter (Figs. 54 and 56).

3. In general there is an inverse relationship between nitrate nitrogen and number of organisms per liter (Figs. 54 and 57).
4. For the first two weeks the orthophosphate and number of organisms per liter increase together. The peak for phosphorus is reached on 7/18, and the peak for organism count is on 7/31. Thus it is noted that phosphorus lags behind the organism count (Figs. 54 and 58).
5. No relationship exists between pH and number of organisms per liter. Both conditions decrease together for the last three sampling periods (Figs. 54 and 59).
6. Total alkalinity and number of organisms per liter are inversely related (Figs. 54 and 50).
7. Temperature and number of organisms per liter are directly related (Figs. 54 and 61).

At Station III the relationships are:

1. A dubious direct relationship between ammonia nitrogen and number of organisms per liter exists (Figs. 62 and 63).
2. No relationship is present between nitrite nitrogen and number of organisms per liter (Figs. 62 and 64).
3. Nitrate nitrogen and organism count are inversely related from 7/4 to 7/18. Then both factors increase. The peak for number of organisms per liter is reached on 7/31 and then decreases sharply.

Nitrate reaches its peak on 8/18, then decreases quickly (Figs. 62 and 65).

4. No clear relationship exists between orthophosphate and number of organisms per liter. It is worthy of note that the phosphorus peak lags behind the organism count peak (Figs. 62 and 66).
5. No relationship between pH and number of organisms per liter except that both decrease for the last three sampling periods (Figs. 62 and 67).
6. Total alkalinity and number of organisms per liter are inversely related (Figs. 62 and 68).
7. A direct relationship exists between temperature and number of organisms per liter (Figs. 62 and 69).

Swift Current Lake-July 4, 18, 31, Aug. 18, Sept. 3

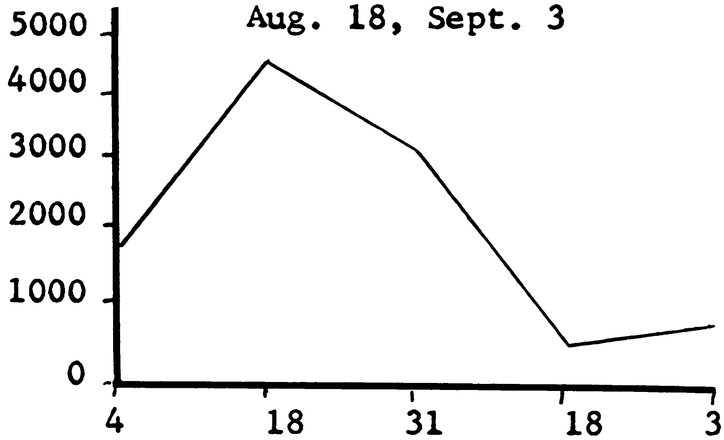


Fig. 46. Station I
Organisms per liter

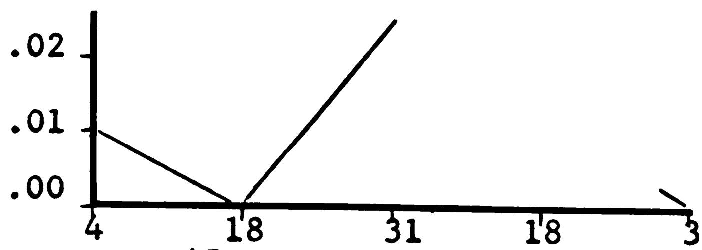


Fig. 47. Station I
Ammonia nitrogen ppm.

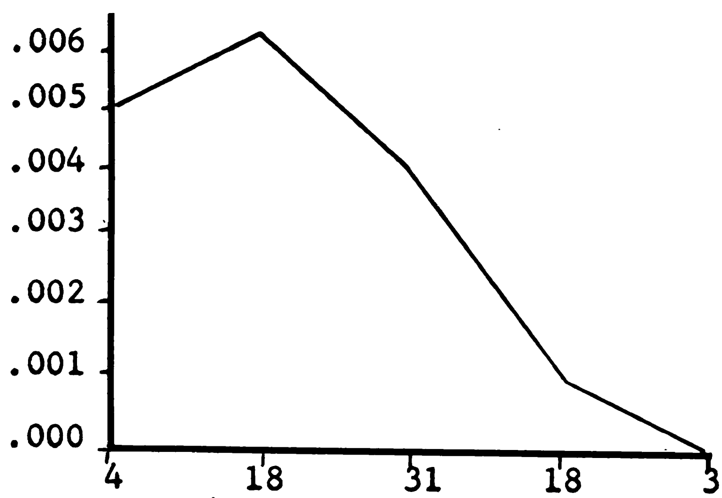


Fig. 48. Station I
Nitrite nitrogen ppm.

Swift Current Lake-July 4, 18, 31, Aug. 18, Sept. 3

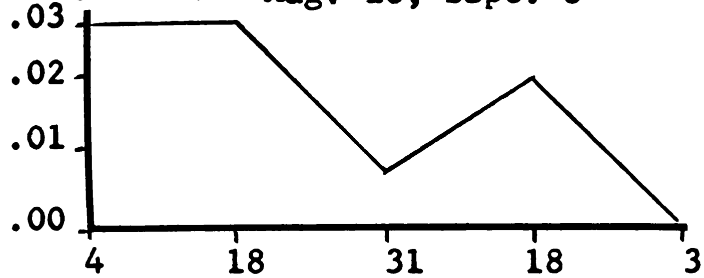


Fig. 49. Station I
Nitrate nitrogen ppm.

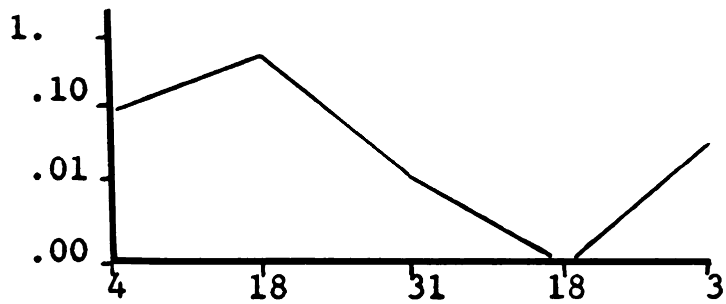


Fig. 50. Station I
Orthophosphate ppm.

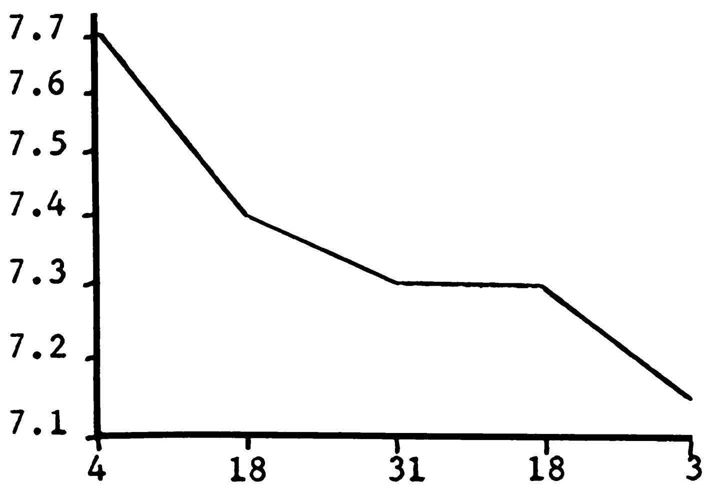


Fig. 51. Station I
pH

Swift Current Lake-July 4, 18, 31,

Aug. 18, Sept. 3

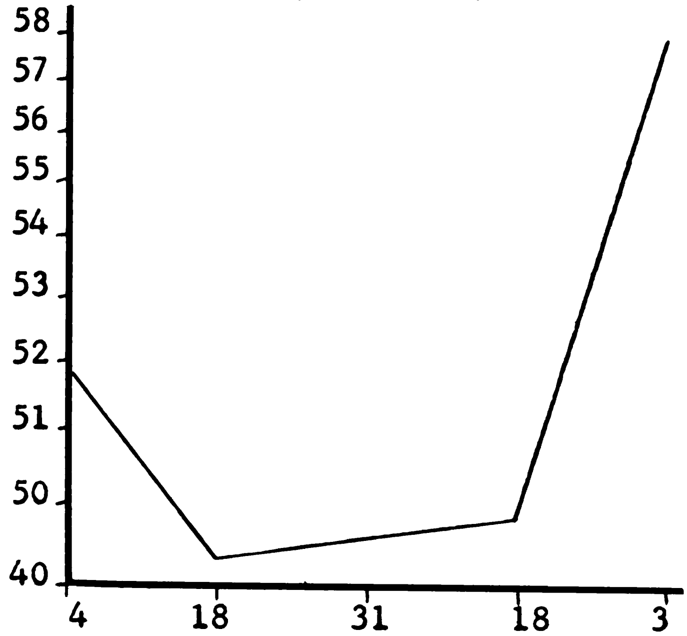


Fig. 52. Station I
Total alkalinity mg/l

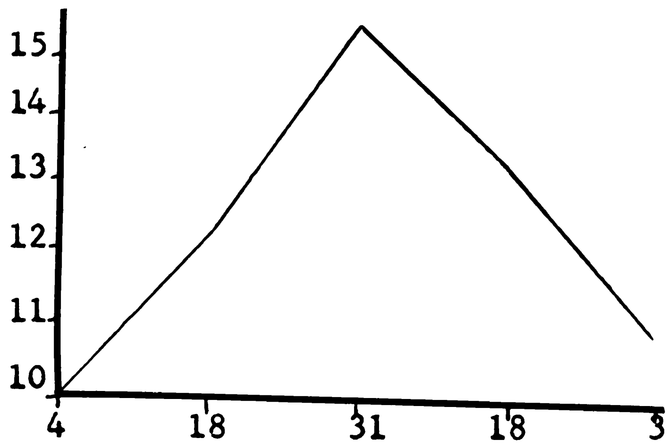


Fig. 53. Station I
Temperature °C

Swift Current Lake-July 4, 18, 31, Aug. 18, Sept. 3

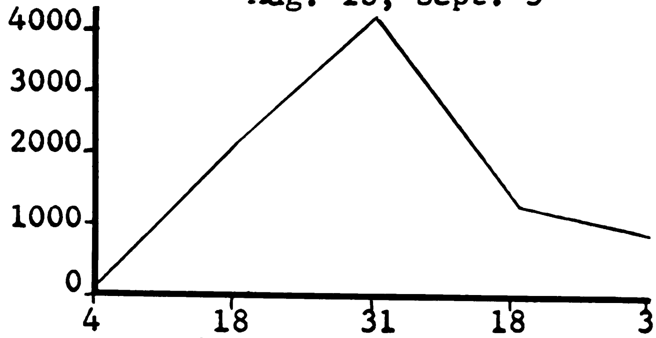


Fig. 54. Station II
Organisms per liter

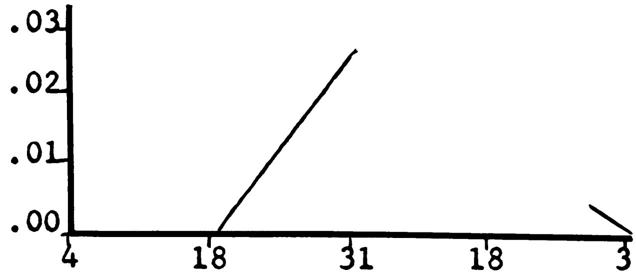


Fig. 55. Station II
Ammonia nitrogen ppm.

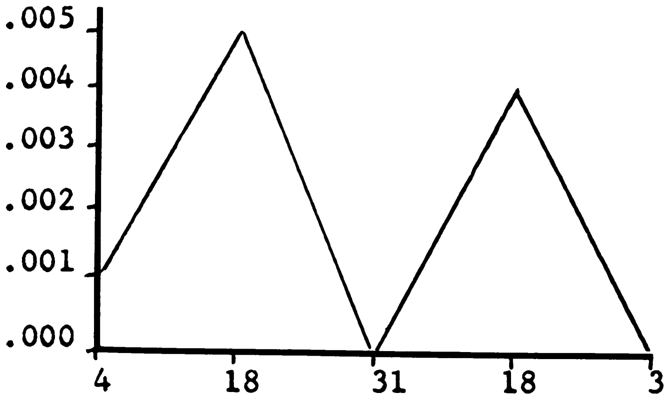


Fig. 56. Station II
Nitrite nitrogen ppm.

Swift Current Lake-July 4, 18, 31,
Aug. 18, Sept. 3

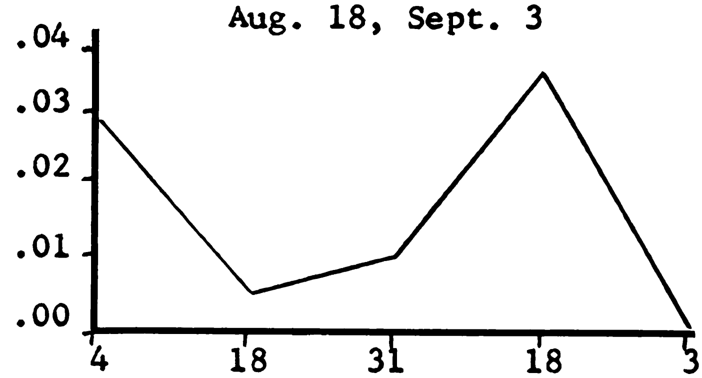


Fig. 57. Station II
Nitrate nitrogen ppm.

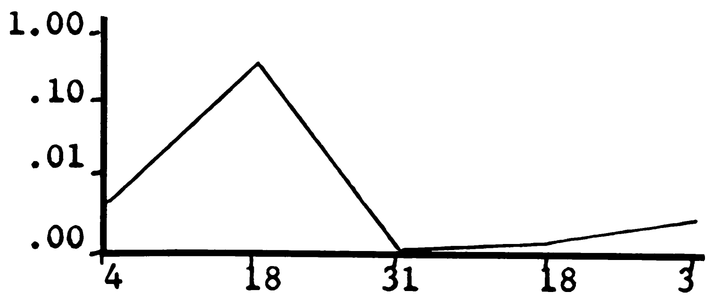


Fig. 58. Station II
Orthophosphate ppm.

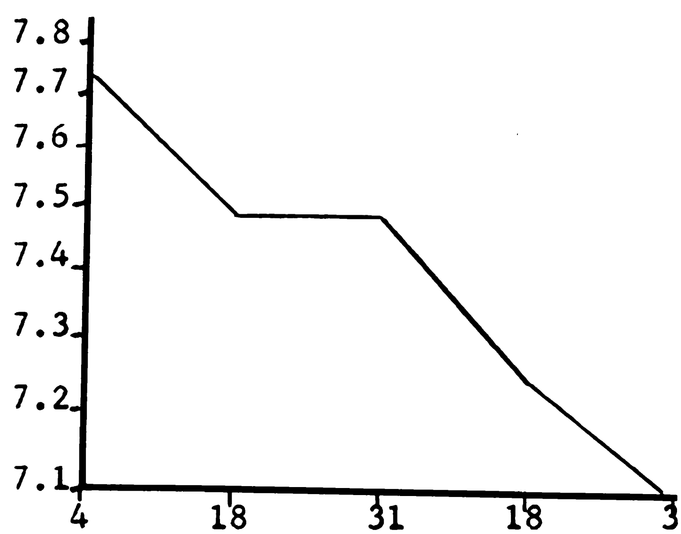


Fig. 59. Station II
pH

Swift Current Lake-July 4, 18, 31,
Aug. 18, Sept. 3

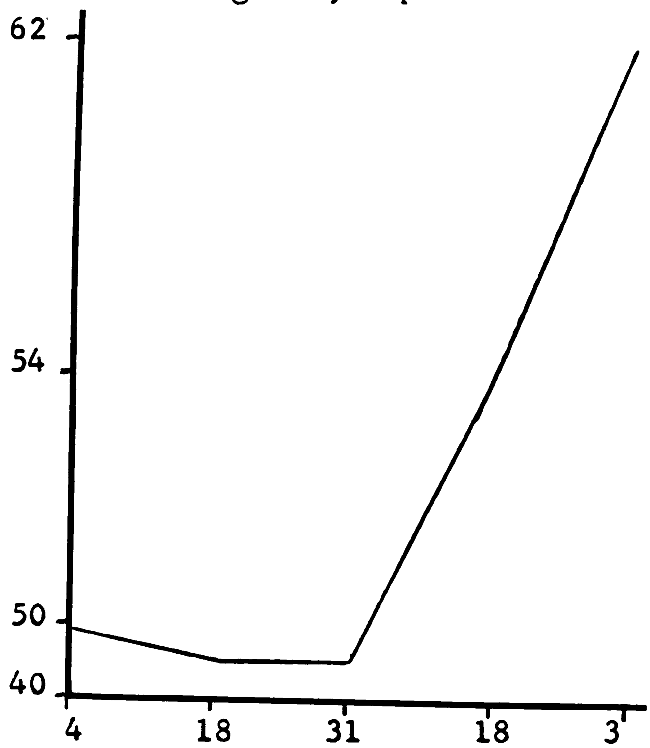


Fig. 60. Station II
Total alkalinity mg/l

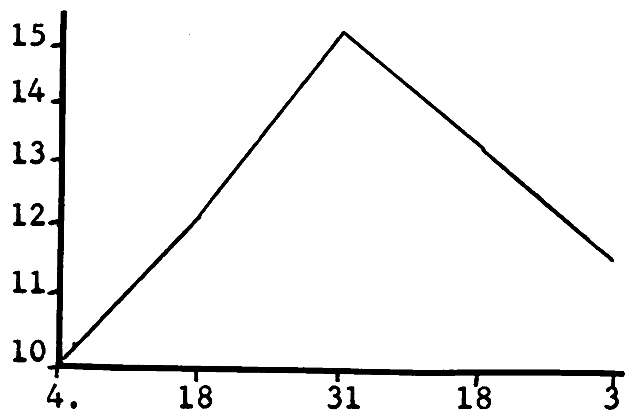


Fig. 61. Station II
Temperature °C

Swift Current Lake-July 4, 18, 31,
Aug. 18, Sept. 3

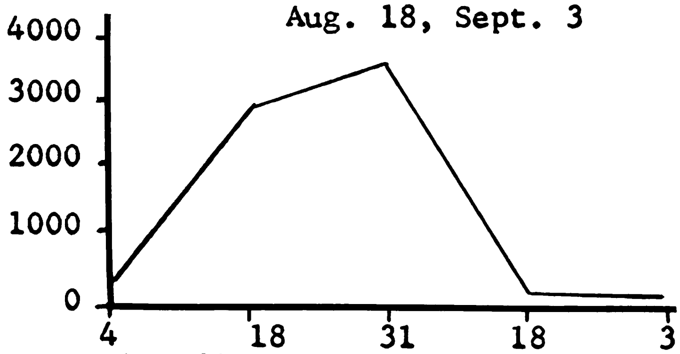


Fig. 62. Station III
Organisms per liter

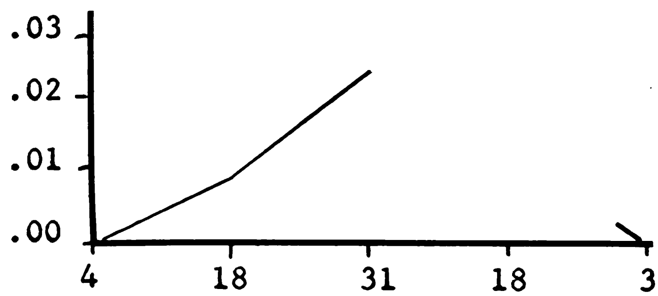


Fig. 63. Station III
Ammonia nitrogen ppm.

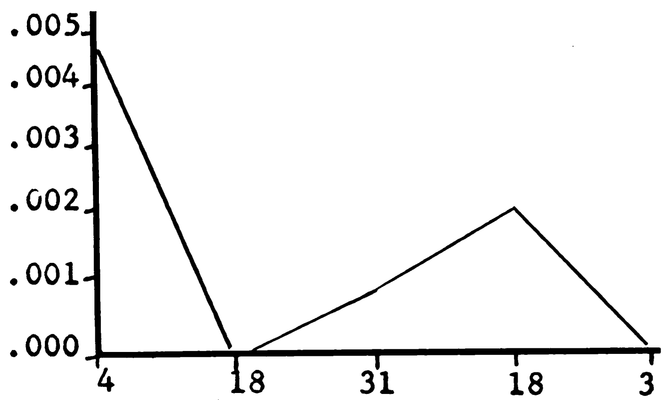


Fig. 64. Station III
Nitrite nitrogen ppm.

Swift Current Lake-July 4, 18, 31, Aug. 18, Sept. 3

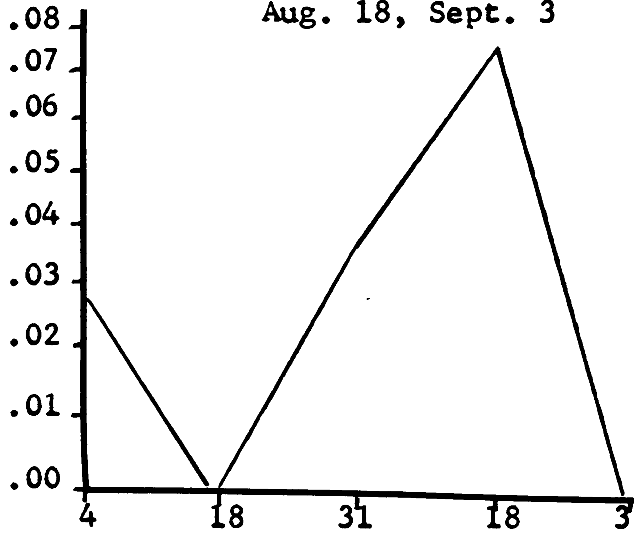


Fig. 65. Station III
Nitrate nitrogen ppm.

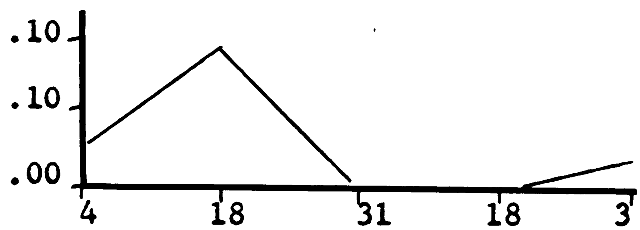


Fig. 61. Station III
Orthophosphate ppm.

Fig. 67. Station III
pH

Swift Current Lake-July 4, 18, 31,
Aug. 18, Sept. 3

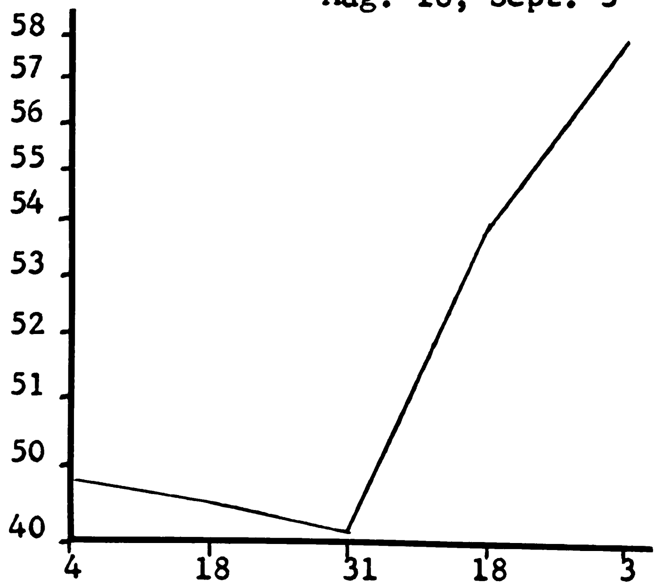


Fig. 68. Station III
Total alkalinity mg/l

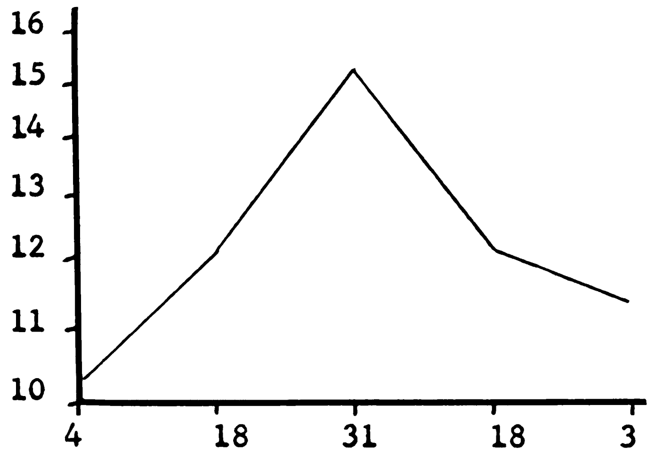


Fig. 69. Station III
Temperature $^{\circ}C$

Discussion

Members of the phyla Chlorophyta and Chrysophyta have the largest representation in Swift Current Lake. Coscinodiscus, Navicula, Tabellaria, Synedra, Fragilaria, Gomphonema, and Dinobryon sociale, were the most frequently occurring forms in the qualitative collections. Since only 36 species existed in the qualitative collections (net tows and hand-grabs) as compared to 46 in Lost Lake and 23 in Lower St. Mary Lake, this is the second most floristically rich lake on the eastside of the park. But on the basis of quantitative counts this would be the poorest lake in terms of standing crop (see pgs. 86, 115 and 146). This relationship is interesting because Swift Current Lake is colder and has lower concentrations of nutrients than the other two lakes mentioned above. Unlike Lower St. Mary Lake and Lost Lake, no phytoplankton blooms existed in Swift Current Lake during the collection period of July 4th to Sept. 3rd. The water chemistry is of interest because it was quite erratic during the summer. Ammonia nitrogen remained at either 0.01 ppm., or quite commonly at 0.00 ppm. most of the summer except at one collection date. This factor was relatively high in the other two lakes studied on the east-side of the continental divide. Nitrite and nitrate nitrogen showed no relationship to the number of organisms per liter, but were present in the lake water in low amounts. As mentioned for previous discussions, the amount of orthophosphate seems too high for this type of habitat. In general the pH and number of organisms per liter decreased during the summer,

while the total alkalinity increased. In the selection of a critical factor, the author would select temperature because of the observed direct relationship between total organism count and this variable. The information below summarizes the conditions for Swift Current Lake.

Lake type: flowage

Lake size: medium (0.3 x 0.9 mi.)

Benthic vegetation: abundant

Species abundance: 36

Range of total organism count: 281-4,777

Range of ammonia nitrogen: 0.00-0.025 ppm.

Range of nitrite nitrogen: 0.000-0.0065 ppm.

Range of nitrate nitrogen: 0.00-0.078 ppm.

*Range of orthophosphate: 0.00-0.56 ppm.

Range of pH: 7.1-7.75

Range of total alkalinity: 42-62 mg/l.

Range of temperature: 10-16° C.

*Values suspect

Hidden Lake

Hidden Lake is located near Logan Pass on the continental divide. It is a two-mile hike from the summit parking area. Because this lake was visited only once each summer the following account attempts to be descriptive only of the conditions at the time of sampling. Stations were located at the north end of the lake.

Description of Lake

Hidden Lake apparently has resulted from a glacial scour. It is directly fed by a glacier and has only one outlet stream which forms a water fall. Its altitude is 6,375 ft. and its rocky bottom supports no growth of vegetation. Generally one has to wait until about the first seek in July before the trail into Hidden Lake is clear of snow.

Algal species collected were: Pediastrum Sp., Cosmarium Sp., Oscillatoria Sp., Ulothrix zonata, Sphaerocystis Schroeteri, Fragilaria Sp., Gomphonema Sp., Coscinodiscus Sp., Tabellaria Sp., Navicula Sp., Asterionella Sp., Chlamydomonas Sp., Gyrosigma Sp., and Calothrix Sp.

Chemical and Physical Conditions

On 7/12/61 the conditions were Temp. 9° C., Total alk. 52 mg/l., and pH 8.3. The conditions for 8/1/62 were NH_4-N 0.0 ppm. at all three stations, NO_2-N 0.004 ppm. at Station I, 0.003 ppm. at Station II, and 0.005 ppm. at Station III; NO_3-N 0.027 ppm. at Station I, 0.027 ppm. at Station II, and 0.045 ppm. at Station III; PO_4-ortho 0.1 ppm. at Station I,

0.06 ppm. at Station II, 0.08 ppm. at Station III; pH 7.3 at Station I, 7.2 at Station II, and 7.1 at Station III; and total alk. 40 mg/l. at Station I, 40 mg/l. at Station II, and 44 mg/l. at Station III; and temp. 13° C. at Station I, 13° C. at Station II, and 13° C. at Station III.

Phytoplankton Abundance

At Station I the organisms per liter were Coscinodiscus 656 and Gomphonema 656. Station II had Coscinodiscus 656, Gomphonema 656, and unknown diatom 656. Station III had Tabellaria 281, Navicula 281, Gomphonema 281, and unknown diatom 281.

Discussion

The species previously listed represent all of the forms collected on two different occasions. The number of species is thus seen to be very small. Temperature is low compared to the other park habitats on these approximate dates. Chemical analysis indicates only trace amounts of each ion tested. Total alkalinity seems to be moderately high as compared to Johns Lake but lower in concentration than some of the other park lakes. In 1961 the hydrogen ion concentration was 8.3 but in 1962 it is very nearly neutral. As in the other lakes studied, orthophosphate is too high in value, and has been mentioned in previous discussions.

Bowman Lake

Description of Lake

Bowman Lake is located about 8 miles northeast of the Pole Bridge Ranger Station. The lake is approximately .5 mi. wide by 6.8 mi. long. Bowman Lake is dammed by an end moraine and apparently is in excess of 96 ft. deep at the western end of the lake. Bottom materials include rock and some silt. Vegetation is very sparse in this lake. There are several glacially fed inlet streams that enter the lake at the northern most end. Bowman Creek represents the only outlet stream.

Location of Stations

All three stations are situated in the western sector of the lake. Station I is opposite the Ranger Station and Station II is opposite the dock area at the picnic grounds, and Station III is opposite Bowman Creek. Water depth at each station was in excess of 30 ft.

Taxonomy and Species Abundance

Table 8 provides an analysis of the classification for the plankton algae collected. This table shows that the Chlorophyta and Chrysophyta are the most abundant groups in Bowman Lake

Table 8. An Analysis of Classification for the Phytoplankton in Bowman Lake

Phylum	Classes	Orders	Families	Genera	Species
Chlorophyta	1	2	4	6	6
Chrysophyta	2	3	7	11	12
Pyrrhophyta	1	1	2	2	2
Cyanophyta	1	2	2	3	4
Totals	5	8	15	22	24

Table 9 lists the plankton forms collected at each station and their date of collection. At all three stations the number of species collected is relatively constant for all five sampling periods. This is in contrast to the lakes already mentioned on the east side of the park where the number of species was low in June and early July and rose significantly in numbers by the end of July and early August. Forms collected at all three stations were *Coscinodiscus* Sp., *Asterionella* Sp., *Fragilaria* Sp., *Dinobryon divergens*, *Peridinium* Sp., and *Ceratium hirundinella*.

Table 9. Plankton Forms Collected at Each Station on Bowman Lake

Station I

Plankton	6/28	7/12	7/25	8/10	9/2
Coscinodiscus Sp.	X	X	X	X	
Asterionella Sp.	X	X	X	X	
Tabellaria Sp.		X	X	X	
Navicula Sp.		X	X		
Synedra Sp.	X	X	X		
Fragilaria Sp.	X	X	X	X	
Pinnularia Sp.			X		
Melosira Sp.	X	X			
Hyalotheca dissiliens			X		
Dictyosphaerium pulchellum					X
Spirogyra Sp.			X		
Dinobryon bavaricum	X	X			
Dinobryon divergens	X	X	X	X	
Ceratium hirundinella		X	X	X	
Peridinium Sp.	X	X	X		
Chroococcus turgidus	X			X	
Chroococcus limneticus	X	X			
Totals	16	12	12	7	1

Station II

Plankton	6/28	7/12	7/25	8/10	9/2
Coscinodiscus Sp	X	X	X	X	
Asterionella Sp.	X	X	X	X	
Tabellaria Sp.		X	X		

Plankton	6/28	7/12	7/25	8/10	9/2
Navicula Sp.		X	X		
Synedra Sp.	X	X	X	X	
Fragilaria Sp.	X	X	X	X	
Gomphonema Sp.				X	
Pinnularia Sp.	X				
Melosira Sp.		X	X		
Cyclotella Sp.	X				
Epithemia Sp.					X
Micrasterias pinnatifida			X		
Staurastrum Sp.	X				
Xanthidium cristatum			X		
Chlorosarcina consociata		X	X		
Dinobryon bavaricum	X	X			
Dinobryon divergens	X	X	X	X	
Ceratium hirundinella	X	X	X	X	
Peridinium Sp.	X	X	X	X	
Chroococcus limneticus		X	X		
Oscillatoria nigra			X		
Totals	11	13	15	8	1

Station III

Coscinodiscus Sp.	X	X	X	X	
Asterionella Sp.	X	X		X	
Tabellaria Sp.		X			
Navicula Sp.			X		
Synedra Sp.	X	X			

Plankton	6/28	7/12	7/25	8/10	9/2
Fragilaria Sp.	X	X	X	X	
Pinnularia Sp.	X		X		
Melosira Sp.		X			
Pediastrum Boryanum		X			
Dinobryon bavaricum	X		X		
Dinobryon divergens	X	X	X	X	
Ceratium hirundinella		X	X	X	
Peridinium Sp.	X	X	X		
Anabaena Sp.	X				
Chroococcus limnetica		X	X		
Chroococcus turgidus				X	
Totals	9	11	9	6	

Phytoplankton Abundance

Graphs 23. through 25. show the phytoplankton count estimates for each species at the various stations during the summer of 1962. Asterionella, Coscinodiscus, and Dinobryon divergens were the three most abundant species per liter during the summer. The total number of organisms per liter at all three stations at each collection date were as follows:

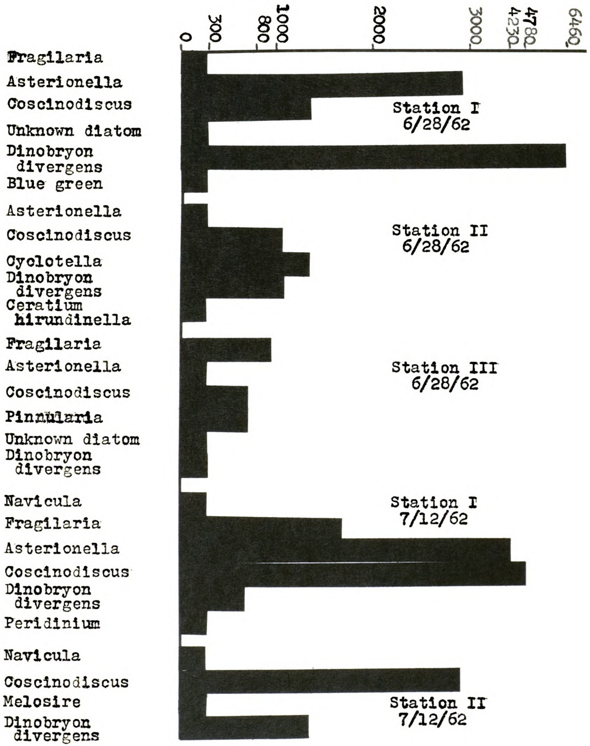
6/28/62-Station	I,	11,237;	II,	3,750;	III,	3,092
7/12/62-Station	I,	11,917;	II,	4,777;	III,	5,533
7/25/62-Station	I,	7,197;	II,	5,340;	III,	6,935
8/10/62-Station	I,	6,272;	II,	4,680;	III,	6,113
9/2/62-Station	I,	8,255;	II,	no data	III,	5,429
Station total		44,877		18,547		27,102

Physical and Chemical Factors

The results of the analyses for physical and chemical factors are in Graphs 26. through 29. In some instances a multiplier for the Y axis value is given along with the variable on the X axis.

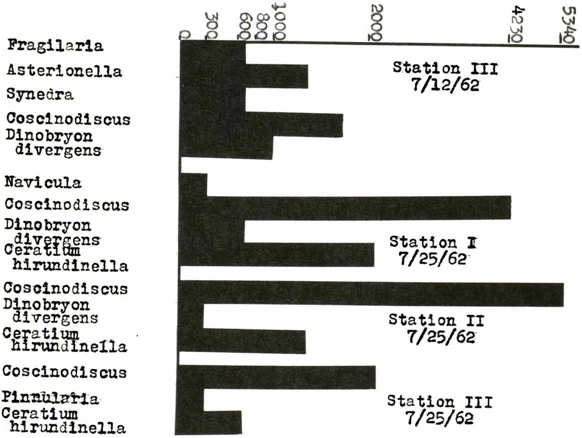
Graph 23. BOWMAN LAKE

Organisms Per Liter



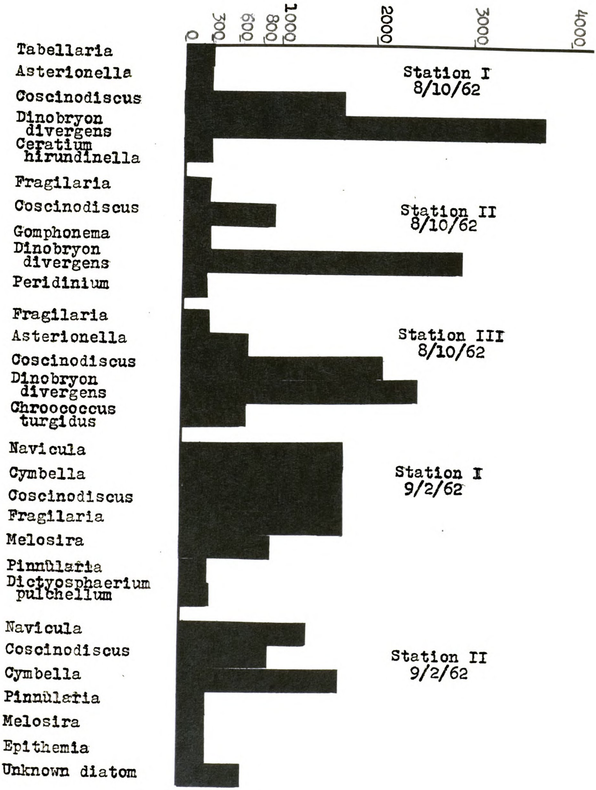
Graph 24. BOWMAN LAKE

Organisms Per Liter



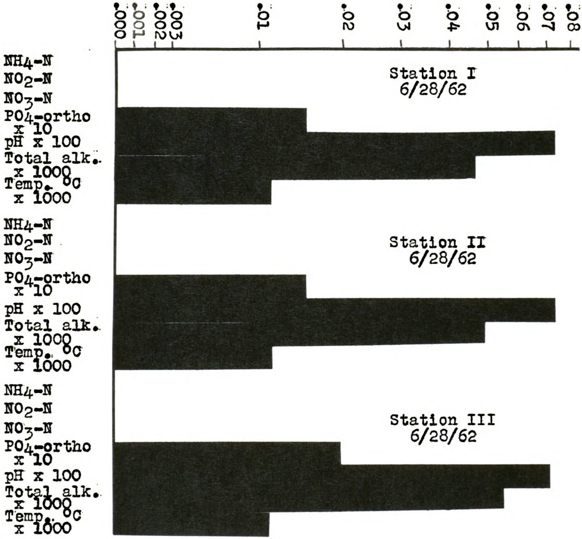
Graph 25. BOWMAN LAKE

Organisms Per Liter



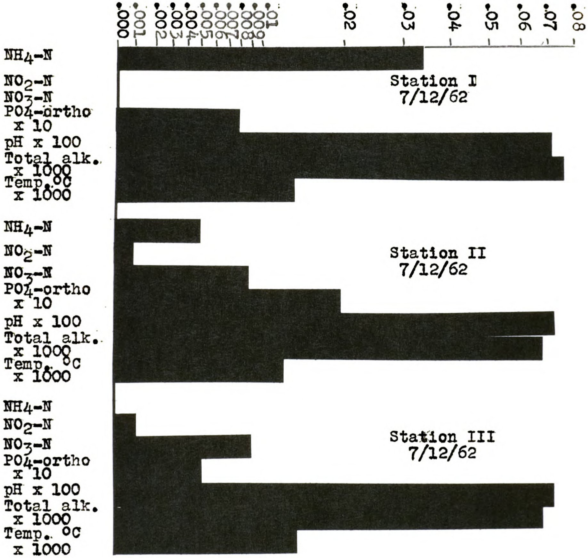
Graph 26. BOWMAN LAKE

Chemical and Physical Conditions



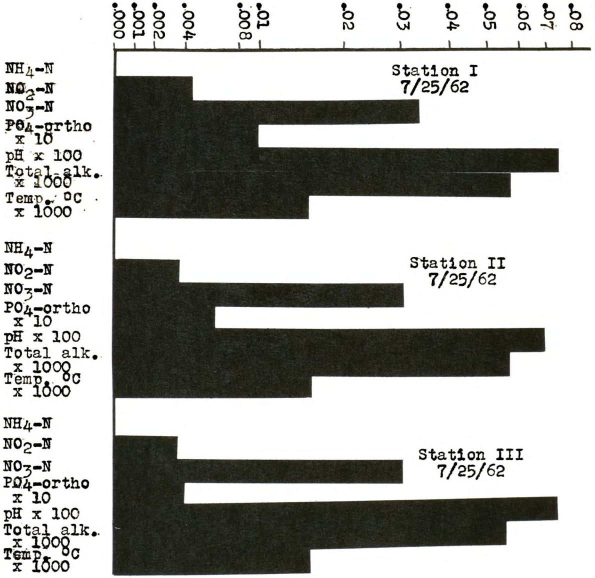
Graph 27. BOWMAN LAKE

Chemical and Physical Conditions



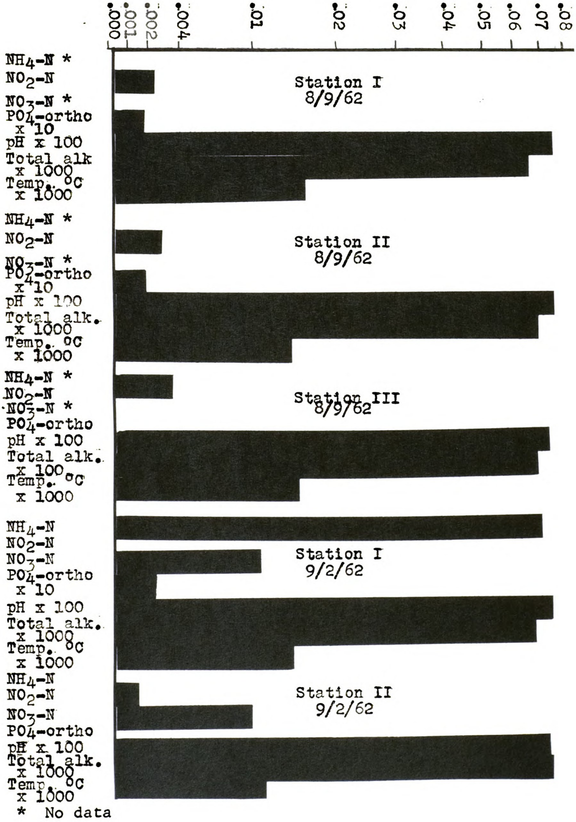
Graph 28. BOWMAN LAKE

Chemical and Physical Conditions



Graph 29. BOWMAN LAKE

Chemical and Physical Conditions



Generalizations

Figures 70-77 show the relationships for organisms per liter and the chemical and physical conditions at Station I. These relationships are:

1. Ammonia nitrogen and organisms per liter are directly related (Figs. 70 and 71).
2. Nitrite nitrogen and organisms per liter show in general an indirect relationship (Figs. 70 and 72).
3. Nitrate nitrogen and organisms per liter show an inverse relationship (Figs. 70 and 73).
4. No relationship exists between orthophosphate and organisms per liter (Figs. 70 and 74).
5. Organisms per liter and pH are inversely related (Figs. 70 and 75).
6. Total alkalinity and organisms per liter are directly related (Figs. 70 and 76).
7. Temperature and organisms per liter are inversely related for the last four sampling periods (Figs. 70 and 77).

Figures 78-85 show the conditions for Station II. These relationships are:

1. No relationship is indicated between ammonia nitrogen and organisms per liter (Figs. 78 and 79).
2. Nitrite nitrogen and organisms per liter show a direct relationship (Figs. 78 and 80).
3. Nitrate nitrogen and organisms per liter may be directly related (Figs. 78 and 81).

4. Orthophosphate and organisms per liter show no relationship. Note that the peak for phosphorus occurs on 7/2, however, and then declines sharply for the remainder of the summer. The peak for estimated counts is reached on 7/25 (Figs. 78 and 82).
5. No relationship exists between pH and organisms per liter (Figs. 78 and 83).
6. In general there is a direct relationship between total alkalinity and organisms per liter (Figs. 78 and 84).
7. No relationship exists between temperature and organisms per liter (Figs. 78 and 85).

Figures 86-91 show the conditions for Station III. The relationships between organisms per liter and the chemical and physical conditions are:

1. No graph was drawn for ammonia nitrogen because the data was too insufficient for the realization of any relationships.
2. No relationship exists between nitrite nitrogen and organisms per liter (Figs. 86 and 87).
3. No graph was drawn for nitrate nitrogen because of insufficient data.
4. No relationship exists between orthophosphate and organisms per liter (Figs. 86 and 88).
5. No relationship exists between pH and organisms per liter (Figs. 86 and 89).

6. There was a direct relationship between total alkalinity and organisms per liter (Figs. 86 and 90).
7. There was no relationship between temperature and organisms per liter (Figs. 86 and 91).

Bowman Lake-June 28, July 12, 25, Aug. 10, Sept. 2

Fig. 70. Station I
Organisms per liter

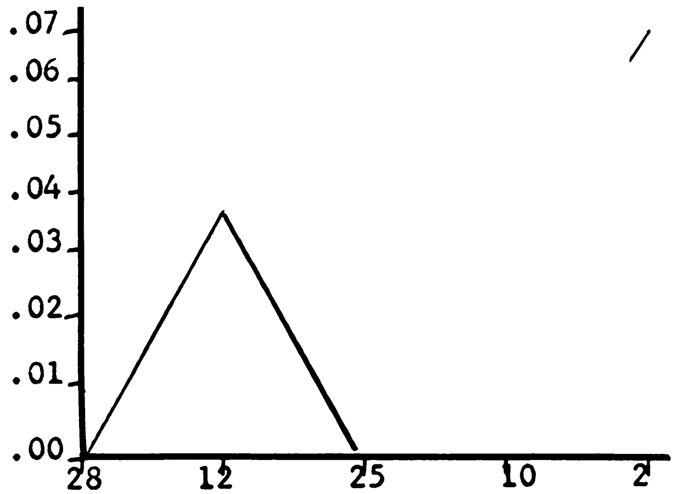


Fig. 71. Station I
Ammonia nitrogen ppm.

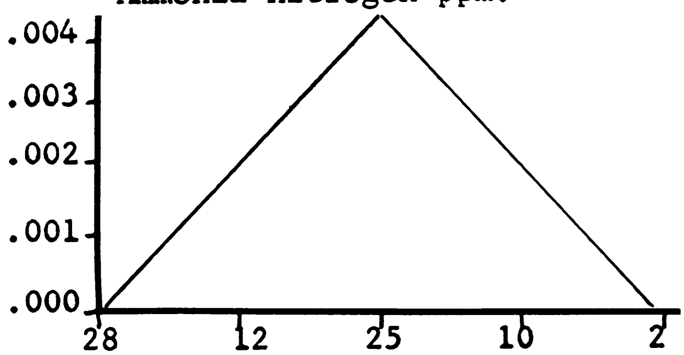


Fig. 72. Station I
Nitrite nitrogen ppm.

Bowman Lake-June 28, July 12, 25, Aug. 10, Sept. 2

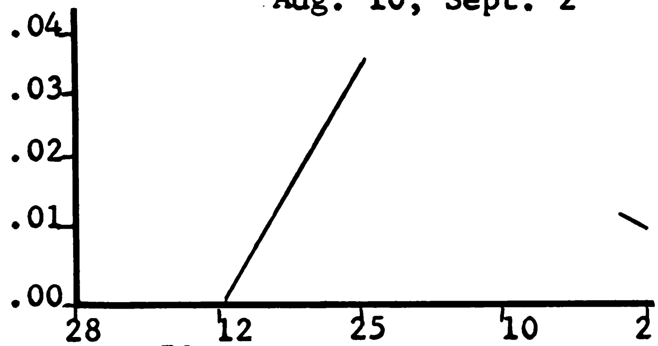


Fig. 73. Station I
Nitrate nitrogen ppm.

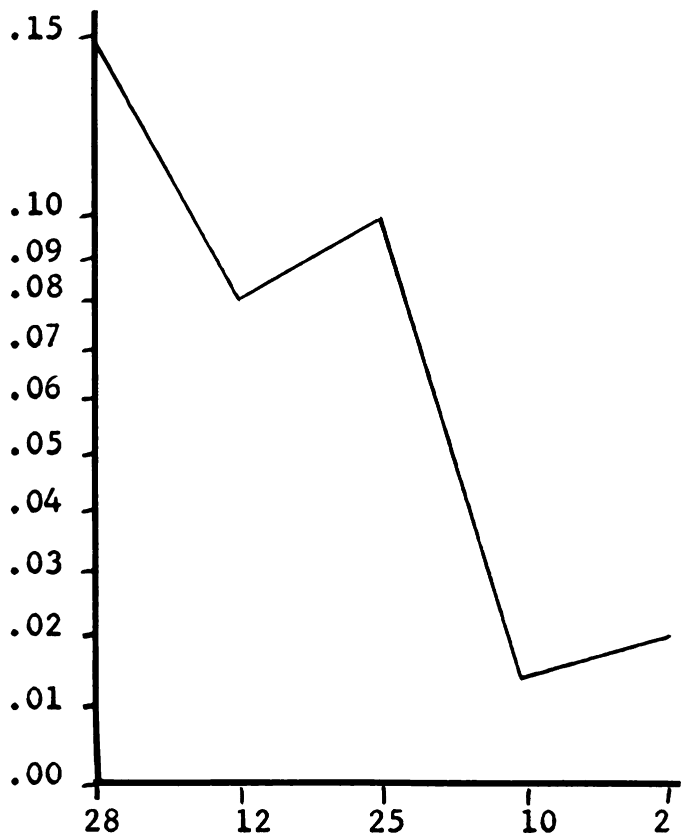


Fig. 74. Station I
Orthophosphate ppm.

Bowman Lake-June 28, July 12, 25, Aug. 10, Sept. 2

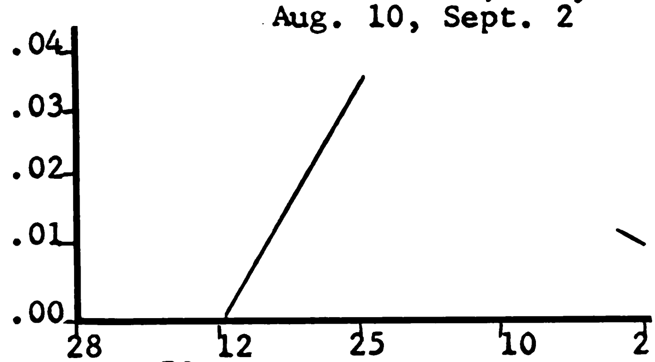


Fig. 73. Station I
Nitrate nitrogen ppm.

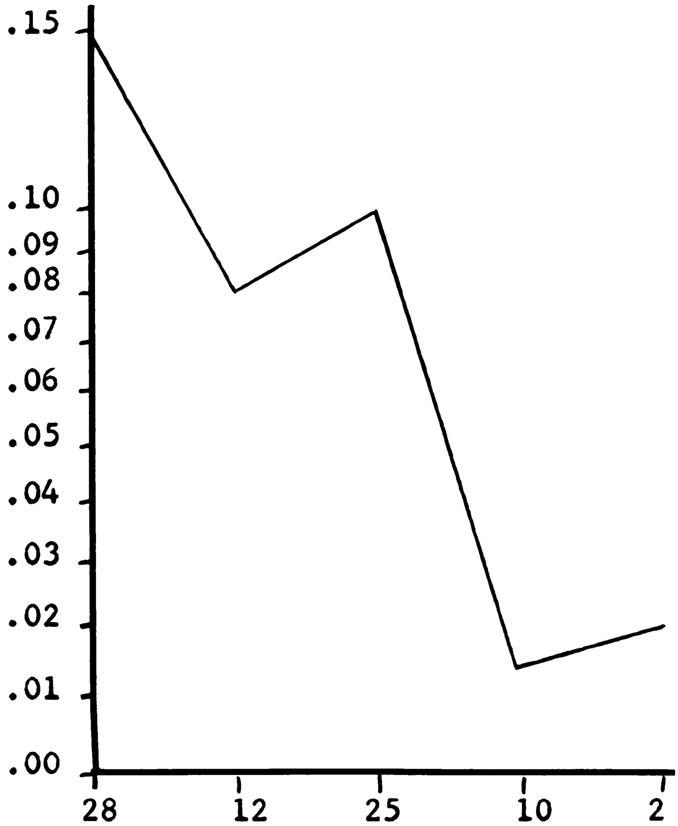


Fig. 74. Station I
Orthophosphate ppm.

Bowman Lake-June 28, July 12, 25,
Aug. 10, Sept. 2

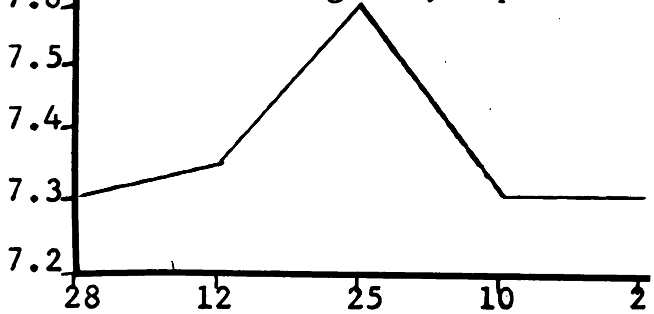


Fig. 75. Station I
pH

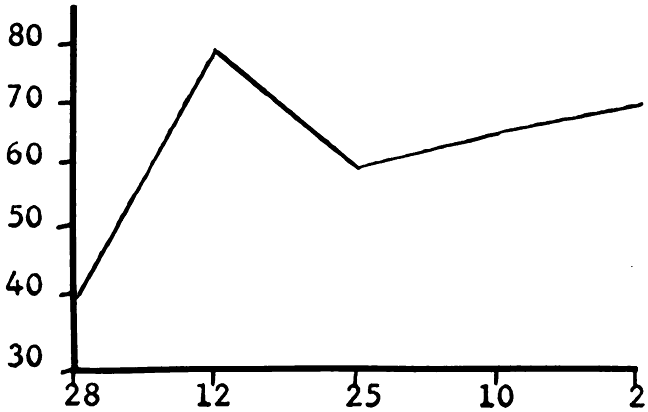


Fig. 76. Station I
Total alkalinity mg/1

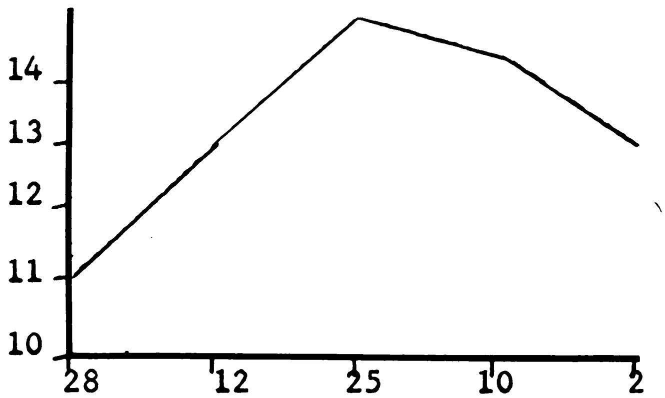


Fig. 77. Station I
Temperature °C

Bowman Lake-June 28, July 12, 25,
Aug. 10, Sept. 2

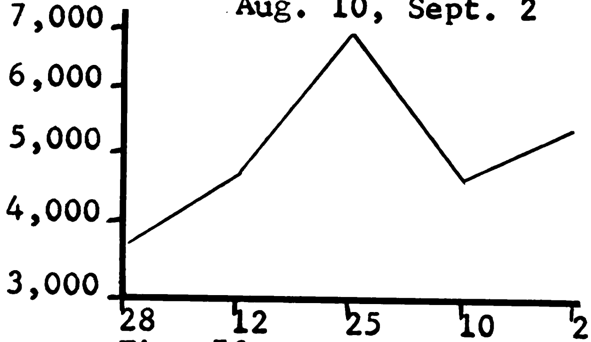


Fig. 78. Station II
Organisms per liter

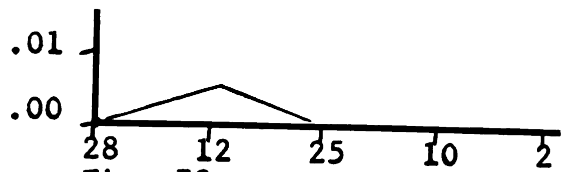


Fig. 79. Station II
Ammonia nitrogen ppm.

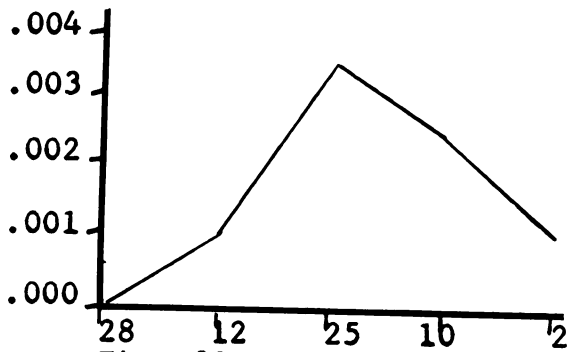


Fig. 80. Station II
Nitrite nitrogen ppm.

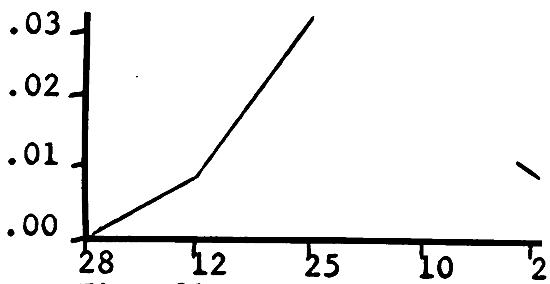


Fig. 81. Station II
Nitrate nitrogen ppm.

Bowman Lake-June 28, July 12, 25,
Aug. 10, Sept. 2

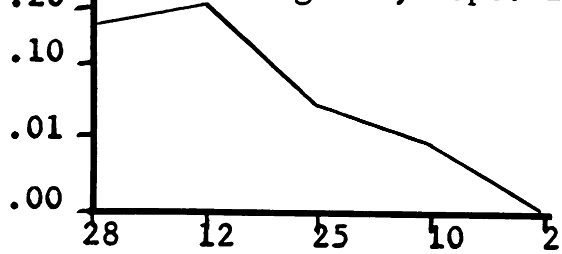


Fig. 82. Station II
Orthophosphate ppm.

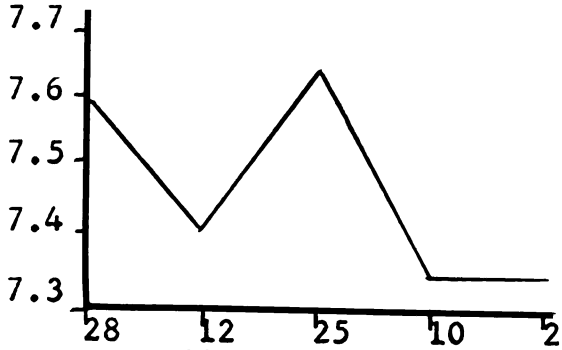


Fig. 83. Station II
pH

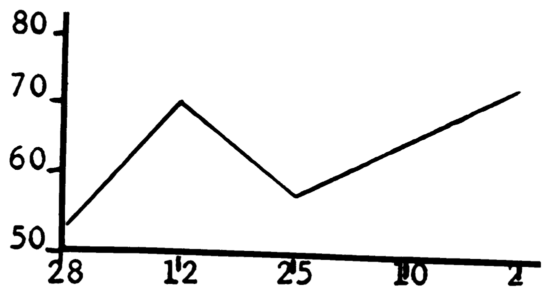


Fig. 84. Station II
Total alkalinity mg/1

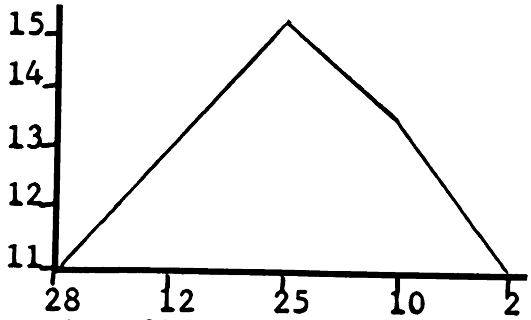


Fig. 85. Station II
Temperature °C

Bowman Lake-June 28, July 12, 25,
Aug. 10, Sept. 2

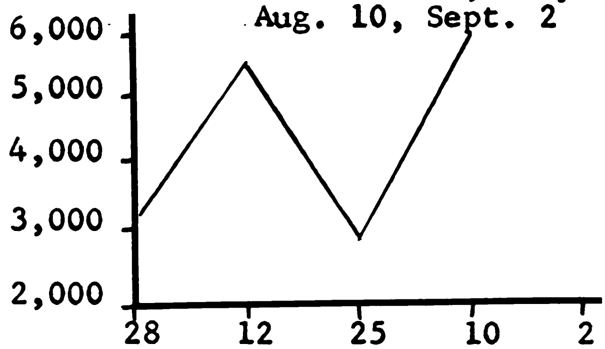


Fig. 86. Station III
Organisms per liter

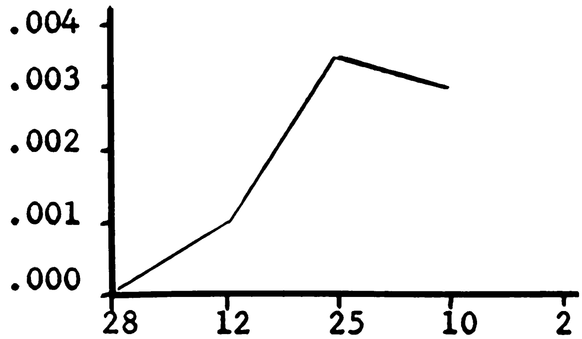


Fig. 87. Station III
Nitrite nitrogen ppm.

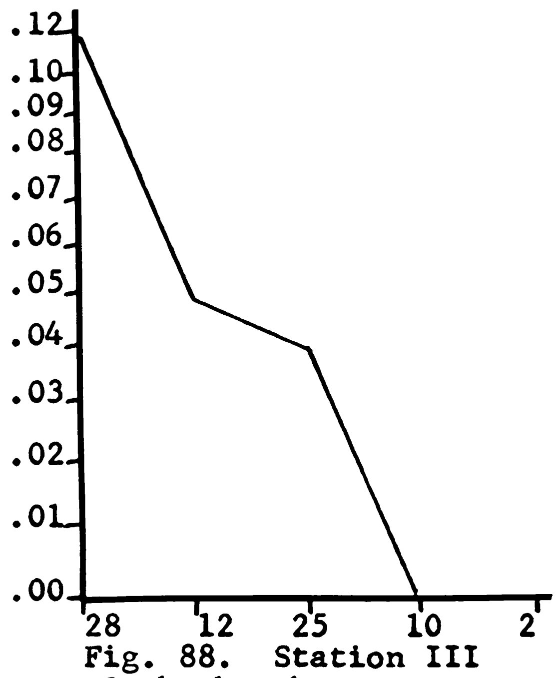


Fig. 88. Station III
Orthophosphate ppm.

Bowman Lake-June 28, July 12, 25,
Aug. 10, Sept. 2

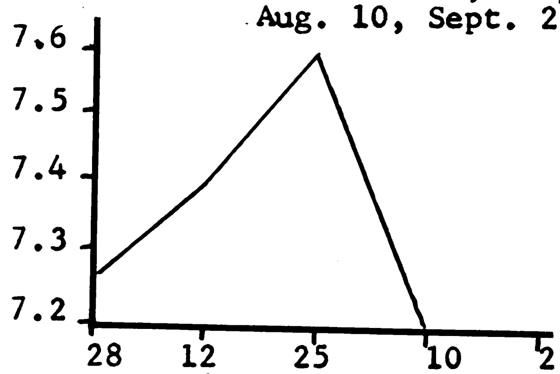


Fig. 89. Station III
pH

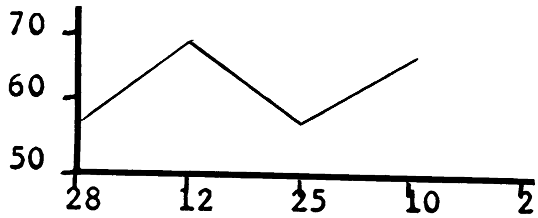


Fig. 90. Station III
Total alkalinity mg/l

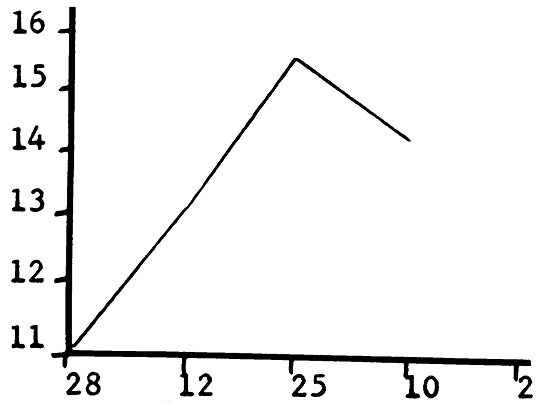


Fig. 91. Station III
Temperature °C

Discussion

Representatives of the phyla Chlorophyta and Chrysophyta are the most abundant forms in Bowman Lake. Prominent examples would be Coscinodiscus, Asterionella, Fragilaria, Dinobryon divergens, Peridinium, and Ceratium hirundinella. The number of species collected during the summer was 24, which is lower than Johns Lake (72) and Lake McDonald (31). These are lakes located on the westside of the continental divide. Only Lower St. Mary Lake on the eastside of the continental divide had a slightly lower number of different species (23).

It is also worthy of note that the species collected by qualitative methods (net tows) were relatively constant for the five sampling periods, whereas the lakes studied on the eastside of the park were not constant throughout the summer. In terms of phytoplankton abundance, Station I was more productive than the other two station. This was due to the relatively higher numbers of Asterionella, Coscinodiscus, and Dinobryon divergens, in the quantitative samples early in July. Except for the above mentioned condition at Station I, the counts were rather uniform at each station and between stations for the entire summer. It would seem then that Bowman Lake did not have the proper conditions to produce phytoplankton blooms during the summer sampling period. Bowman Lake produced a greater total number of organisms or standing crop than Swift Current Lake, but it was below that of Lower St. Mary Lake and Lost Lake. The water chemistry was quite

uniform from station to station at each sampling date. Decrease of numbers of organisms, pH, and total alkalinity, with a concomitant rise in temperature was noted for Bowman Lake. These same relationships were also noted for the lakes on the eastside of the continental divide. The other factors did not show any significant relationship to the number of organisms per liter. No one factor appears to be more important than any other in Bowman Lake. A summary of conditions at Bowman Lake are given below.

Lake type: flowage

Lake size: large (.5 x 6.8 mi.)

Benthic vegetation: sparse

Species abundance: 24

Total organism count range: 3,092-11,917

Ammonia nitrogen range: 0.00-0.01 ppm.

Nitrite nitrogen range: 0.000-0.0045 ppm.

Nitrate nitrogen range: 0.00-0.032 ppm.

*Orthophosphate range: 0.00-0.15 ppm.

Range of pH: 7.2-7.6

Total alkalinity range: 48-78 mg/l

Temperature range: 11-15.3° C.

*Values suspect

Johns Lake

Description of Lake

This lake is located near McDonald Creek Falls and is reached by a 0.9 of a mile hike south of Going-to-the-Sun Highway. The lake is approximately circular with a diamter of 0.2 mi. Johns Lake is located West of the continental divide and is characterized by being a small bog lake with bottom vegetation restricted to the shore region and with bottom materials composed of silt.

Location of Stations

Station I was located near the east end of Johns Lake where water depth is about 3 ft. Station II is located in the middle of the lake where water depth is 9 ft. Station III is located near the west shore of the lake at a water depth of 3 ft.

Taxonomy and Species Abundance

Table 10 provides an analysis of the classification for the plankton algae collected. This table shows that the Chlorophyta is the prominent group although the Chrysophyta and Cyanophyta are well represented in Johns Lake. Table 11 lists the plankton forms and their date of collection at each station. If one considers the totals at the bottom of these tables, it can be seen that the numbers of species at all three stations rise sharply from a low, late in June, to a high early in August and then decrease by September 4th.

Table 10. An Analysis of the Classification for Phytoplankton Collected in Johns Lake

Phylum	Classes	Orders	Families	Genera	Species
Chlorophyta	1	6	13	21	40
Chrysophyta	2	3	8	16	16
Cyanophyta	1	2	2	9	13
Pyrrhophyta	1	1	2	3	3
Totals	5	12	25	49	72

Tabellaria Sp., and Navicula Sp., were the abundant forms in the Chrysophyta collected; Abundant Chlorophyta representatives collected were Staurastrum cuspidatum, Staurastrum paradoxum, Spyrogyra Sp., and Dictyosphaerium pulchellum; prominent Cyanophyta collected were Chroococcus minimus, Oscillatoria Bornetii, and Lyngbya Martensiana.

Table 11. Plankton Forms Collected at Each Station on Johns Lake

Station I

Plankton	6/25	7/11	7/23	8/7	9/4
Coscinodiscus Sp.		X	X	X	
Asterionella Sp.				X	
Tabellaria Sp.		X	X	X	X
Navicula Sp.	X		X	X	X
Synedra Sp.			X	X	X
Fragilaria Sp.				X	
Gomphonema Sp.	X		X		

Plankton	6/25	7/11	7/23	8/7	9/4
Pinnularia Sp.			X		
Melosira Sp.			X	X	
Surirella Sp.		X		X	
Cymbella Sp.				X	
Cyclotella Sp.			X		
Rhopalodia Sp.				X	X
Micrasterias pinnatifida		X			
Spondylosium planum		X			
Staurastrum longicaudatum	X				
Staurastrum teliferum	X				
Staurastrum cuspidatum			X	X	X
Staurastrum paradoxum			X	X	X
Staurastrum furcigerum		X	X		X
Staurastrum natator					X
Cosmarium dentatum	X			X	
Cosmarium moniliforme			X	X	
Cosmarium reniforme				X	
Cosmarium binum					X
Desmidium Swartzii				X	X
Spirogyra Sp.		X	X	X	
Moegeotia Sp.	X				
Oocystis parva			X	X	
Sphaerocystis Schroeteri		X	X	X	
Dictyosphaerium pulchellum	X	X	X	X	
Pediastrum obtusum			X	X	
Pediastrum Boryanum					X

Plankton	6/25	7/11	7/23	8/7	9/4
Scenedesmus incrassatulus			X		
Oedogonium Sp.					X
Elakatothrix gelatinosa			X	X	
Gloeocystis ampla			X	X	
Coelophaerium Kuetzingianum			X	X	
Coelastrum cambricum				X	
Ceratium hirundinella		X	X	X	X
Peridinium Sp.				X	
Gomphosphaeria lacustris				X	X
Anabaena Sp.			X		
Chroococcus minimus		X	X	X	X
Chroococcus dispersus				X	
Chroococcus turgidus				X	
Oscillatoria nigra		X		X	
Oscillatoria Bornetii	X	X	X	X	X
Lyngbya Martensiana		X	X	X	
Dactylococopsis fascicularis				X	
Aphanothece stagnina			X		
Totals	7	14	27	35	16

Station II

Coscinodiscus Sp.		X	X	X	
Asterionella Sp.				X	
Tabellaria Sp.		X	X		
Navicula Sp.		X	X	X	X
Synedra Sp.	X			X	

Plankton	6/25	7/11	7/23	8/7	9/4
Gomphonema Sp.			X	X	
Surirella Sp.		X	X		
Pinnularia Sp.	X			X	
Melosira Sp.	X			X	
Micrasteria pinnatifida		X	X		
Cymbella Sp.			X		X
Rhopalodia Sp.		X	X	X	
Staurastrum obiculare		X			
Staurastrum Sp.	X				
Staurastrum natator		X	X		
Staurastrum cuspidatum			X		X
Staurastrum paradoxum			X	X	
Staurastrum Tohopekaligense			X		
Staurastrum cornutum			X		
Hyalotheca dissiliens			X		
Cosmarium moniliforme				X	
Cosmarium Sp.			X		
Cosmarium dentatum		X			
Cosmarium sexangulare			X		
Cosmarium binum			X		
Euastrum elegans			X		
Desmidium Swartzii			X		
Spirogyra Sp.		X	X	X	
Sphaerocystis Schroeteri		X	X		
Dictyosphaerium pulchellum		X			

Plankton	6/25	7/11	7/23	8/7	9/4
Pediastrum araneosum var. rugulosum				X	
Scenedesmus incrassatulus			X		
Elakatothrix gelatinosa			X	X	
Gloeocystis ampla		X	X		
Ulothrix zonata	X				
Coelosphaerium Kuetzingianum		X			
Peridinium Sp.				X	
Gomphosphaeria lacustris			X	X	X
Gomphosphaeria aponina			X		
Anabaena Sp.			X	X	
Chroococcus minimus		X	X	X	
Chroococcus dispersus				X	
Oscillatoria Bornetii		X	X	X	X
Oscillatoria nigra			X		
Lyngbya Martensiana		X	X		
Dactylococcopsis fascicularis			X		
Nostoc paludosum			X		
Merismopedia tenuissima			X		
Totals	5	17	34	19	5

Station III

Coscinodiscus Sp.		X	X	X	
Tabellaria Sp.		X	X	X	X
Navicula Sp.	X	X	X	X	X
Synedra Sp.			X	X	
Gomphonema Sp.			X	X	

Plankton	6/25	7/11	7/23	8/7	9/4
Pinnularia Sp.	X	X		X	
Cymbella Sp.	X		X	X	
Frustula Sp.				X	
Rhopalodia		X		X	
Micrasterias radiata			X		
Micrasterias laticeps			X		
Micrasterias pinnatifida			X		
Staurastrum cuspidatum			X		
Staurastrum natator		X			
Staurastrum brevispinum				X	
Xanthidium antilopaeum				X	
Cosmarium sexangulare			X		
Cosmarium reniforme			X		
Cosmarium dentatum			X		
Cosmarium margaritatum			X		
Cosmarium moniliforme			X		
Desmidium Baileyi			X		
Desmidium Swartzii		X			
Spirogyra Sp.		X		X	
Oocystis parva				X	
Sphaerocystis Schroeteri			X	X	
Dictyosphaerium pulchellum		X	X		
Pediastrum obtusum			X		
Scenedesmus incrassatulus				X	
Elakatothrix gelatinosa				X	
Pandorina morum			X		

Plankton	6/25	7/11	7/23	8/7	9/4
Schizochlamys gelatinosa			X	X	
Dinobryon sociale				X	
Gomphosphaeria lacustris			X	X	X
Gomphosphaeria aponina			X		
Anabaena Sp.			X	X	
Chroococcus minimus		X	X	X	
Chroococcus minor				X	
Chroococcus turgidus				X	
Osillatoria Bornetii		X	X	X	X
Lyngbya Martensiana		X	X	X	
Lyngbya Sp.				X	
Aphanothece stagnina				X	
Dactylococcopsis fascicularis				X	
Totals	3	12	28	27	4

Phytoplankton Abundance

Graphs 30. through 33. show the phytoplankton count estimates for each species at the various stations during the summer of 1962. The measure of standing crop as total number of organisms per liter at all three stations at each collecting period are as follows:

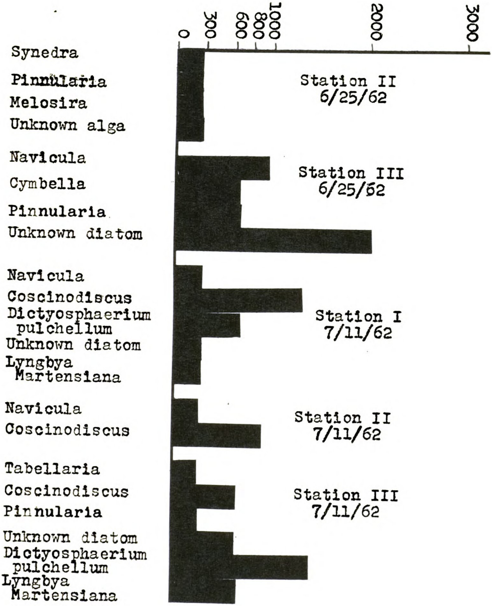
6/25/62-Station	I,	no data	II,	1,125;	III,	4,279
7/11/62-Station	I,	2,813;	II,	1,218;	III,	3,844
7/23/62-Station	I,	13,418;	II,	13,422;	III,	12,926
8/7/62-Station	I,	16,105;	II,	11,801;	III,	15,457
9/4/62-Station	I,	,843;	II,	1,124;	III,	,562
Station total		33,179		28,690		37,069

Chemical and Physical Factors

The results of the analyses for physical and chemical factors are given in graphs 34. through 38. In some instances a multiplier for the Y axis is given along with the variable on the X axis.

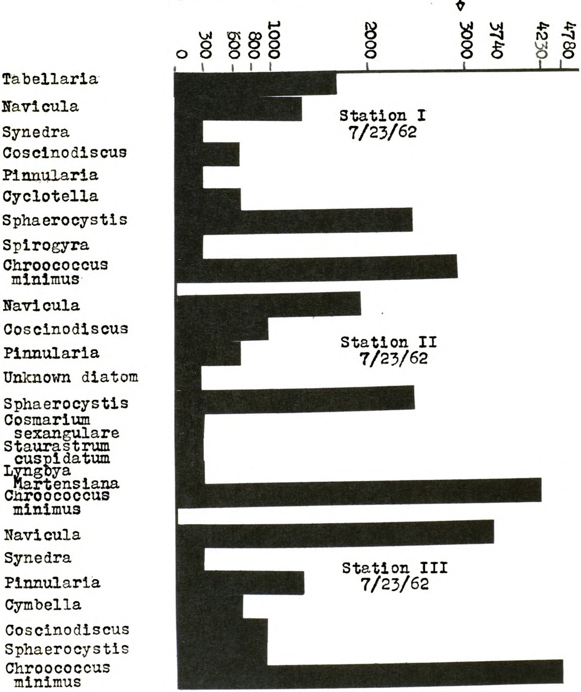
Graph 30. JOHNS LAKE

Organisms Per Liter



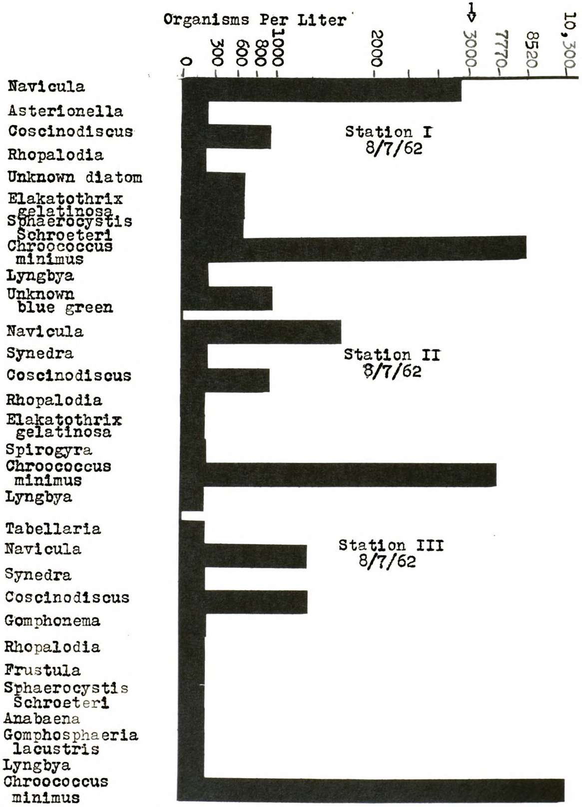
Graph 31.[1] JOHNS LAKE

Organisms Per Liter



1. Values above 3000 modified to fit on scale

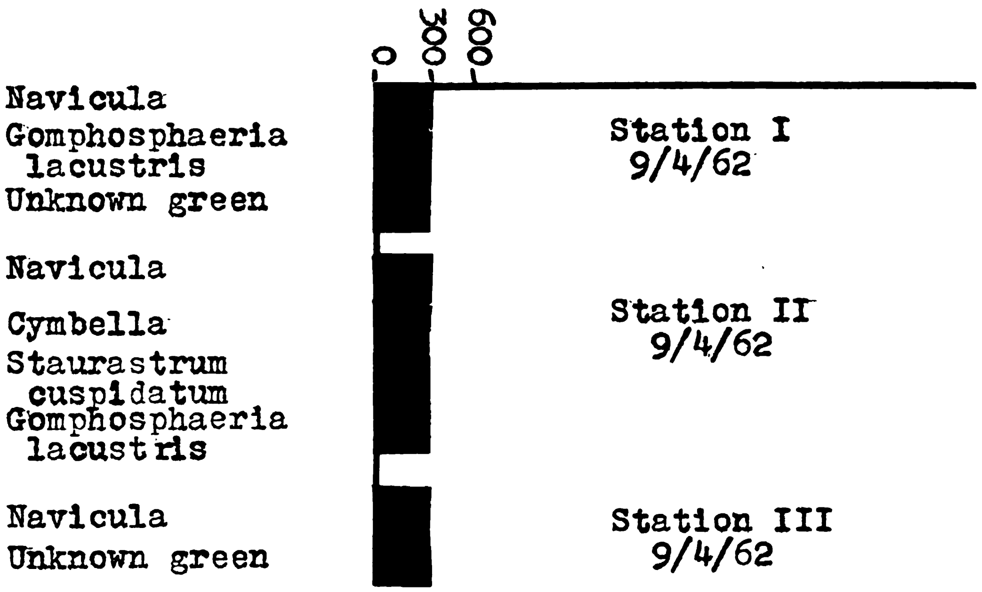
Graph 32. JOHNS LAKE



1. Values above 3000 off scale

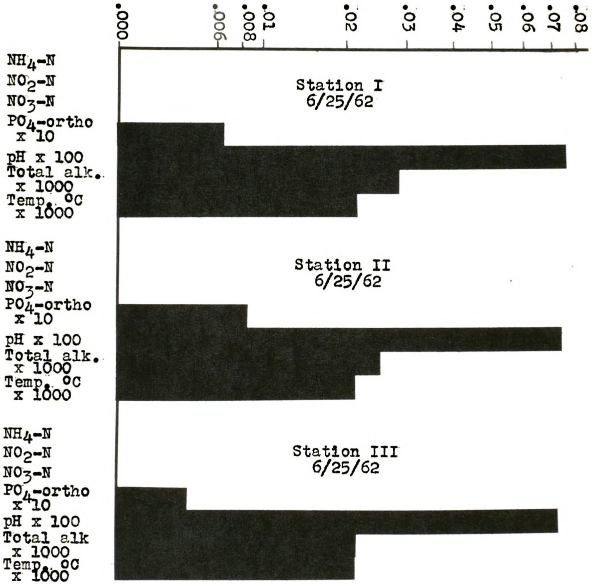
Graph 33. JOHNS LAKE

Organisms Per Liter



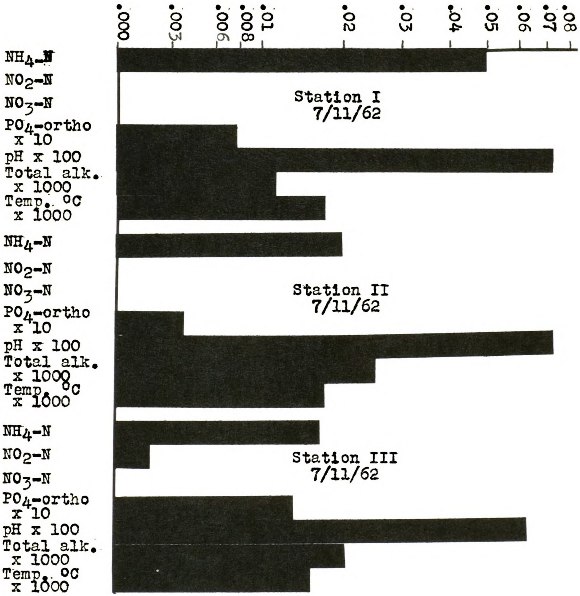
Graph 34. JOHNS LAKE

Chemical and Physical Conditions



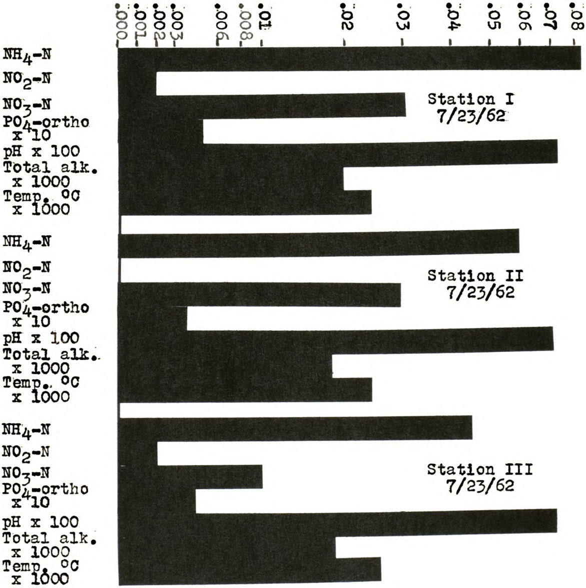
Graph 35. JOHNS LAKE

Chemical and Physical Conditions



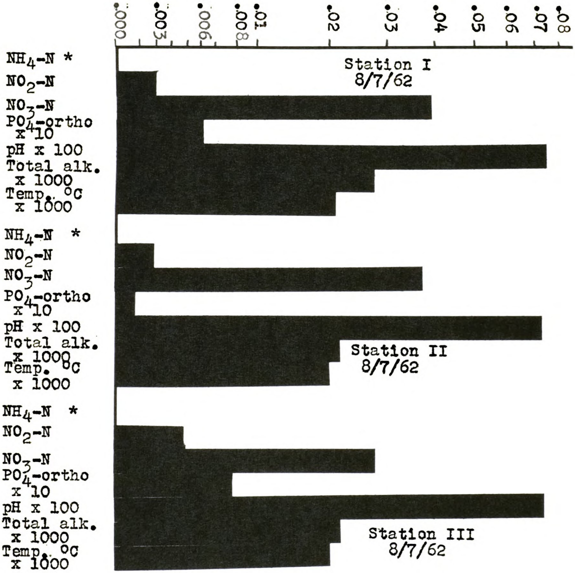
Graph 36. JOHNS LAKE

Chemical and Physical Conditions



Graph 37. JOHNS LAKE

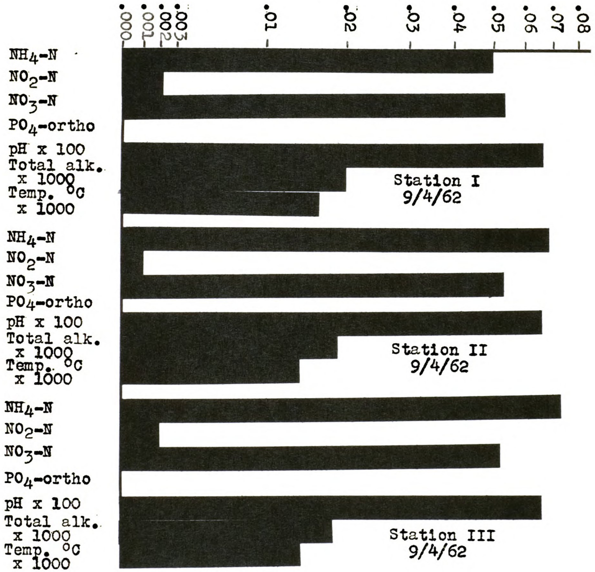
Chemical and Physical Conditions



* No data

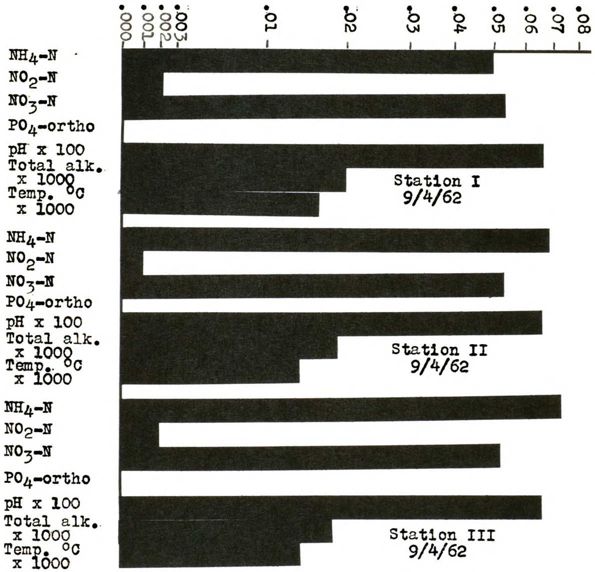
Graph 38. JOHNS LAKE

Chemical and Physical Conditions



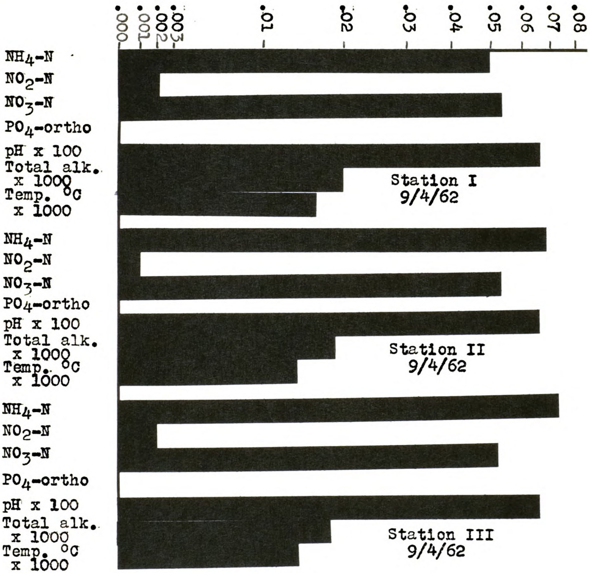
Graph 38. JOHNS LAKE

Chemical and Physical Conditions



Graph 38. JOHNS LAKE

Chemical and Physical Conditions



Generalizations

At Station I the relationships between organisms per liter and chemical and physical factors are as follows.

1. Organisms per liter and ammonia nitrogen appear to be directly related but the data are incomplete for these two factors (Figs. 92 and 93).
2. Organisms per liter and nitrite nitrogen show no relationship (Figs. 92 and 94).
3. Organisms per liter and nitrate nitrogen are directly related except for the last sampling date (Figs. 92 and 95).
4. Organisms per liter and orthophosphate show an inverse relationship for the first four sampling periods and then decrease sharply together from 8/7 to 9/4. In general as the organism count increases the orthophosphate declines for the first four sampling dates (Figs. 92 and 96).
5. Organisms per liter and pH show an inverse relationship for the first four sampling periods and then decrease sharply together from 8/7 to 9/4 (Figs. 92 and 97).
6. Organisms per liter and total alkalinity show no marked relationship. Total alkalinity remains fairly constant for the summer with a slight decrease from 6/25 to 9/4 (Figs. 92 and 98).
7. Organisms per liter and temperature show no relationship (Figs. 92 and 99).

At Station II the relationships are:

1. Organisms per liter and ammoni a nitrogen show no relationship (Figs. 100 and 101).
2. Organisms per liter and nitrite nitrogen show a direct relationship for the sampling periods 7/23 to 9/4 (Figs. 100 and 102).
3. Organisms per liter and nitrate nitrogen show no relationship (Figs. 100 and 103).
4. Organisms per liter and orthophosphate show a direct relationship from 7/23 to 9/4. The amount of phosphorous is relatively high on 6/25 while the organism count is low (Figs. 100 and 104).
5. Organisms per liter and pH show the same relationships already mentioned for phosphorus (Figs. 100 and 105).
6. Organisms per liter and total alkalinity show no relationship (Figs. 100 and 106).
7. Organisms per liter and temperature show a direct relationship for the sampling periods 7/11 through 9/4 (Figs. 100 and 107).

At Station III the conditions are:

1. Organisms per liter and ammonia nitrogen show no relationship (Figs. 108 and 109).
2. Organisms per liter and nitrite nitrogen show no relationship (Figs. 108 and 110).
3. Organisms per liter and nitrate nitrogen show no relationship (Figs. 108 and 111).

4. Organisms per liter and orthophosphate show no relationship except that phosphorus has a peak (7/11) before the peak (7/23) for organism count (Figs. 108 and 112).
5. Organisms per liter and pH are directly related from 7/23 to 9/4. That is, both decline together (Figs. 108 and 113).
6. Organisms per liter and total alkalinity show no relationships (Figs. 108 and 114).
7. Organisms per liter and temperature are directly related (Figs. 108 and 115).

Johns Lake-June 25, July 11, 23, Aug. 7, Sept. 4

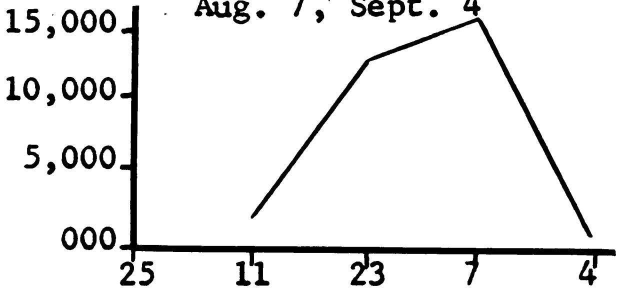


Fig. 92. Station I
Organisms per liter

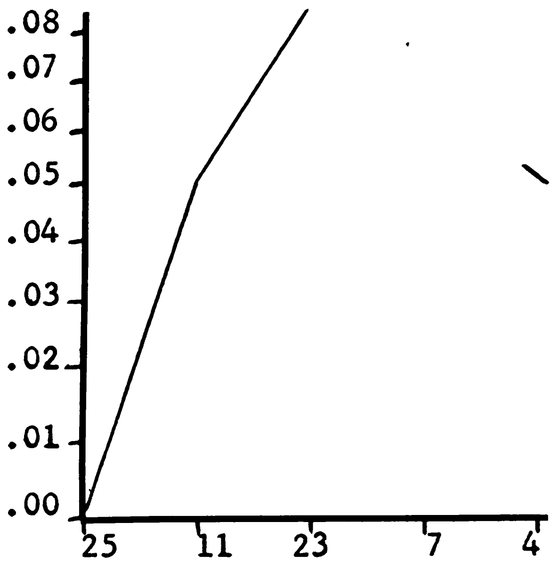


Fig. 93. Station I
Ammonia nitrogen ppm.

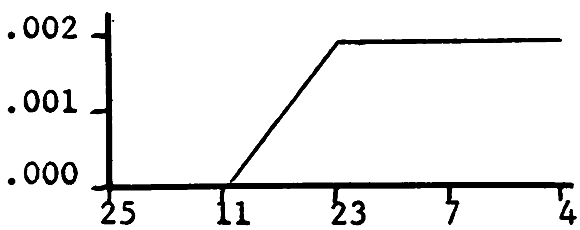


Fig. 94. Station I
Nitrite nitrogen ppm.

Johns Lake-June 25, July 11, 23,
Aug. 7, Sept. 4

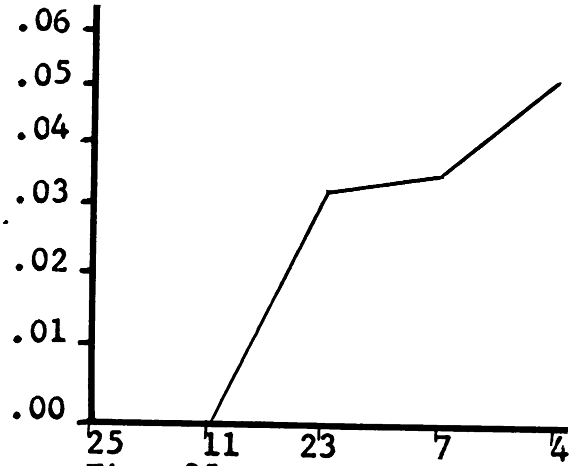


Fig. 95. Station I
Nitrate nitrogen ppm.

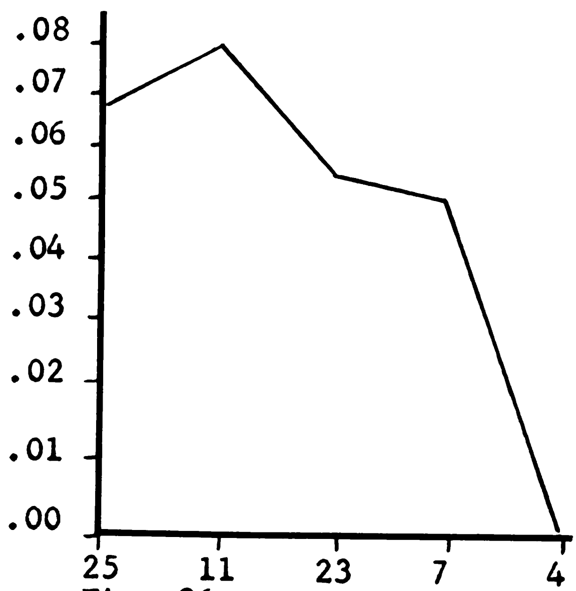


Fig. 96. Station I
Orthophosphate ppm.

Johns Lake-June 25, July 11, 23,
Aug. 7, Sept. 4

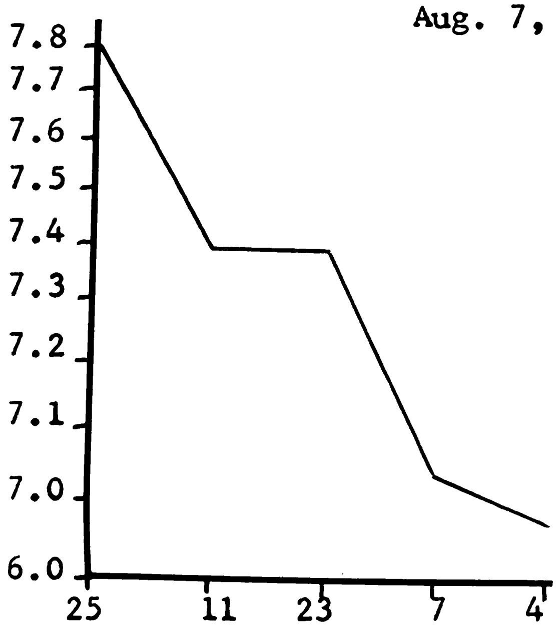


Fig. 97. Station I
pH

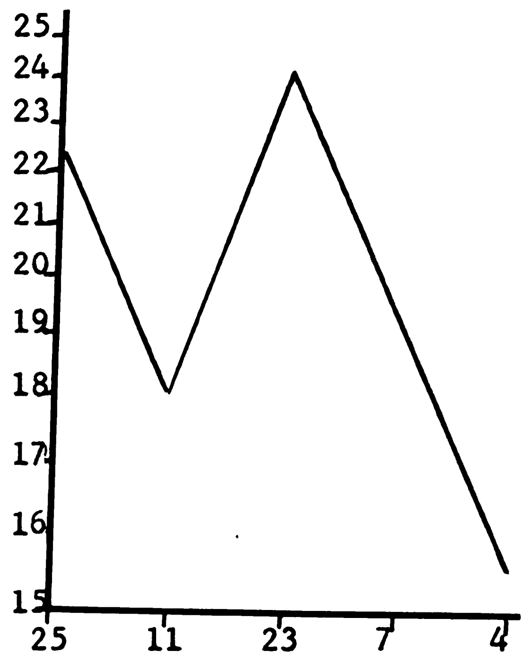


Fig. 99. Station I
Temperature °C

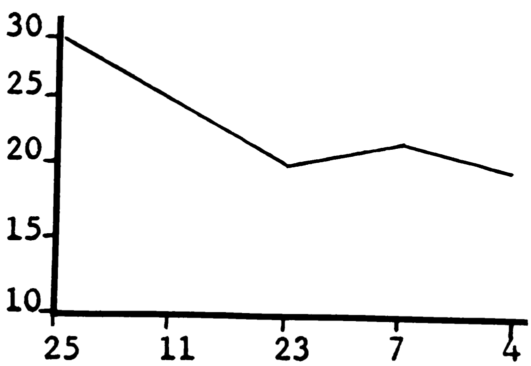


Fig. 98. Station I
Total alkalinity mg/l

Johns Lake-June 25, July 11, 23,
Aug. 7, Sept. 4

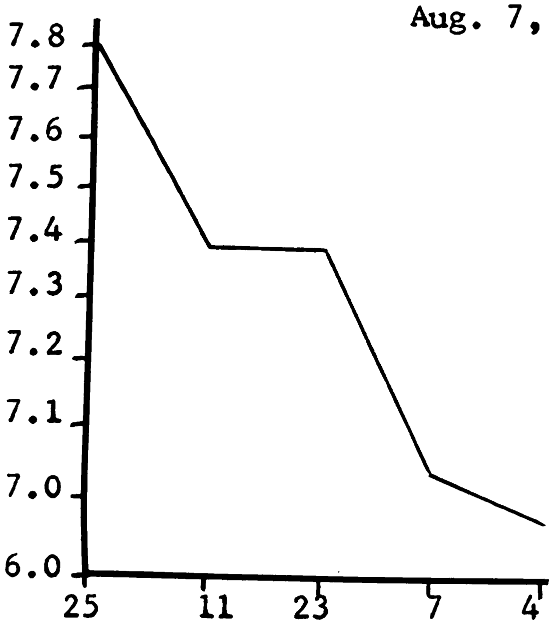


Fig. 97. Station I
pH

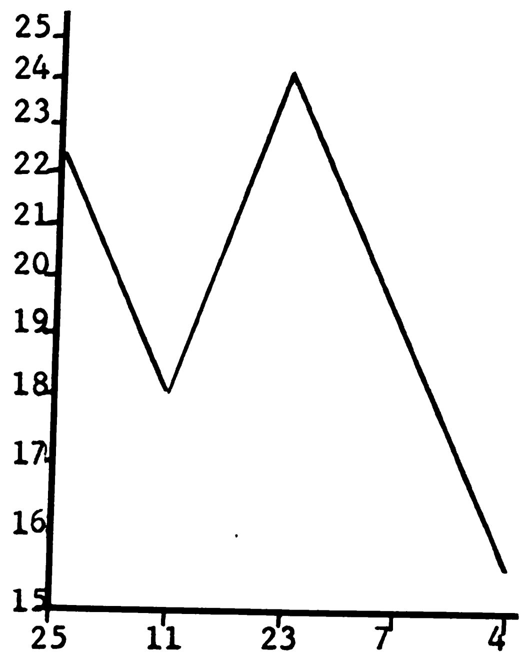


Fig. 99. Station I
Temperature °C

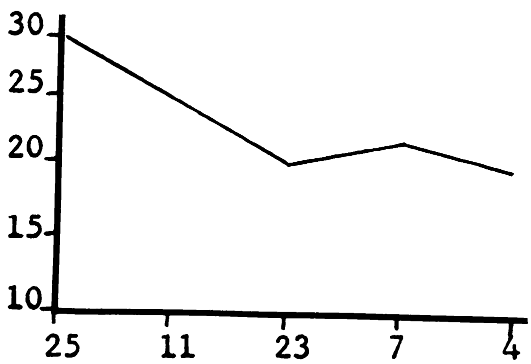


Fig. 98. Station I
Total alkalinity mg/l

Johns Lake-June 25, July 11, 23, Aug. 7, Sept. 4

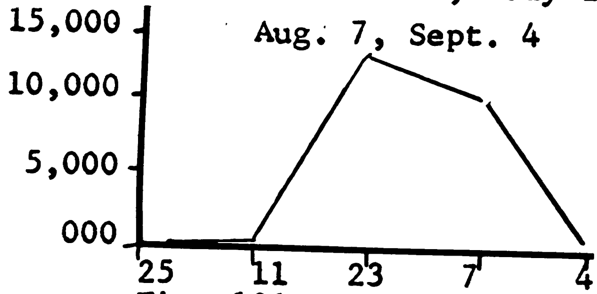


Fig. 100. Station II
Organisms per liter

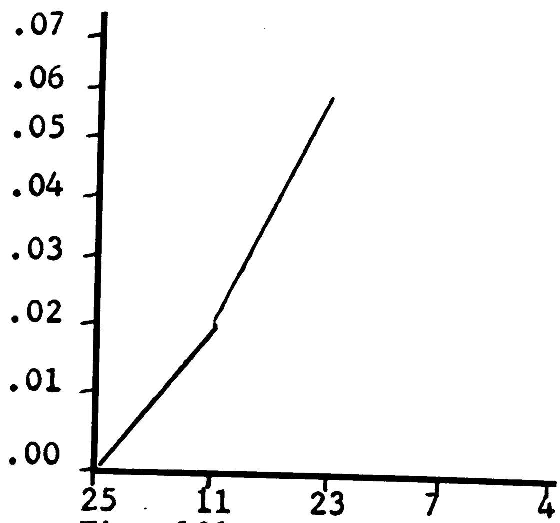


Fig. 101. Station II
Ammonia nitrogen ppm.

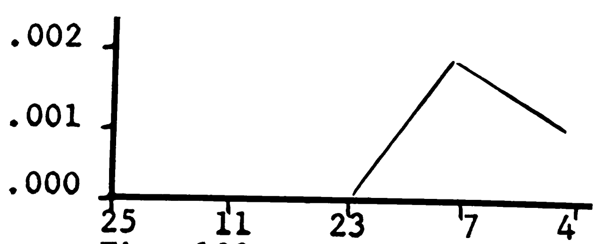


Fig. 102. Station II
Nitrite nitrogen ppm.

Johns Lake-June 25, July 11, 23, Aug. 7, Sept. 4

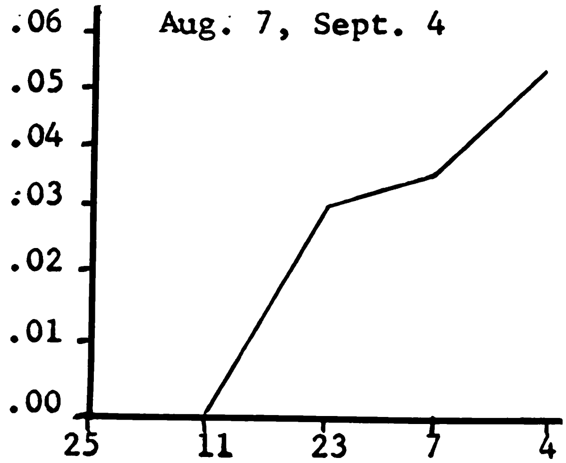


Fig. 103. Station II
Nitrate nitrogen ppm.

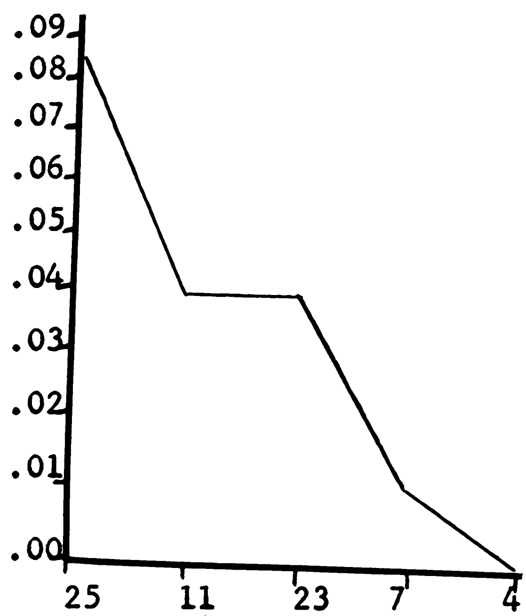


Fig. 104. Station II
Orthophosphate ppm.

Johns Lake-June 25, July 11, 23,
Aug. 7, Sept. 4

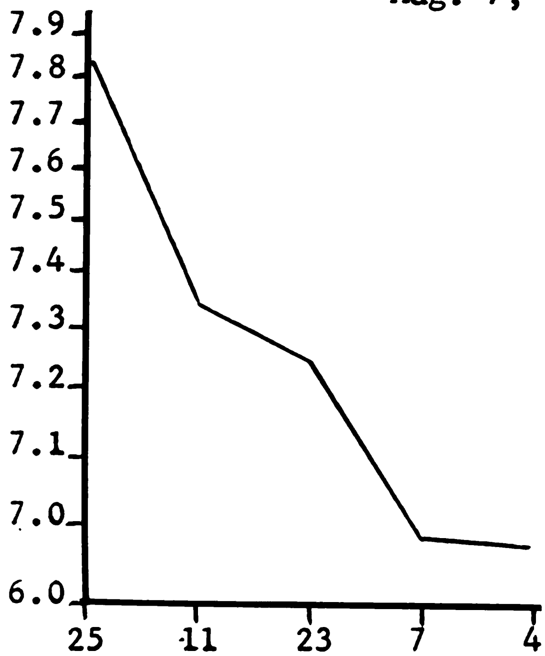


Fig. 105. Station II
pH

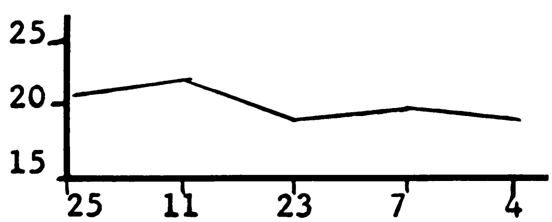


Fig. 106. Station II
Total alkalinity mg/l

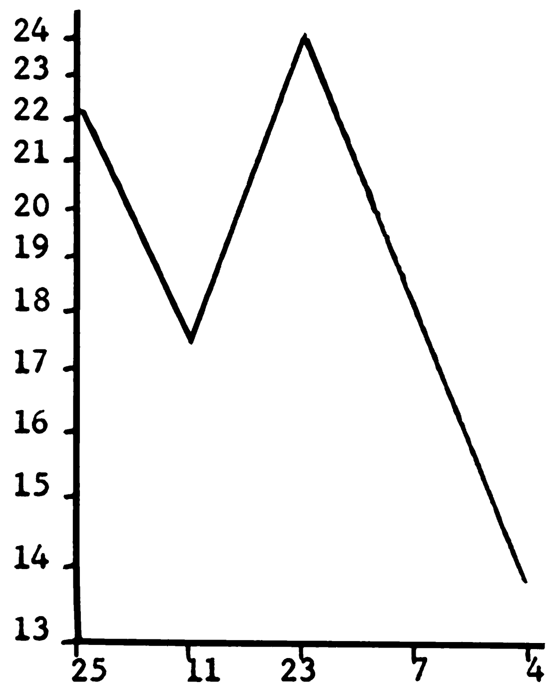


Fig. 107. Station II
Temperature °C

Johns Lake-June 25, July 11, 23,
Aug. 7, Sept. 4

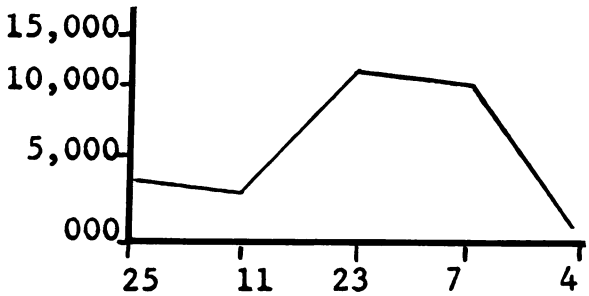


Fig. 108. Station III
Organisms per liter

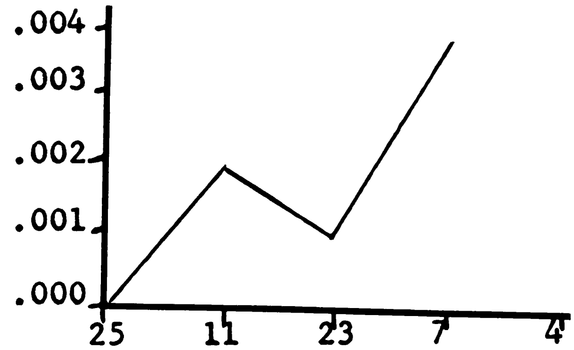


Fig. 110. Station III
Nitrite nitrogen ppm.

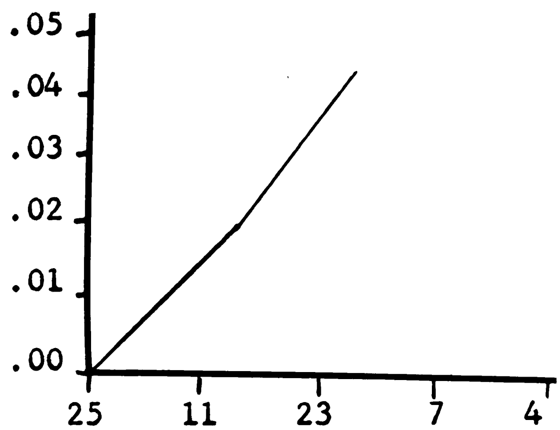


Fig. 109. Station III
Ammonia nitrogen ppm.

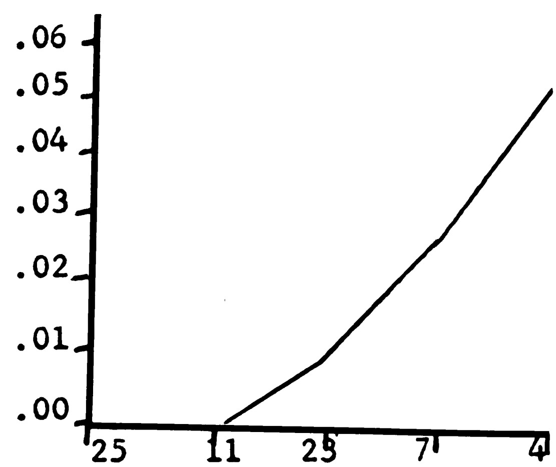


Fig. 111. Station III
Nitrate nitrogen ppm.

Johns Lake-June 25, July 11, 23,
Aug. 7, Sept. 4

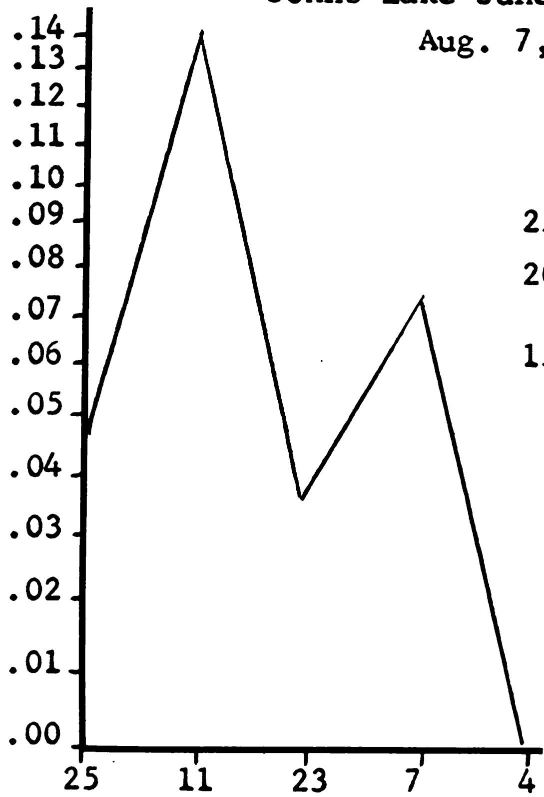


Fig. 112. Station III
Orthophosphate ppm.

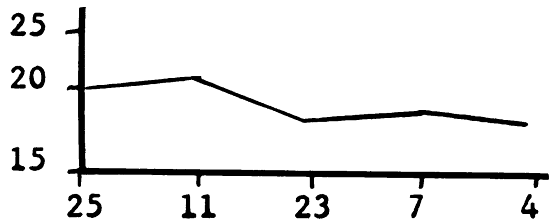


Fig. 114. Station III
Total alkalinity mg/l

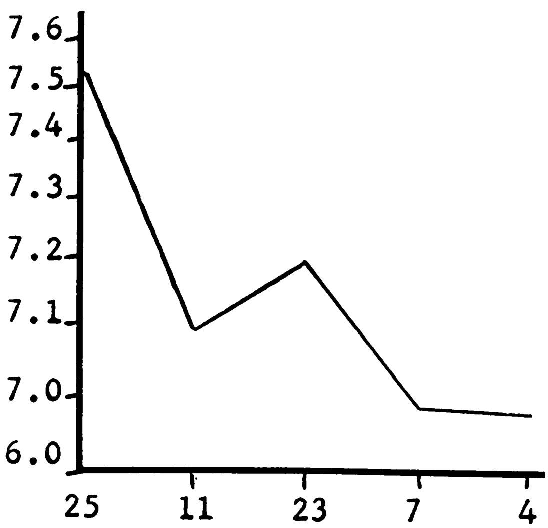


Fig. 113. Station III
pH

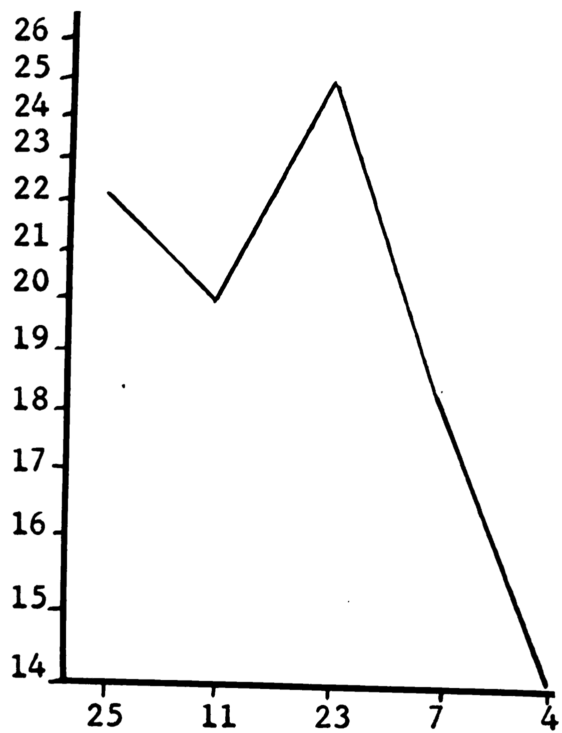


Fig. 115. Station III
Temperature °C

Discussion

The Chlorophyta are prominent although the Chrysophyta and Cyanophyta are well represented in this lake. This represents the only one of the six lakes studied in which the Cyanophyta (blue-greens) are relatively abundant in the phytoplankton (13 species). In Johns Lake the kinds of phytoplankton were low in June and reached their high point in early August and then decreased by September 4th. This increase and decrease is to be contrasted with Bowman Lake and Lake McDonald which are the other two lakes studied west of the continental divide. In the latter two lakes the kinds of species remained relatively constant. This fact is brought out by a review of the species totals at the end of each plankton list for Johns Lake, Bowman Lake and Lake McDonald. In terms of number of species (72) Johns Lake ranks the highest for the lakes studied in Glacier National Park. This fact is interesting because in qualitative terms Johns Lake was more productive than any other lake studied, but in quantitative terms (number of organisms per liter) it was less productive than two of the lakes on the eastside of the park-Lower St. Mary Lake and Lost Lake (see totals at the end of each station on pgs. 86 , 115 , 203). <u>Chroococcus</u> <u>minimus</u> was the most abundant organism in terms of species per liter. Its largest bloom, 10,300, was reached on the sampling date of 8/7/62 (see pg. 196). Therefore Johns Lake was the only lake studied in which the diatoms were not the most abundant forms in terms of species per liter.

In general, the water chemistry and physical factors were fairly uniform at each sampling date. Relationships between these factors and the number of organisms per liter are rather clear-cut in Johns Lake. The number of organisms per liter are directly related to ammonia nitrogen and temperature. There is a general decrease from the beginning of the sampling period to the end of the sampling period in pH, orthophosphate and temperature. Total alkalinity was lower in this lake than any other lake studied (20-30 mg/1). It was also relatively the same concentration throughout the summer collecting period. No one chemical or physical factor seems to be more critical than any other. Temperature and pH decrease together at the end of the summer, which would be an expected relationship since the cooler water would contain more carbon dioxide which can then form carbonic acid. This relationship was also seen for the other lakes studied. Unlike the other lakes studied, pH decreased until the lake water was acid. A summary for Johns Lake follows on the next page.

Lake type: Bog-seepage

Lake size: Small (0.2 mi. diameter)

Species abundance: 72

Total organism count range: 562-15,457

Ammonia nitrogen range: 0-0.09 ppm.

Nitrite nitrogen range: 0-0.006 ppm.

Nitrate nitrogen range: 0-0.058 ppm.

Orthophosphate range: 0-0.2 ppm

Range of pH: 6.8-8

Total alkalinity range: 12-36 mg/1

Temperature range: 13.2-25.56^{o} C.

Lake McDonald

Description of Lake

This lake is located beside Going-to-the-Sun Highway near the west entrance to Glacier National Park. It is 1.5 mi. wide by 12 mi. long. A terminal end moraine dams the west end of the lake. McDonald Creek is the main inlet, flowing from the mountains and entering the lake at the east end. A creek by the same name serves as the outlet near the village of Apgar on the western shore. The lake bottom is composed primarily of glacial boulders and silt. Benthic vegetation is nearly lacking.

Location of Stations

Station I was located at the east end of the lake at the McDonald Lake Motel about 10 feet beyond the dock. Station II was off shore at the west end of the lake near Apgar. Station III was near Apgar but further west at the boat launching area. Water depth was 30 ft. at these stations.

Taxonomy and Species Abundance

Table 12 provides classification of the plankton algae. This table shows that the Chrysophyta and the Chlorophyta were equally abundant. Table 13 lists the plankton forms and date of collection at each station. If one considers the totals at the bottom of these tables, it can be seen that the numbers of species at each station remains relatively the same for the entire sampling period. The most abundant

forms representing the Chrysophyta were Coscinodiscus Sp., Asterionella Sp., Tabellaria Sp., Fragilaria Sp., Synedra Sp., and Dinobryon divergens. Ceratium hirundinella and Peridinium Sp. were frequent-occurring members of the Pyrrhophyta.

Table 12. An Analysis of the Classification for Phytoplankton Collected in Lake McDonald

Phylum	Classes	Orders	Families	Genera	Species
Chlorophyta	1	6	9	12	13
Chrysophyta	2	3	7	11	13
Pyrrhophyta	1	1	2	2	3
Cyanophyta	1	1	1	2	2
Totals	5	11	19	27	31

Table 13. Plankton Forms Collected at Each Station on Lake McDonald

Station I

Plankton	6/26	7/11	7/24	8/8	9/4
Coscinodiscus Sp.	X	X	X	X	X
Asterionella Sp.	X	X	X	X	X
Tabellaria Sp.	X	X	X	X	
Navicula Sp.	X		X	X	X
Synedra Sp.	X	X	X	X	X
Fragilaria Sp.	X	X	X	X	
Gomphonema Sp.	X			X	X
Melosira Sp.	X				

Plankton	6/26	7/11	7/24	8/8	9/4
Cymbella Sp.		X	X		X
Staurastrum gracile	X				
Moegeotia Sp.	X	X			
Oocystis parva			X	X	
Sphaerocystis Schroeteri			X	X	
Pediastrum glanduliferum				X	
Pediastrum Boryanum	X				
Gloeocystis vesiculosa				X	
Ulothrix zonata	X				
Dictyosphaerium pulchellum		X	X		
Oedogonium Sp.		X			
Dinobryon divergens	X	X	X	X	
Dinobryon Sp.		X			
Ceratium hirundinella	X	X	X	X	X
Peridinium Sp.	X	X	X	X	X
Chroococcus minimus				X	
Totals	15	13	13	15	8

Station II

Coscinodiscus Sp.	X	X	X	X	X
Asterionella Sp.	X	X	X	X	X
Tabellaria Sp.	X	X	X		X
Navicula Sp.				X	
Synedra Sp.	X	X	X	X	X
Fragilaria Sp.	X	X		X	X
Pinnularia Sp.		X			

Plankton	6/26	7/11	7/24	8/8	9/4
Oocystis parva			X		
Sphaerocystis Schroeteri			X	X	
Dictyosphaerium pulchellum		X	X		
Pediastrum Boryanum	X				
Dinobryon divergens	X	X		X	X
Dinobryon bavaricum					X
Ceratium hirundinella	X	X	X	X	X
Peridinium Sp.		X	X	X	X
Chroococcus minimus		X		X	
Totals	8	11	9	10	9

Station III

Coscinodiscus Sp.		X	X	X	X
Asterionella Sp.	X	X	X	X	X
Tabellaria Sp.		X	X		
Navicula Sp.				X	X
Synedra Sp.		X	X	X	X
Fragilaria Sp.	X	X	X	X	X
Gomphonema Sp		X			
Cymbella				X	
Unknown diatom		X	X		
Cosmarium ovale			X		
Spirogyra Sp.				X	
Oocystis parva			X		
Sphaerocystis Schroeteri		X		X	
Dictyosphaerium pulchellum			X		

Plankton	6/26	7/11	7/24	8/8	9/4
Gloeocystis vesiculosa				X	
Pandorina morum	X				
Dinobryon divergens	X	X		X	X
Dinobryon bavaricum	X	X			
Ceratium hirundinella	X	X	X	X	X
Peridinium Sp.	X	X	X	X	
Gomphosphaeria lacustris			X		
Chroococcus minimus				X	
Totals	7	12	12	13	7

Phytoplankton Abundance

Graphs 39. and 40. give the estimated phytoplankton counts for each form at the various stations during the summer of 1962. The total organisms per liter, which are used to indicate lake productivity, are as follows:

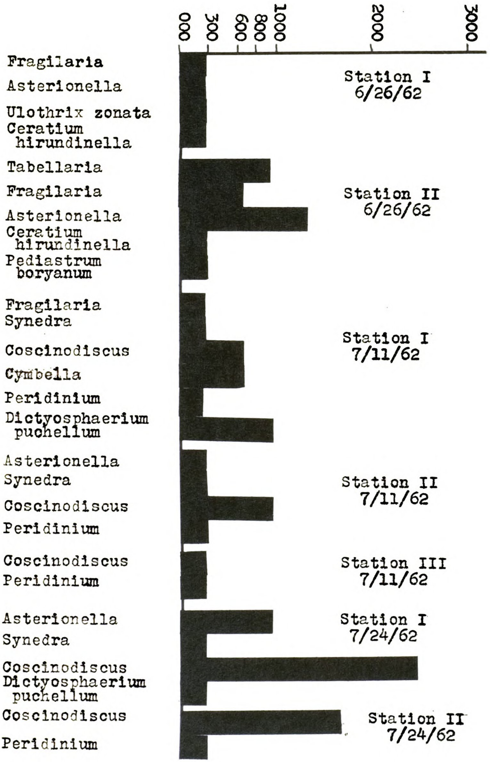
	Station I	II	III
6/26/62	1,124;	3,469;	1,874
7/11/62	1,874;	1,780;	526
7/24/62	3,050;	1,970;	4,961
8/8/62	10,419;	6,279;	5,432
9/4/62	1,499;	3,894;	937
Station total	17,966	17,392	13,730

Chemical and Physical Conditions

The results of the analyses for physical and chemical factors are given in graphs 41. through 45. In some instances a multiplier for the Y axis is given along with the variable on the X axis.

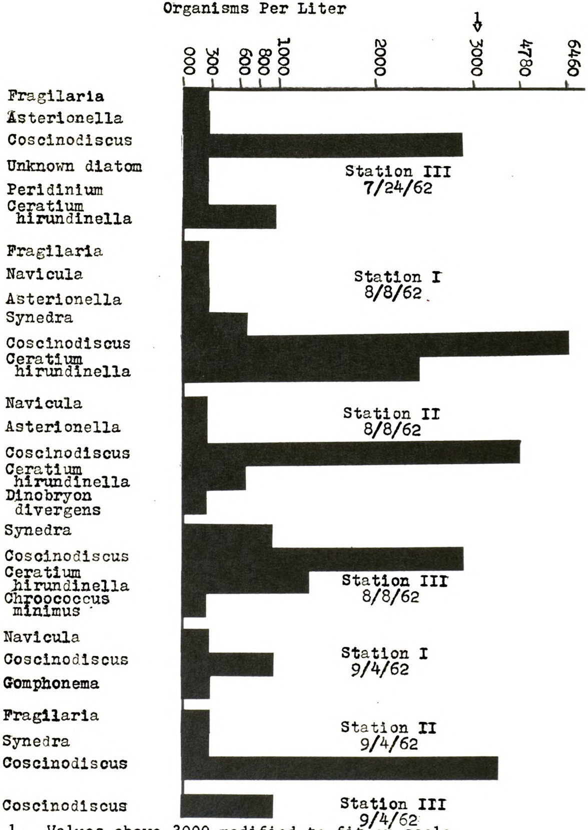
Graph 39. LAKE McDONALD

Organisms Per Liter



Graph 40. LAKE McDONALD

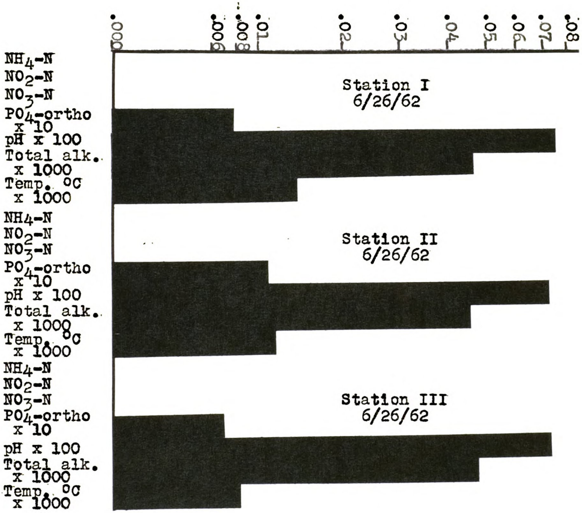
Organisms Per Liter



1. Values above 3000 modified to fit on scale

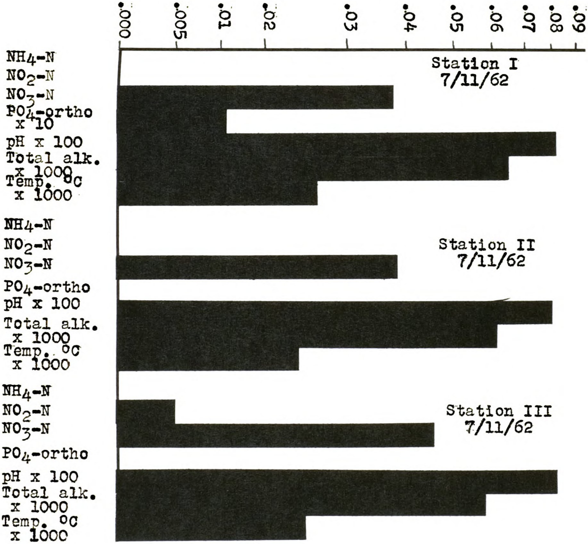
Graph 41. LAKE McDONALD

Chemical and Physical Conditions



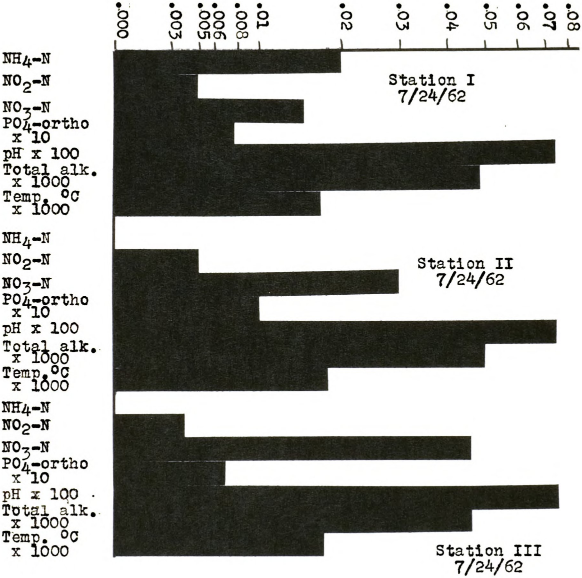
Graph 42. LAKE McDONALD

Chemical and Physical Conditions



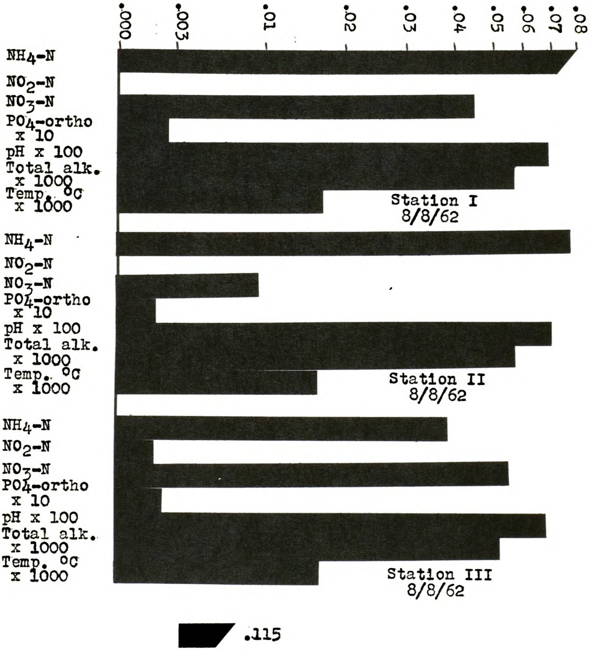
Graph 43. LAKE McDONALD

Chemical and Physical Conditions



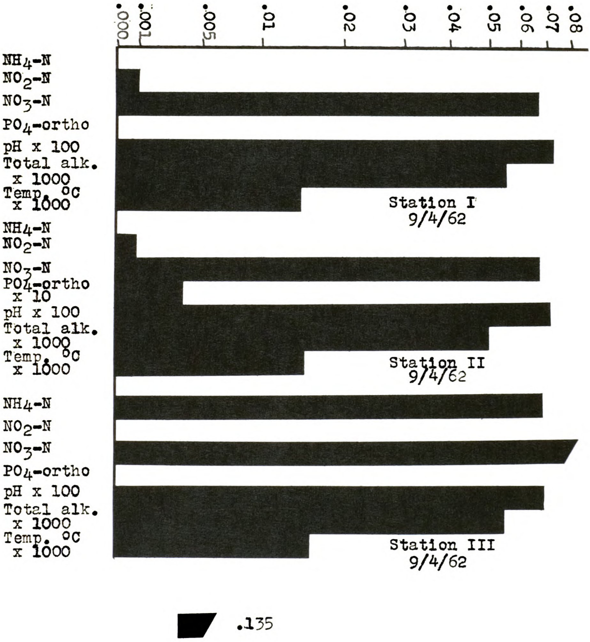
Graph 44. LAKE McDONALD

Chemical and Physical Conditions



Graph 45. LAKE McDONALD

Chemical and Physical Conditions



Generalizations

At Station I the relationships between organisms per liter and the physical and chemical conditions are as follows:

1. Organisms per liter and ammonia nitrogen are directly related (Figs. 116 and 117).
2. Organisms per liter and nitrite nitrogen show no relationship (Figs. 116 and 118).
3. Organisms per liter and nitrate nitrogen show no relationship (Figs. 116 and 119).
4. Organisms per liter and orthophosphate show no exact relationship, however, phosphorus is relatively high from 6/25 to 7/24 and then declines sharply. Organism count increases to a peak on 8/8 then declines rapidly. Thus the phosphorous peak lags behind the organisms per liter (Figs. 116 and 120).
5. Organisms per liter and pH are inversely related except for the period 7/11 to 7/24. In general the pH and organism count are both low at the last sampling period. The pH is relatively high while the organism estimate is low (Figs. 116 and 121).
6. No relationship exists between organisms per liter and total alkalinity (Figs. 116 and 122).
7. Organisms per liter and temperature are directly related (Figs. 116 and 123).

At Station II the relationships between organisms per liter and the physical and chemical factors are as follows:

1. Organisms per liter and ammonia nitrogen show a direct relationship for the sampling period 7/24 to 9/4 (Figs. 124 and 125).
2. Organisms per liter and nitrite nitrogen show no relationship except that the peak for nitrite lags behind the peak for organism count (Figs. 124 and 126).
3. Organisms per liter and nitrate nitrogen are inversely related (Figs. 124 and 127.
4. Organisms per liter and orthophosphate are directly related from 6/26 to 7/24, then the peak for phosphorus lags behind the peak for organism count. They are inversely related from 7/24 to 9/4 (Figs. 124 and 128).
5. Organisms per liter and pH are directly related for the period 6/26 to 7/24 but then are inversely related from 7/24 to 9/4. The pH peak lags behind that of the organism count peak (Figs. 124 and 129).
6. Organisms per liter and total alkalinity are inversely related from 6/26 to 7/24 and then are directly related from 7/24 to 9/4 (Figs. 124 and 130).
7. No relationship exists between organisms per liter and temperature (Figs. 124 and 131).

At Station III the relationships between organisms per liter and physical and chemical conditions are as follows:

1. No relationship exists between organisms per liter and ammonia nitrogen, however, the peak for nitrogen occurs after the peak for organism counts (Figs. 132 and 133).
2. In general there is a direct relationship between nitrite nitrogen and organisms per liter. The nitrite peak lags behind the organism peak (Figs. 132 and 134).
3. No relationship exists between nitrate nitrogen and organisms per liter. The nitrate peak occurs after the organism count peak (Figs. 132 and 135).
4. Organisms per liter and orthophosphate are directly related except for the fact that the phosphorus peak lags behind that of the organism count peak (Figs. 132 and 136).
5. No relationship exists between pH and organisms per liter (Figs. 132 and 137).
6. No relationship exists between total alkalinity and organisms per liter (Figs. 132 and 138).
7. In general the organisms per liter and temperature are directly related (Figs. 132 and 139).

Lake McDonald-June 26, July 11, 24,

Aug. 8, Sept. 4

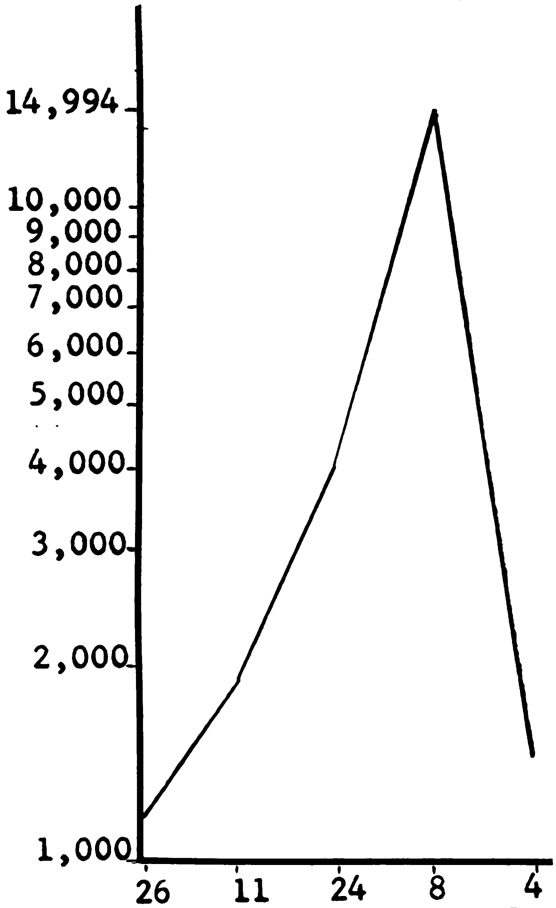


Fig. 116. Station I
Organisms per liter

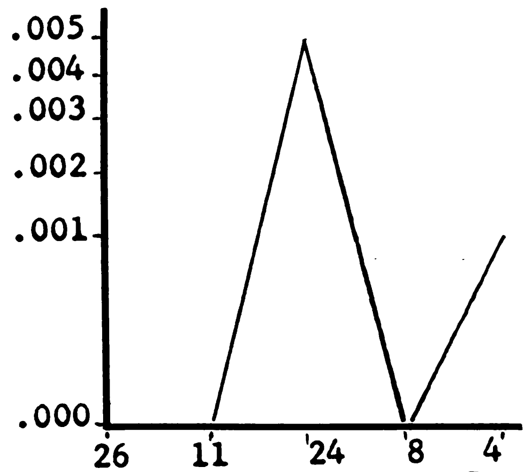


Fig. 118. Station I
Nitrite nitrogen ppm.

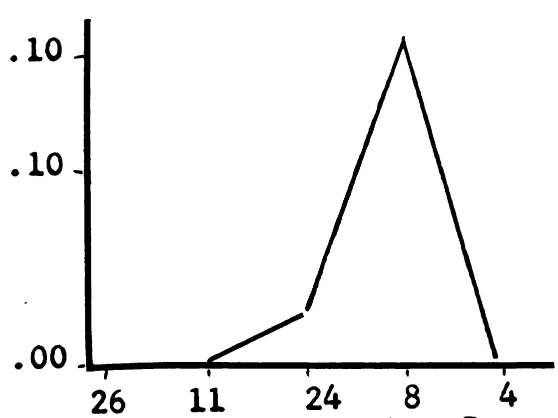


Fig. 117. Station I
Ammonia nitrogen ppm.

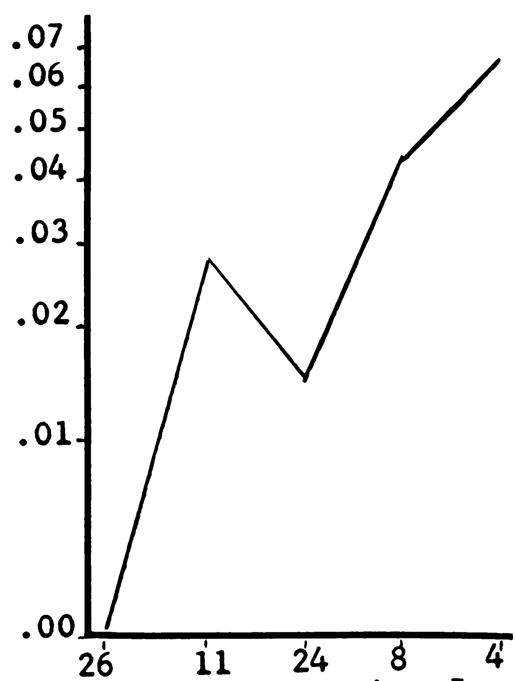


Fig. 119. Station I
Nitrate nitrogen ppm.

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Fig. 120. Station I
Orthophosphate ppm.

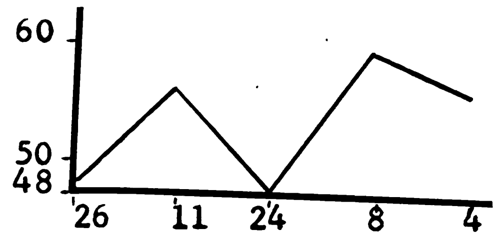

Fig. 122. Station I
Total alkalinity mg/l

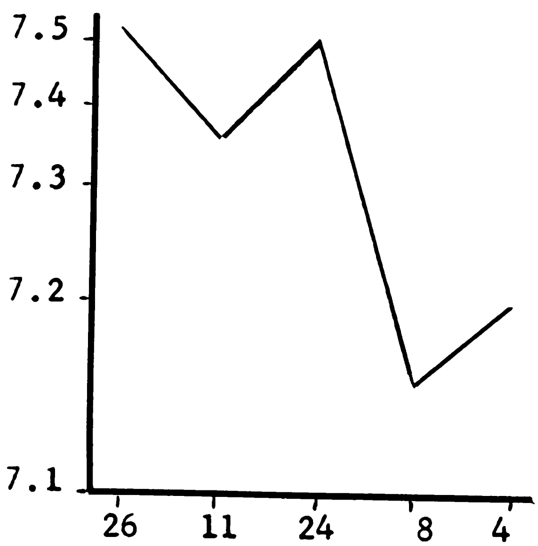

Fig. 121. Station I
pH

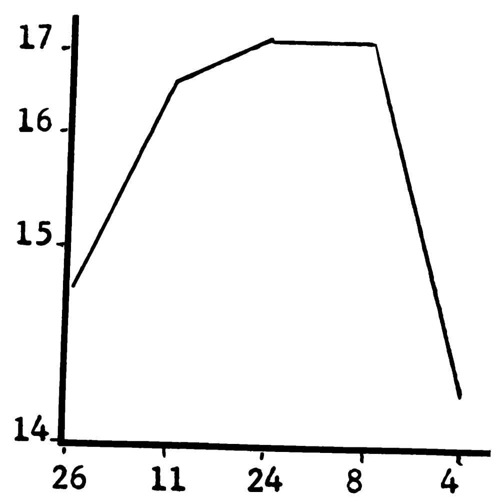

Fig. 123. Station I
Temperature °C

Lake McDonald-June 26, July 11, 24, Aug. 8, Sept. 4

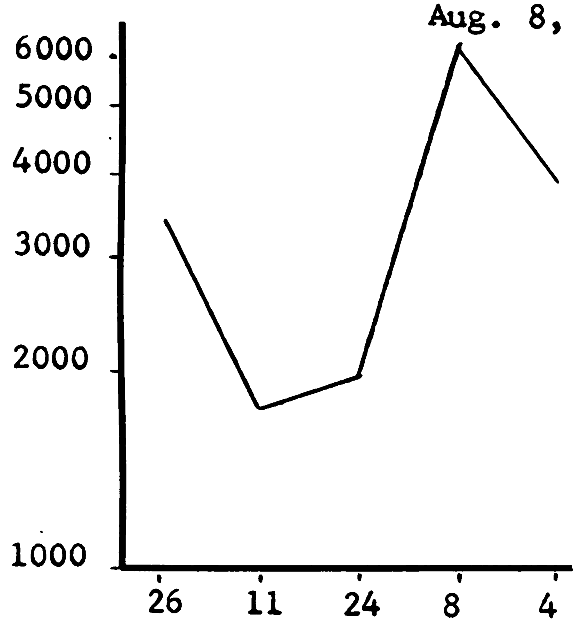

Fig. 124. Station II
Organisms per liter

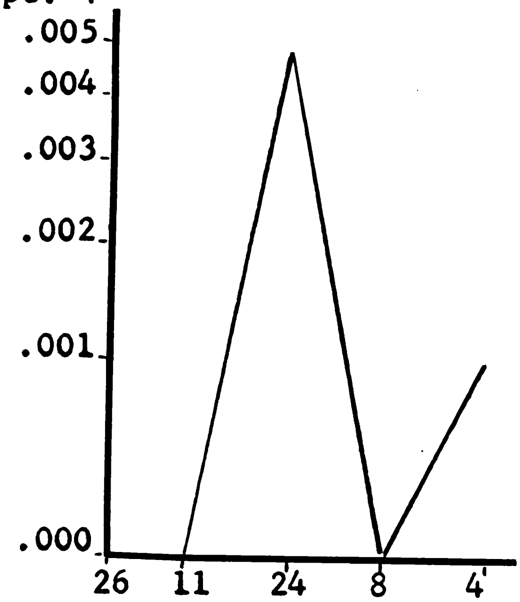

Fig. 126. Station II
Nitrite nitrogen ppm.

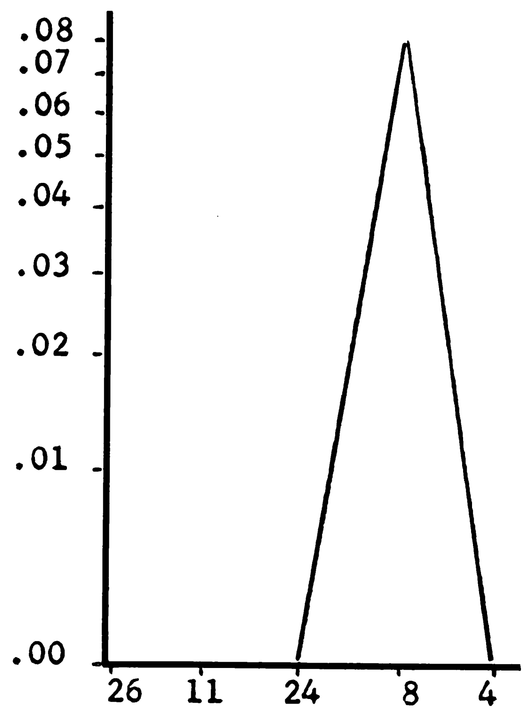

Fig. 125. Station II
Ammonia nitrogen ppm.

Fig. 127. Station II
Nitrate nitrogen ppm.

Lake McDonald-June 26, July 11, 24,

Aug. 8, Sept. 4

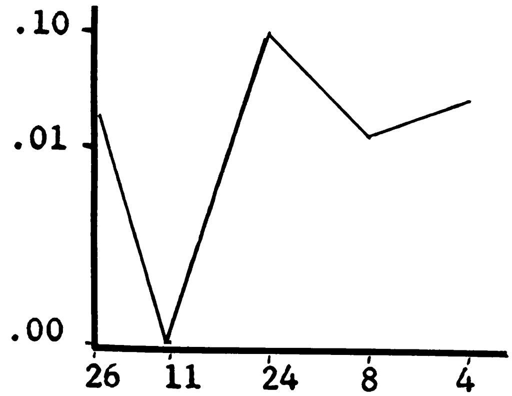

Fig. 128. Station II
Orthophosphate ppm.

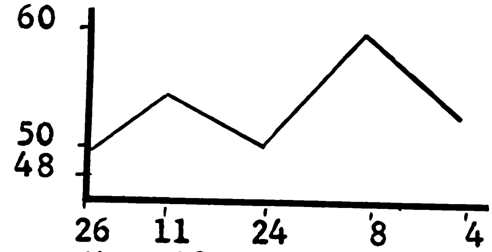

Fig. 130. Station II
Total alkalinity mg/l

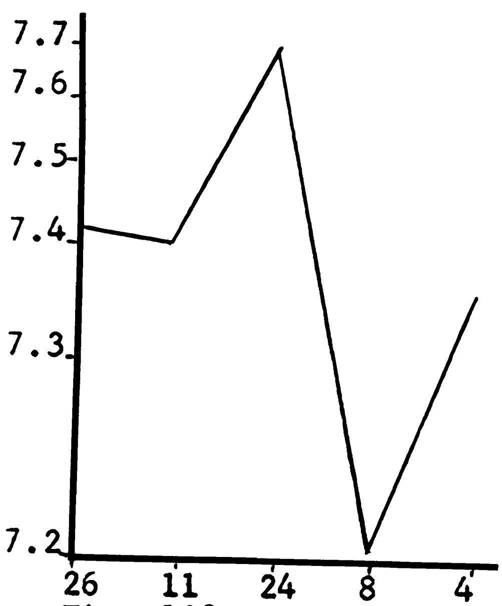

Fig. 129. Station II
pH

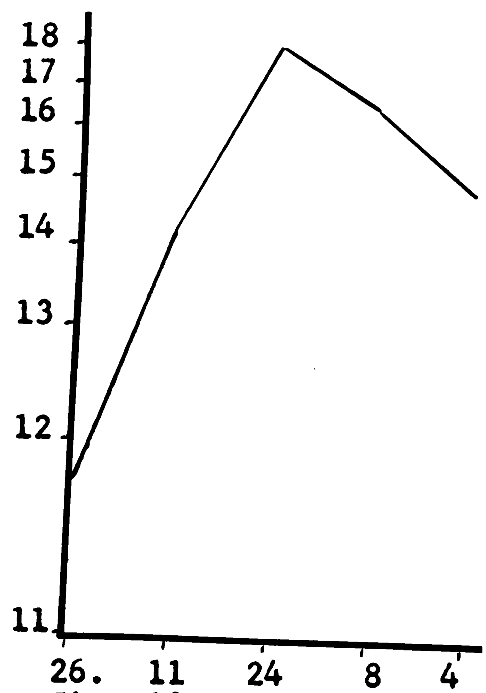

Fig. 131. Station II
Temperature °C

Lake McDonald-June 26, July 11, 24,
Aug. 8, Sept. 4

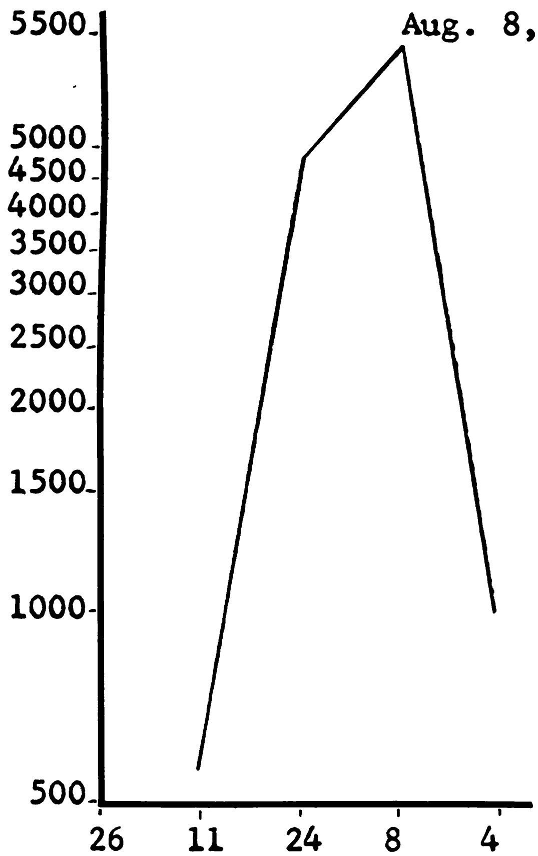

Fig. 132. Station III
Organisms per liter

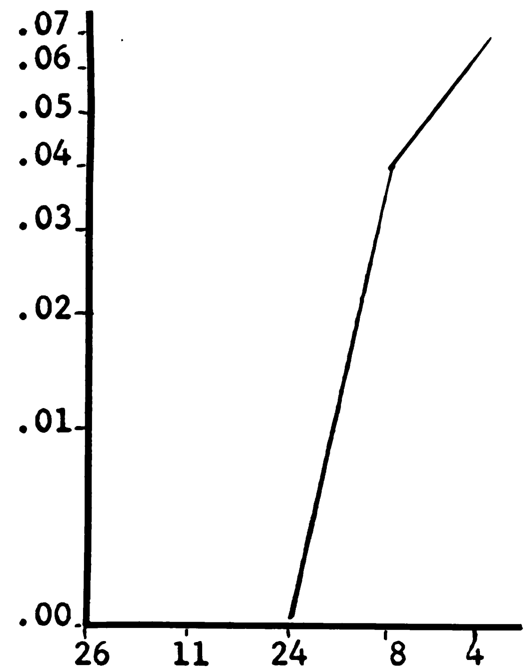

Fig. 133. Station III
Ammonia nitrogen ppm.

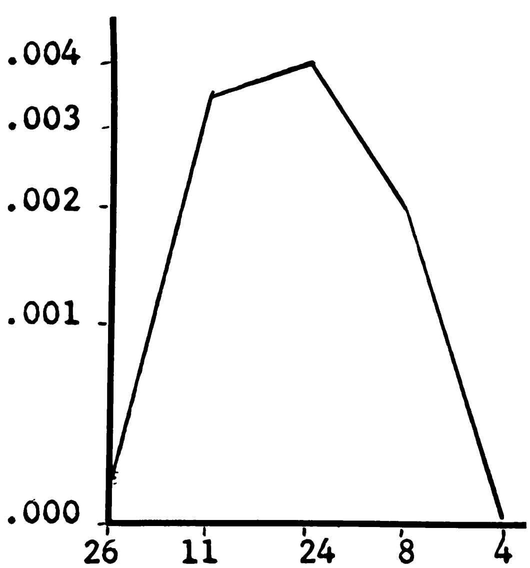

Fig. 134. Station III
Nitrite nitrogen ppm.

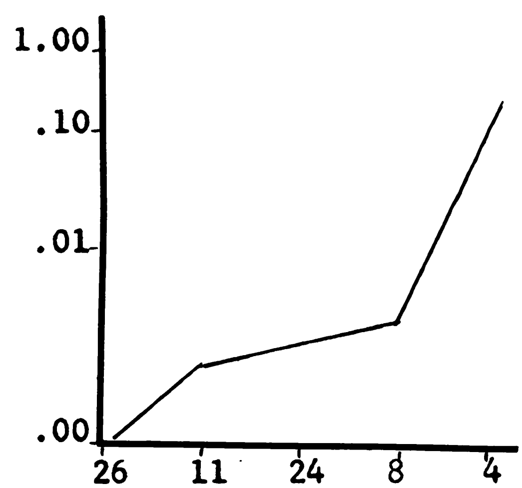

Fig. 135. Station III
Nitrate nitrogen ppm.

Lake McDonald-June 26, July 11, 24,

Aug. 8, Sept. 4

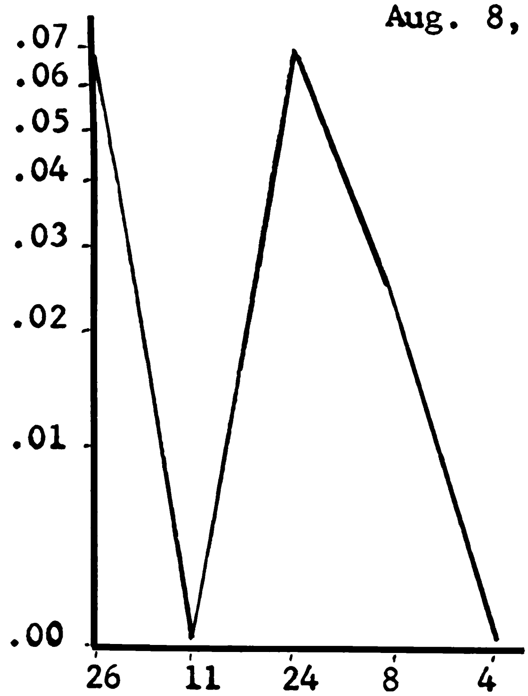

Fig. 136. Station III
Orthophosphate ppm.

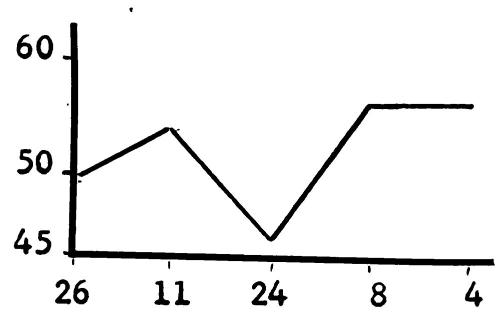

Fig. 138. Station III
Total alkalinity mg/l

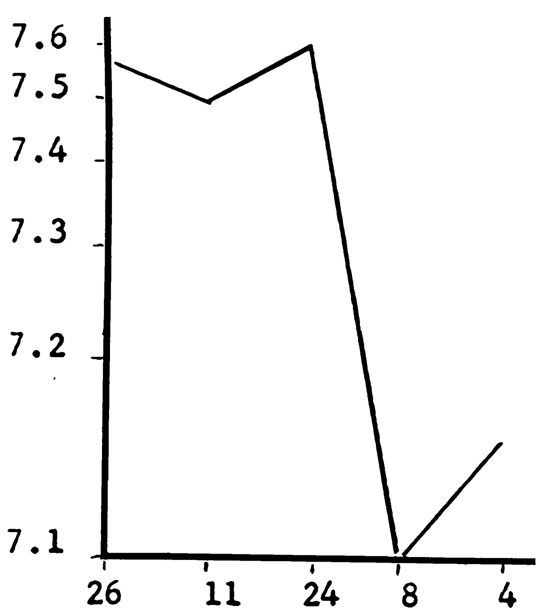

Fig. 137. Station III
pH

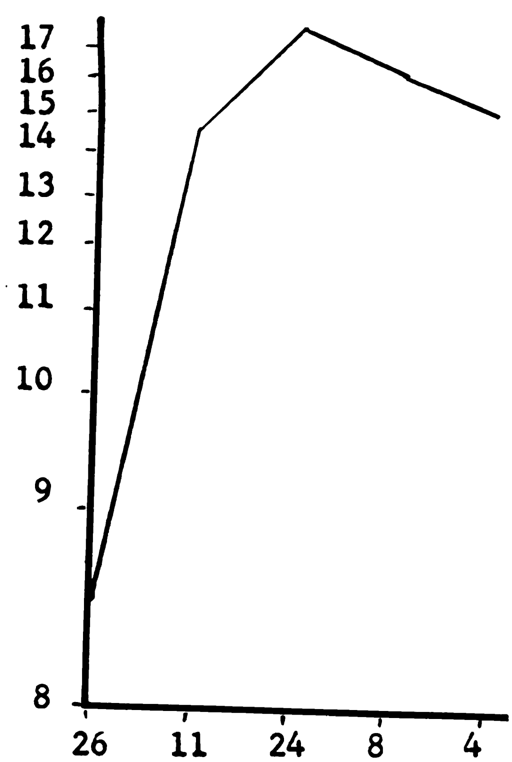

Fig. 139. Station III
Temperature °C

Discussion

The Chrysophyta and Chlorophyta were equally prominent in Lake McDonald. The number of species at each station remains relatively the same for the summer collecting period. The most numerous forms were Coscinodiscus, Asterionella, Tabellaria, Fragilaria, Synedra, Dinobryon divergens, Ceratium hirundinella and Peridinium. The total number of phytoplankton species was 31. Lower St. Mary Lake, Lost Lake, and Johns Lake were the park lakes which were more numerous than Lake McDonald in regard to kinds of species. Each station was approximately equal in regard to total number of organisms per liter (see pg. 218). In terms of total organisms per liter, Lake McDonald ranked higher only in productivity than Swift Current Lake. In regard to the chemical and physical conditions the number of organisms per liter was directly related to ammonia nitrogen, orthophosphate and temperature. Total alkalinity increases near the end of the summer, while the temperature, pH and total number of organisms per liter decreases. This is true of the other park lakes except Johns Lake. In general as the temperature rose from a low of about 14° C. at the beginning of the summer the total number of organisms also increased. Thus temperature seems to be the most important factor in this lake, provided that enough other nutrients are present for the growth of the organisms, which is the case for Lake McDonald. The following tabulation summarizes the conditions for Lake McDonald.

Lake type: flowage

Lake size: large (1.5 x 12 mi.)

Species abundance: 31

Total organism count range: 526-10,419

Ammonia nitrogen range: 0.0-0.15 ppm.

Nitrite nitrogen range: 0.0-0.005 ppm.

Nitrate nitrogen range: 0.0-0.15 ppm.

Orthophosphate range: 0.0-0.2 ppm.

Range of pH: 7.1-7.8

Total alkalinity range: 44-60 mg/l

Temperature range: 7.78-18.33° C.

DISCUSSION

Aquatic ecology represents a field which is a combination of many disciplines, namely: physics, chemistry, geology, and biology. An attempt is made to use differences in the algal component of the biota as well as certain physical and chemical conditions to obtain an insight into the ecology of these algae along a transcontinental divide transect.

Floristic Distribution, Elevation, and Maximum Summer Water Temperature

The following list summarizes the elevation, direction from the continental divide, maximum summer water temperature and the number of kinds of phytoplankton species collected by means of net tows.

	Elevation	Direction	Species	Max. Temp.
Lake McDonald	3144 ft.	West	31	18.3°C
Johns Lake	3300 ft.	West	72	25.6°C
Bowman Lake	4020 ft.	West	24	15.3°C
Swift Current Lake	4861 ft.	East	36	16.0°C
Lost Lake	4700 ft.	East	46	19.2°C
Lower St. Mary Lake	4462 ft.	East	23	18.0°C

It is evident from this list that the largest number of species occur in warmer waters. It seems entirely possible that water temperature is one of the more important factors controlling algal floristic distribution in Glacier National Park. Since the lakes at higher elevations occur where the climate is cooler and receive glacial melt water more directly, they would be expected to have lower summer water temperatures.

Phytoplankton with Elevation

Table 13 shows the occurrence of the more abundant (greater than 656 individuals per liter) phytoplankton according to habitat, elevation and maximum summer water temperature. Species of *Coscinodiscus* were the most frequently encountered abundant forms, reaching the minimum count in all seven lakes. The next most prominent phytoplankters were *Tabellaria*, *Fragilaria* and *Asterionella*. These organisms occurred at minimum levels in five out of seven lakes. However, this does not mean that these organisms were not collected in two of the lakes, because *Tabellaria* was present at below minimum level in Hidden Lake and in Bowman Lake; *Fragilaria* was not present at all in quantitative samples from Johns Lake and Hidden Lake, but it was found in qualitative samples (net tows) taken from these two lakes; and *Asterionella* was present only in qualitative collections taken from Hidden Lake and was at below minimum level in quantitative samples taken from Johns Lake. The next most abundant alga was *Synedra* which occurred in four out of seven lakes. Of the three lakes in which it was not recorded (Table 13), *Synedra* was present only in qualitative samples taken from Johns Lake, and it was below minimum level in Swift Current Lake and it was absent in all samples taken from Hidden Lake. All of these abundant algae mentioned so far are diatoms and they existed over a greater range of elevation and temperature than any of the others. This is particularly evident when one notes (pg. 169) that the common forms at Hidden Lake

(elevation 6375 ft. and maximum water temperature 13° C) were forms having a wide range of occurrence in the lakes studied. On the other hand, not all diatoms are widely distributed in Glacier National Park, for example, Ceratoneis existed only in Swift Current Lake. In addition it is noted that the blue-green algae, Lyngbya Martensiana, Anabaena Sp. and Chroococcus minimus were present at or above minimum level in only the two very small seepage lakes studied. These lakes were also quite warm. The only blue-green alga which occurred at minimum level or above in a flowage lake (Bowman Lake) was Chroococcus turgidus. It is an enigma that no blue-green algae were present in either phytoplankton or hand grab collections taken from Lower St. Mary Lake. Since relatively warm temperatures (18°C) prevailed in this lake and since sufficient nutrients were also present, one would expect blue-green algae to be present. Table 13 also shows that large numbers of the green algae, Sphaerocystis Schroeteri and Elakatothrix gelatinosa are restricted to the two relatively warm, small, seepage lakes (Johns Lake and Lost Lake). Only one green alga is widely distributed as an abundant species and that is Dictyosphaerium pulchellum. Other algae which had narrow ranges of abundance at the higher numbers were Dinobryon bavaricum and Dinobryon divergens.

Table 13. A summary of the common phytoplankton (656 or more individuals /L) according to lake, elevation, water temperature, water source, and direction from the continental divide.

	Lake McDonald	Johns Lake	Bowman Lake	Hidden Lake	Swift Current	Lost Lake	Lower St. Mary
Maximum water temperature	18.3	25.6	15.3	13.0	16.0	19.2	18.0
Elevation	3144	3300	4020	6375	4861	4700	4462
Direction	West	West	West	----	East	East	East
Relative size	Large	Small	Large	Medium	Medium	Small	Large
Lake type	Flowage	Seepage	Flowage	Flowage	Flowage	Seepage	Flowage
Navicula		X	X		X		
Coscinodiscus	X	X	X	X	X	X	X
Pinnularia		X	X			X	
Cymbella	X	X	X				
Tabellaria	X	X			X	X	X
Fragilaria	X		X		X	X	X
Asterionella	X		X		X	X	X
Synedra	X		X			X	X
Cyclotella		X	X				

	Lake McDonald	Johns Lake	Bowman Lake	Hidden Lake	Swift Current	Lost Lake	Lower St. Mary
Melosira			X				
Gomphonema				X			
Ceratoneis					X		
Ceratium hirundinella	X		X				
Dinobryon bavaricum						X	
Dinobryon divergens			X				
Chroococcus minimus		X					
Chroococcus turgidus			X				
Anabaena Sp.						X	
Lyngbya Martensiana		X					
Sphaerocystis Schroeteri		X					
Elakatothrix gelatinosa		X				X	
Dictyosphaerium pulchellum	X	X				X	

Biological Similarity

Community coefficients were used to estimate the biological similarity between lakes, times, and different stations sampled at the same time in one lake. The number of stations sampled at one time in one lake is small (3) and coefficients of similarity between stations range from zero to 98 percent with an average of 50 percent (see Table 14). Significance levels cannot be given for the differences among the coefficients within a lake or between lakes or between periods. Even so, they are presented here as a guide for eliciting questions about the lakes, such as whether certain of them were biotically more similar than other lakes in any one sampling period; whether certain lakes become less alike as the season progresses; whether there is a relationship between the biota of flowage and seepage lakes; whether there is a biota-elevation relationship; and a comparison of east-west similarity indexes.

Kulczynski's community coefficient, 2w/a+b times 100 was used as an index of similarity (Oosting, 1956). Thus lakes with a higher coefficient would be more similar in community structure than those with a lower value. The sum of the lowest of each set of phytoplankton counts shared in common between two populations being compared is represented by w. This value is doubled (2w) because these species are shared between populations a and b to the level of the lowest number (if 2w were not used then it would be possible for an <u>a</u> and <u>b</u> population, which are identical, to have a value of 50 percent instead of a true value of 100 percent).

Samples were taken at three stations on a lake and by comparing lakes or time of sampling in a lake an average was calculated for each species and then these averages were summed to give a and b. Community coefficients were then arranged so that they could be easily compared for each collecting period (see Table 15). The highest coefficient was 45 percent for the between-lake indexes. Since the between-sample comparison in the same lake at the same time ranged from 0 to 98 percent with a mean of 50 percent, one can have a relative degree of confidence in these values because they are all below the 50 percent average for between station coefficients in a lake. In other words, there is less between-lake variation than interstation variation in a lake.

Table 14. Community coefficients (C=2w/a+b) for different stations sampled at the same time in a lake.

	Date	I & II %	I & III %	II & III %
McDonald	6/26	36.7	----	----
	7/11	62.5	31.5	47.9
	7/24	57.0	67.8	56.8
	8/8	68.5	61.4	60.7
	9/4	35.7	80.2	39.1
Johns	6/25	----	20.8	----
	7/11	60.4	56.3	74.0
	7/23	56.7	48.3	73.3
	8/7	80.5	73.5	79.7
	9/2	57.1	80.0	33.3
Bowman	6/28	28.7	24.8	35.6
	7/12	45.9	50.2	52.3
	7/25	82.4	52.8	54.2
	8/10	70.0	67.0	68.1
	9/2	65.7	----	----
Swift Current	7/4	00.0	00.0	00.0
	7/18	35.1	64.2	52.8
	7/31	67.5	34.0	31.3
	8/18	00.0	00.0	00.0
	9/3	66.7	50.0	50.0
Lost Lake	7/3	00.0	43.5	00.0
	7/16	00.0	74.0	00.0
	8/2	98.3	82.5	82.5
	8/18	74.2	47.2	47.2
	9/3	61.3	57.3	90.1
Lower St. Mary	7/5	89.3	75.4	81.4
	7/19	00.0	1.3	90.7
	7/31	88.0	96.9	70.7
	8/18	77.0	67.8	50.7
	9/3	68.2	70.5	73.8
Hidden Lake	8/1	80.0	23.0	36.0

Biological Similarity Between Different Stations Sampled at the Same Time in One Lake

Examination of Table 14 shows that between-station coefficients varied considerably. This would indicate that the phytoplankton populations were heterogeneous in composition. For example, zero coefficients of similarity on 8/18 for Swift Current Lake (Table 14) indicates that there was no similarity between the three sampling stations on this date. At Station I there were 281 *Fragilaria* per liter and 281 *Staurastrum paradoxum* per liter; at Station II there were 657 *Tabellaria* per liter, 281 *Navicula* per liter, and 281 *Cymbella* per liter; and at Station III there were 281 *Synedra* per liter. No one kind of phytoplankter was present in the 7.2 liter samples at more than one station at this collecting period. It is of interest to note that there were zero coefficients of similarity for the first sampling period (7/4) as well as for the collecting period 8/18. Swift Current is a flowage lake and the heavy discharge of water early in the season could have caused the interstation heterogeneity on 7/4, while heavy storm activity during and immediately preceding sampling possibly caused phytoplankton heterogeneity between stations on 8/18.

However another flowage lake, Lake McDonald, had interstation coefficients which were consistently relatively high. The consistent, high counts of *Coscinodiscus* were largely responsible. The greatest interstation heterogeneity in this lake occurred at the second and last collecting periods.

Responsible for these large differences are the following: Dictyosphaerium pulchellum which occurred only at Station I where it reached large numbers on the second sampling period; Coscinodiscus which occurred in small numbers at Station III as compared to the other two stations on the last collecting period (pgs. 232 and 233).

Johns Lake also showed a high degree of interstation homogeneity except for the last collecting period. This heterogeneity at the last sampling period was due to a drop in the abundance of Navicula from the previous sampling period. This interstation similarity was due primarily to high counts of Chroococcus minimus.

Bowman Lake was also very uniform in respect to interstation similarity indexes. This homogeneity was determined by Coscinodiscus, Ceratium hirundinella, Dinobryon divergens, Navicula and Cymbella.

Lower St. Mary Lake was quite homogeneous because of an all-season Tabellaria bloom.

The preceding discussion has provided some evidence for the pattern of phytoplankton in a lake. By the use of interstation coefficients one is able to recognize that phytoplankters have varying degrees of dissimilarity between stations. It is now known (Hutchinson, 1953) that heterogeneity in water masses may be caused by light, temperature, humidity or density gradients, changes of state in certain directions, currents, winds, reproductive patterns (how close the offspring remain to the parent), social patterns, competition

brought about by the interaction of species, and the laws of chance which effect the distribution of organisms in a random manner.

Biological Similarity Between Lakes

Inspection of Table 15 indicates that for the period 6/28 to 7/5 the coefficients are uniformly low, suggesting that the lakes were not very similar in respect to phytoplankton early in the season. Although Lake McDonald and Swift Current Lake have the highest index (15 percent), examination of pg. 232 shows that *Asterionella* and *Tabellaria* were prominent in Lake McDonald, whereas *Coscinodiscus* and *Navicula* were prominent in Swift Current Lake (pg. 147); these lakes were not alike because of the presence of different phytoplankters in each lake. The greater similarity between these two lakes was because of the presence of large numbers of *Fragilaria* and *Tabellaria* in both lakes (pgs. 147 and 232). Therefore none of the lakes showed strong biological similarity in the early part of the season.

For the collecting period 7/11 to 7/19 the highest coefficient was 33 percent for Lake McDonald and Johns Lake. This coefficient was due to the relatively large counts of *Coscinodiscus* in both lakes. The next higher coefficients, 29 percent, were between Swift Current Lake and Bowman Lake, and between Swift Current Lake and Lost Lake. Inspection of the graphs for these lakes on pgs. 116, 147, and 176, show that *Fragilaria* is present in fairly large numbers in all three lakes; *Asterionella* is abundantly present in both

Bowman Lake and Swift Current Lake; and Coscinodiscus is abundant in both Bowman Lake and Lost Lake. This common abundance of particular taxa explains why the indexes of similarity were higher for the collecting period 7/11 to 7/19.

For the sampling period 7/24 to 8/2 the highest coefficient was 25 percent for Hidden Lake (sampled during this period only) and Bowman Lake. The presence of high counts of Coscinodiscus in both these lakes caused them to be biologically similar in respect to the phytoplankton (pgs. 169 and 177). The next highest coefficient was 21 percent for Johns and Swift Current Lakes. This was caused by the abundance of Navicula and Tabellaria in both lakes (pgs. 148 and 205). Most of the coefficients were low, and thus show that the dominant species in the various lakes were not alike.

The next period, 8/7 to 8/18 also showed low indexes of similarity, but it is noted that the two large flowage lakes on the west side of the park have the highest similarity (30 percent), and that the next higher coefficient was 27 percent for Lost and Lower St. Mary Lakes. Since Coscinodiscus was abundant in both Bowman Lake and Lake McDonald these two lakes appear quite similar for this collecting period. Both of these lakes are on the west side of the divide and both are flowage lakes. Because Asterionella was abundant in both Lost Lake and Lower St. Mary Lake, these two lakes were quite similar in community structure as contrasted to the other combinations of lake comparisons. In general, most of the lakes had low coefficients of similarity which show that they were

not very similar for this sampling period (pgs. 89, 117, 178, and 206). This was due to the absence of common bloom organisms.

The period 9/2 to 9/3 was interesting because of great similarity between Lake McDonald and Bowman Lake (45 percent). This similarity is related to the prominence of Coscinodiscus in both lakes (pgs. 178, 233). However, the other coefficients were low for this collecting period which indicates low degrees of similarity between the lakes. This was caused by the absence of common bloom organisms.

It may be concluded that Glacier National Park Lakes were very dissimilar at the first collecting period, but were more similar during the second collecting period, and as noted above they became less similar again as the season progressed. Further, the significance of the occurrences of stronger similarities is the common blooming or at least high counts of one organism. The most significant meaning of low similarities was that striking differences in abundance of one or a very few organisms occurred between the lakes.

Biological Similarity Between Flowage and Seepage Lakes

When the coefficients of similarity in the table of matrices are averaged for flowage versus flowage lakes, flowage versus seepage lakes, and seepage versus seepage lakes, for each collecting period, the following relationships are suggested. Coefficient of similarity for flowage versus flowage lakes average low for the first sampling period,

increase in similarity at the second collecting period, maintain moderate similarity the rest of the season (7%, 15%, 6%, 10%, and 11%). Coefficients of similarity for flowage versus seepage lakes show the same relationship as for flowage versus flowage lakes, namely, greater similarity at the second sampling period but then a drop to lower similarity than the former later in the season (4%, 17%, 8%, 7.5%, and 8%). Seepage versus seepage lake coefficients of similarity indicate high homogeneity for the first two sampling periods and great heterogeneity the remainder of the season (13%, 15%, 1%, 1%, and 2%). The time of greatest similarity was reached at the second sampling period (15%, 17%, and 15%). It is not possible to evaluate the significance of these differences but the trends help focus attention on the questions of similarities and differences.

Biological Similarity and Direction from the Continental Divide

Lakes on the west side of the continental divide appear to be more alike than lakes on the east side of the continental divide. This relationship is suggested when one averages the community coefficients for each collecting period for east versus west side lakes. These averages are 4%, 13%, 5%, 10%, and 7% for east side lakes; 8%, 15%, 6%, 5%, and 5% for west side lakes. The above values are listed in order from the first sampling period to the last sampling period. Inspection shows high indices of similarity (27%, 18%, and 21%) for the west side lakes as compared to the east side lakes, or to the

west and east side lakes. All of the lakes became more similar at the second sampling period (27%, 15%, and 13%) because of the common abundance of certain organisms. West-east lake comparisons and east lake comparisons show low indices of similarity for the remainder of the season but the west lake comparisons remained relatively high for the last two sampling periods.

In general, lakes on the west side of the continental divide were biologically more alike during the sampling season than lakes on the east side of the continental divide. This was caused by the more common occurrence of abundant phytoplankters in west side lakes than in east side lakes.

Table 15. Five matrices of community coefficients showing estimates of similarity between each pair of lakes for each period.

	Lower St. Mary	Lost Lake	Swift Current	Bowman Lake	Johns Lake	Lake McDonald
		6/26-7/5				
Lower St. Mary Lake	----					
Lost Lake	* 5%	----				
Swift Current Lake	1%	* 7%	----			
Bowman Lake	3%	* 5%	13%	----		
Johns Lake	* 3%	*13%	* 6%	* 5%	----	
Lake McDonald	* 8%	* 4%	*15%	* 3%	* 0%	----
		7/11-7/19				
Lower St. Mary Lake	----					
Lost Lake	4%	----				
Swift Current Lake	7%	29%	----			
Bowman Lake	4%	18%	29%	----		
Johns Lake	1%	15%	16%	23%	----	
Lake McDonald	2%	25%	25%	26%	33%	----
		7/24-8/2				
Lower St. Mary Lake	----					
Lost Lake	7%	----				
Swift Current Lake	6%	3%	----			
Bowman Lake	2%	0%	6%	----		
Johns Lake	5%	1%	21%	10%	----	
Lake McDonald	6%	6%	8%	6%	11%	----

* Only two stations were available to calculate the coefficient.

	Lower St. Mary	Lost Lake	Swift Current	Bowman Lake	Johns Lake	Lake McDonald
		8/7-8/18				
Lower St. Mary Lake	----					
Lost Lake	27%	----				
Swift Current Lake	3%	2%	----			
Bowman Lake	6%	7%	6%	----		
Johns Lake	4%	1%	4%	13%	----	
Lake McDonald	8%	3%	7%	30%	12%	----
		9/2-9/3				
Lower St. Mary Lake	----					
Lost Lake	22%	----				
Swift Current Lake	0%	0%	----			
Bowman Lake	* 6%	10%	* 9%	----		
Johns Lake	0%	2%	0%	* 14%	----	
Lake McDonald	1%	14%	7%	* 45%	6%	----

General Discussion of the Interaction Between Phytoplankton and Environmental Factors

Nitrogen

The function of this discussion and the presentation of the raw-data for each lake (see Tables 16 through 21) as apposed to line graphs using averages of the raw-data (see chapters for each lake), is to ascertain if any additional information could be gained to illustrate what chemical and physical conditions affect the biota and also what affects the biota may have on the chemical and physical conditions. The author will show that interaction did take place between the biota and these conditions.

Examination of the data showed that Lost Lake (a small seepage lake at an altitude of 4700 ft.) had the highest value for ammonia nitrogen (0.35 ppm. at the surface on Sept. 3); whereas Lower St. Mary Lake (a flowage lake at an altitude of 4462 ft.) displayed 0.00 ppm. of ammonia nitrogen for all sampling dates but one. Ruttner has recorded a range of from 0.00 to 0.03 ppm. in the Austrian Alps in the trophogenic layers of various lakes (in Hutchinson, 1957). Most of the ammonia nitrogen readings for Glacier National Park were within this range. In natural waters, one would usually expect ammonia to be in concentrations of usually 1.0 ppm. or less (Reid, 1961). The Glacier National Park Lakes all have concentrations of ammonia nitrogen below this value. Other comparable values are 0.016 to 0.052 ppm. for lakes of the Convict Creek Basin in Mono County, California (Reimers and

Maciolek, 1955); "about 0.06 ppm." for two Colorado Lakes (Olive, 1953); and 0.00-0.07 ppm. for Flathead Lake, Montana (Baker and Potter, 1961).

Nitrite nitrogen was highest in Lost Lake (0.009 ppm., surface, August 2) but lower values of 0.000, 0.002, and 0.005 ppm. were more often encountered in Glacier Park Lakes. Comparable data were 0.001-0.003 ppm. for lakes of the Convict Creek Basin region in California (Reimers and Maciolek, 1955); 0.000-0.005 ppm. for Flathead and Rogers Lake, Montana (Potter and Baker, 1961). The fact that values of more than 0.004 ppm. were detected in Montana waters would raise the suspicion that our national parks and national forest areas are becoming polluted. Hutchinson (1957) cites data by Juday, Birge, and Meloche. They reported in 1938 concentrations of 0.004 ppm. nitrite nitrogen in sewage pollution. Dr. Potter (1961) has run bacteriological studies on Flathead Lake which indicate pollution in Polson Bay (verbal communication). Although only 20 percent of the readings in Glacier Park were above the value of 0.004 ppm. it is of interest to speculate whether the heavy use of Glacier National Park by tourists over the ensuing years will lead to pollution conditions. It is my opinion that a thorough study of existing water chemistry and biota of those lakes accessible to tourists should be made now so that future studies can be used for comparison and to determine what effect man is having on northern Montana recreational areas so that there would be a possibility also of remedying the situations before they become serious.

Nitrate nitrogen values were highest in Lower St. Mary Lake (0.14 ppm. at 15 ft. on August 18) and in Lake McDonald (0.15 ppm. at 15 ft. on Sept. 4). Comparable values for other regions would be 0.1-0.3 ppm. (Domogalla, Juday, and Peterson in Reid, 1961) for Lake Mendota, Wisconsin; the world average for nitrate nitrogen in unpolluted fresh waters is 0.30 ppm. (Reid, 1961); 0.00-0.12 ppm. for Flathead and Rogers Lake (1961); and 0.04 to 0.19 ppm. (Reimers and Maciolek, 1955).

In summary, the above discussion indicates that values for inorganic nitrogen were similar to values obtained elsewhere for similar habitats in the temperate zone.

Phytoplankters are able to obtain their nitrogen either by fixation or from ammonia and nitrate. It is clear that fluctuations in these factors could be caused by the biota absorbing them from the water, or by releasing them during decay. Since direct fixation is not known to occur in very many algae, it seems probable that in natural water, ammonia and nitrate nitrogen are the most important forms to consider. Ammonia is produced by ammonification of dead organic material and animal excretory products. Thus one would anticipate fluctuations in the ammonia concentration because organisms would be taking it up. It is well known that phytoplankton populations can decline exponentially and their decay increases the amount of ammonia in the water, however, it is also possible for algae to decay and the organic residue never be reduced to ammonia. Nitrite and nitrate would be formed by successive oxidations of the nitrogen atom. Both

of these forms of nitrogen are utilized by algae, but nitrate is generally the most important (Lewin, 1962). Thus growth of phytoplankton organisms could alter the concentration of the various forms of nitrogen in lake water by differentially absorbing them, or by releasing them into the water through decay in surface waters. Algae can utilize inorganic nitrogen at concentrations below 0.1 mg. N/L (Lund, 1950 in Lewin). This fact is important because of the low concentrations reported by the author for Glacier National Park. The purpose of this resume concerning the nitrogen cycle in natural waters is to point out that one expects fluctuations in inorganic nitrogen due to utilization by algae and by release during decay. Also it is appropriate to further point out that nitrogen could become limiting at very low concentrations. Since these cycling procedures do occur with great rapidity, it is possible that chemical changes could be missed by collecting every two weeks as was done during this investigation. But the data presented in tables 16 through 21 indicates that cycling does occur and therefore this study shows that it would be of value for future researchers to study this phenomenon over shorter collecting periods.

The next step is to inspect the raw-data tables for Glacier Park Lakes and to see if these fluctuations have occurred. Table 17 for Lost Lake does show a fluctuation in ammonia nitrogen concentration. It was possible that when the organism count was low on July 3, and then increased substantially to August 2, that the decrease in ammonia nitrogen

between July 3 and July 16, was determined by uptake of this substance by the algae. This table also shows an increase in ammonia after this date which could be caused by decay of the organisms. Nitrite nitrogen increased by August 2, and then declined. Its increase could be explained by the oxidation of ammonia to nitrite. Nitrate increased by August 18, and was most likely formed by decay. In this lake the organisms per liter reached their peak during August and then declined. These fluctuations of biota and inorganic nitrogen very well could be caused by the various interactions between them. But no generalization should be made for all lakes because no relationship is shown in Tables 16, 18, and 19. Inspection of Table 20 for Johns Lake shows an increase in ammonia nitrogen from 0.00 ppm. to higher values on July 11. Nitrite and nitrate nitrogen also increased by July 23. The organisms per liter increased to a high on August 7, and then declined. It may be that the organisms per liter were low because of very little inorganic nitrogen in the water. Then as inorganic nitrogen became available, the biota increased. A very good relationship between inorganic nitrogen and the phytoplankton is clearly indicated at Station I in Table 21. Note that a bloom occurred on August 8, and that ammonia nitrogen was also high on this date, probably because the organisms had increased for several weeks and decay had produced this high concentration of ammonia. It is noted that nitrite reached a peak concentration two weeks before this bloom and then dropped to 0.00 ppm. on August 8. This could indicate

that the organisms used up nitrite as a nitrogen source. It is also possible that this phenomenon was not related to the biota because nitrite could have changed to ammonia and caused its peak of concentration. No direct cause and effect relationship is brought out by reference to the raw-data tables, but since there were examples of fluctuations in both the biota and the inorganic nitrogen, it is appropriate to speculate that interaction between the two caused these fluctuations.

Orthophosphate

The highest orthophosphate value was 1.5 ppm. on July 18, at a depth of 15 ft. in Swift Current Lake. This value was very high when compared to 0.08 ppm. at the surface for the same date. Comparable data for other world regions would be 0.000-0.046 ppm. for the Austrian Alps (Ruttner, in Reid, 1961) and 0.002-0.046 ppm. for Swedish lakes (Lohammer, in Reid, 1961). Although the values included for Glacier National Park were only occassionally above these values, they do seem high for what would be expected in western alpine and subalpine regions. Juday and Birge report a soluble phosphate range of from 0.000-0.013 ppm. for 494 Wisconsin Lakes (1931). My values were too high in this study when compared to the values cited above for other regions. The stannous chloride method used in this study is very sensitive to interference and contamination. However, tests run for contamination on all glassware used were run without producing any evidence of contamination. It is my belief that these readings should

be treated as suspect values until such time as future investigations support or refute these phosphorus data.

Since phosphorus is a necessary nutrient it is reasonable to expect a decrease in phosphorus if it is absorbed by algae, resulting in population increase, and an increase in phosphorus when decay occurs. Radioactive phosphorus experiments have shown that phosphorus is taken up immediately by phytoplankton and some of it released back into the water in a few days (Hutchinson, 1957). If this is the case, then one would predict that the concentration of phosphorus in the water would be very erratic from one collecting date to the next. Examination of Tables 16-21 indicate very sharp changes in the phosphorus concentrations. This relationship is further emphasized if one again reviews the line graphs drawn for phosphorus at the end of each chapter. This interaction between biota and phosphorus is amplified further if one examines the raw-data tables 16-21, and finds readings indicating that organisms are increasing and phosphorus is declining, showing that phosphorus is being utilized by the organisms. Such an example would be Table 17, but the other tables do not show any such relationship. I think that there is a definite reason why my data does not indicate the classical relationship of decline and rise of a nutrient with rise and decline of the population, and that is because organisms are able to store phosphate and thus exist for long periods of time in limiting supplies of phosphorus.

Alkalinity, pH, and Temperature

Reference to the data tables of Glacier National Park Lakes indicates a pH range of 6.8 to 8.0 and a bicarbonate range (total alkalinity) of 12 to 78 mg/l. A statement of pH range indicates that the important chemical reactions taking place in the park lakes are:

$$CO_2 + H_2O = H_2CO_3$$

$$H_2CO_3 = H^+ + HCO_3^-$$

$$HCO_3^- = H^+ + CO_3^=$$

Bicarbonate ion is the more prevalent ion between a pH of 6-8 (Hutchinson, 1957). Examination of Tables 16 through 21 shows values of pH that indicate the waters of the park are mildly alkaline. This is an important generalization because one can then make the statement that pH is regulated by the carbon dioxide-bicarbonate system (Hutchinson, 1957). A review of the above equations illustrate the interaction between the biota and the environment because if the organisms are taking up carbon dioxide then the above equations shift their equilibrium to the left; if decay is adding carbon dioxide to the ecosystem then the equilibrium shifts to the right. One of the major properties of this buffering system is to prevent sudden changes in pH which could materially upset cellular physiology. Since cooler temperatures mean greater solubility of carbon dioxide, one would predict that at cooler water temperatures the equilibrium shifts to the right and results in an increase in bicarbonate concentration,

and also a decrease in pH values (increase in hydrogen ion concentration, or in other words higher acidity). Inspection of Tables 16, 17, and 18 supports these predictions. If one does not take into account the biota the above relationships can be explained by the cooler water temperatures at the end of the summer. However, one can not ignore the fact that the biota are also taking up carbon dioxide, but it seems reasonable to expect that by the end of the summer decay is probably adding more carbon dioxide to the ecosystem than the organisms are using up. Thus one can still rationalize the increase in bicarbonate alkalinity on the basis of pure chemical and physical interactions and still not ignore the role of the phytoplankton. One might ask the question, what kind of data would allow one to minimize the role of the biota to explain the increase in bicarbonate and the increase in acidity? One would predict that the organisms per liter would be declining, which means that smaller amounts of carbon dioxide are used in photosynthesis. Examination of the tables support this prediction. In addition, factors in the environment such as the formation of bicarbonate and carbonate ions, or warmer temperatures could cause carbon dioxide in solution to decrease in concentration. Thus carbon dioxide would begin to accumulate and cause higher acidity and higher bicarbonate ion concentration.

This discussion has supported the view that interaction does occur between the phytoplankton and certain factors in the environment.

Table 16. Lower St. Mary Lake-Raw Data

	July 5		July 19		July 31		August 18		Sept. 3	
	S	15	S	15	S	15	S	15	S	15
Ammonia nitrogen ppm.										
Station I	0.00	0.00	0.00	0.00	0.00	0.00	----	----	0.00	0.00
Station II	0.00	0.00	0.00	0.00	0.00	0.00	----	----	0.00	0.00
Station III	0.05	0.00	0.00	0.00	0.00	0.00	----	----	0.00	0.00
Nitrite nitrogen ppm.										
Station I	0.005	0.002	0.000	0.005	0.000	0.000	0.000	0.003	0.002	0.002
Station II	0.005	0.002	0.005	0.000	0.000	0.000	0.002	0.002	0.002	0.000
Station III	0.005	0.005	0.005	0.005	0.000	0.000	0.002	0.002	0.002	0.002
Nitrate nitrogen ppm.										
Station I	0.015	0.018	0.000	0.015	0.000	0.000	0.030	0.028	0.028	0.138
Station II	0.015	0.018	0.025	0.000	0.000	0.000	0.058	0.038	0.038	0.030
Station III	0.015	0.025	0.015	0.015	0.000	0.000	0.068	0.140	0.018	0.058
Orthophosphate ppm.										
Station I	0.10	0.05	0.20	0.08	0.00	0.00	0.00	0.02	0.10	0.09
Station II	0.02	0.00	0.10	0.08	0.05	0.06	0.02	0.02	0.04	0.04
Station III	0.15	0.09	0.08	0.05	0.05	0.08	0.00	0.02	0.00	0.00
pH										
Station I	7.6	7.4	7.5	7.5	7.7	7.7	7.6	7.8	7.4	7.3
Station II	7.4	8.2	7.7	7.5	7.6	7.6	7.6	7.8	7.1	7.2
Station III	7.7	7.5	7.7	7.5	7.6	7.6	7.6	7.7	7.2	7.2
Alkalinity mg/l										
Station I	64	60	64	60	60	60	68	64	80	76
Station II	72	72	68	68	60	60	68	68	72	76
Station III	68	76	64	64	60	64	68	72	76	72

Lower St. Mary Lake-Raw Data (Cont.)

	July 5		July 19		July 31		August 18		Sept 3	
Temperature	S	15	S	15	S	15	S	15	S	15
Station I	13.33	12.78	15	15	13.33	13.33	15	15	14	14
Station II	11.67	11.67	13.89	13.89	16	16	16.8	16.4	14.4	13.2
Station III	11.11	11.11	12.22	12.22	16.7	16.7	17.8	17.8	13.6	14
Organisms per/1*										
Station I	19181		23000		24039		21065		28306	
StationII	19049		18018		21065		13203		34271	
Station III	13568		19611		35837		36608		48107	

* Combined sample

Table 17. Lost Lake-Raw Data

	July 3		July 16		August 2		August 8		Sept. 3	
	S	15	S	15	S	15	S	15	S	15
Ammonia nitrogen ppm.										
Station I	0.05	0.00	0.00	0.00	0.14	0.09	----	----	0.35	0.04
Station II	0.02	0.25	0.00	0.00	0.08	0.08	----	----	0.02	0.35
Station III	0.05	0.05	0.00	0.00	0.05	0.05	----	----	0.00	0.02
Nitrite nitrogen ppm.										
Station I	0.002	0.002	0.002	0.002	0.005	0.008	0.006	0.004	0.002	0.002
Station II	0.005	0.004	0.002	0.000	0.010	0.008	0.004	0.000	0.002	0.002
Station III	0.000	0.000	0.000	0.005	0.009	0.010	0.003	----	0.000	0.002
Nitrate nitrogen ppm										
Station I	0.018	0.018	0.018	0.038	0.025	0.012	0.074	0.056	0.028	0.028
Station II	0.015	0.017	0.018	0.000	0.020	0.032	0.056	0.080	0.018	0.018
Station III	0.000	0.000	0.000	0.015	0.071	0.070	0.137	0.100	0.020	0.028
Orthophosphate ppm.										
Station I	0.08	0.02	0.05	0.04	0.08	0.06	0.02	0.02	0.02	0.10
	0.05	----								
Station II	0.15	0.00	0.15	0.00	0.08	0.06	0.00	0.00	0.05	0.02
	0.08	0.10								
Station III	0.00	0.05	0.04	0.03	0.08	0.08	0.00	0.00	0.02	0.06
	0.05	----								
pH										
Station I	7.2	7.3	7.3	8.0	7.4	7.2	7.6	7.4	7.2	7.2
Station II	7.9	7.6	7.6	7.7	7.2	7.4	7.6	7.7	7.1	7.0
Station III	7.4	7.6	7.4	7.8	7.4	7.4	7.7	7.6	7.0	7.0

Lost Lake-Raw Data (Cont.)

	July 3		July 16		August 2		August 18		Sept. 3	
Alkalinity mg/l	S	15	S	15	S	15	S	15	S	15
Station I	48	44	40	52	44	44	44	48	56	52
Station II	48	44	44	44	40	48	44	48	52	52
Station III	44	40	44	44	44	40	44	44	52	52
Temperature										
Station I	15.56	14.44	17.22	16.67	19.3	19.1	16.8	16.8	14.0	13.2
Station II	15.00	14.44	17.22	16.67	19.1	18.5	16.8	16.8	14.0	13.0
Station III	15.00	14.44	17.22	17.22	19.1	18.5	16.8	16.8	13.0	10.0
Organisms per/l*										
Station I	1780		1499		16689		14616		13054	
Station II	----		565		17251		9086		6400	
Station III	2530		6092		13638		25424		5254	

* Combined sample

Table 18. Swift Current Lake-Raw Data

	July 4		July 18		July 31		August 18		Sept. 3	
Ammonia nitrogen ppm.	S	15	S	15	S	15	S	15	S	15
Station I	0.00	0.02	0.00	0.00	0.00	0.05	----	----	0.00	0.00
Station II	0.00	0.00	0.00	0.00	0.02	0.03	----	----	0.00	0.00
Station III	0.00	0.00	0.02	0.00	0.03	0.02	----	----	0.00	0.00
Nitrite nitrogen ppm.										
Station I	0.001	0.000	0.008	0.005	0.005	0.003	0.000	0.002	0.000	0.000
Station II	0.002	0.000	0.008	0.002	0.000	0.000	0.002	0.006	0.000	0.000
Station III	0.000	0.001	0.000	0.000	0.000	0.002	0.002	0.002	0.000	0.000
Nitrate nitrogen ppm.										
Station I	0.019	0.030	0.032	0.025	0.015	0.000	0.030	0.028	0.000	0.000
Station II	0.028	0.030	0.012	0.018	0.020	0.010	0.038	0.034	0.000	0.000
Station III	0.030	-----	0.000	0.000	0.020	0.058	0.118	0.038	0.000	0.000
Orthophosphate ppm.										
Station I	0.05	0.15	0.08	1.50	0.03	0.00	0.00	0.00	0.05	0.05
Station II	0.05	0.08	1.00	0.12	0.00	0.00	0.00	0.02	0.03	0.05
Station III	0.08	0.04	0.10	0.10	0.00	0.00	0.00	0.00	0.06	0.03
pH										
Station I	7.6	7.8	7.1	7.7	7.4	7.2	7.4	7.2	7.1	7.2
Station II	7.9	7.6	7.4	7.6	7.4	7.6	7.3	7.2	7.1	7.1
Station III	7.4	7.8	7.6	7.6	7.5	7.5	7.2	7.2	7.1	7.2

Swift Current Lake-Raw Data (Cont.)

	July 4		July 18		July 31		August 18		Sept. 3	
Alkalinity mg/l	S	15	S	15	S	15	S	15	S	15
Station I	52	52	32	56	48	44	48	52	60	56
Station II	52	48	44	48	48	44	56	52	60	64
Station III	44	52	48	44	44	40	52	56	60	56
Temperature										
Station I	10.00	10.00	12.22	12.22	16.00	15.50	13.30	13.30	10.40	11.60
Station II	11.11	8.89	12.22	12.22	15.50	15.00	13.30	13.00	11.20	11.60
Station III	10.56	10.00	12.22	12.22	15.50	15.50	13.30	11.20	11.60	11.20
Organisms per/l*										
Station I	1782		4777		3375		562		281	
Station II	281		2155		4129		1218		281	
Station III	281		2811		3654		281		281	

* Combined sample

Table 19. Bowman Lake-Raw Data

	June 28		July 12		July 25		August 10		Sept. 2	
Ammonia nitrogen ppm.	S	15	S	15	S	15	S	15	S	15
Station I	0.00 0.00	0.00 0.00	0.05	0.00	0.00	0.00	----	----	0.00	0.14
Station II	0.00 0.00	0.00 0.00	0.01	0.00	0.00	0.00	----	----	0.00	0.00
Station III	0.00 0.00	0.00 0.00	0.00	0.00	0.00	0.00	----	----	----	----
Nitrite nitrogen ppm.										
Station I	0.000 0.000	0.000 0.000	0.002	0.002	0.005	0.004	0.002	0.002	0.000	0.000
Station II	0.000 0.000	0.000 0.000	0.002	0.000	0.004	0.003	0.002	0.003	0.000	0.002
Station III	0.000 0.000	0.000 0.000	0.000	0.002	0.005	0.002	0.003	-----	-----	-----
Nitrate nitrogen ppm.										
Station I	0.000 0.000	0.000 0.000	0.000	0.000	0.025	0.036	-----	-----	0.020	0.010
Station II	0.000 0.000	0.000 0.000	0.018	0.000	0.026	0.037	-----	-----	0.000	0.018
Station III	0.000	0.000	0.000	0.018	0.025	0.038	-----	-----	-----	-----
Orthophosphate ppm.										
Station I	0.20 0.10	0.15	0.08	0.12	0.08	0.12	0.03	0.00	0.02	0.02
Station II	0.18 0.18	0.10	0.20	0.20	0.10	0.02	0.00	0.02	0.02	0.00
Station III	0.28	0.15 0.20	0.05	0.05	0.02	0.06	0.00	-----	-----	-----

Bowman Lake-Raw Data (Cont.)

	June 28		July 12		July 25		August 10		Sept. 2	
pH	S	15	S	15	S	15	S	15	S	15
Station I	7.3	7.4	7.4	7.3	7.8	7.4	7.3	7.3	7.4	7.2
	7.3	7.3								
Station II	7.6	7.6	7.4	7.4	7.6	7.7	7.4	7.3	7.4	7.3
	7.6	7.6								
Station II	7.2	7.1	7.4	7.4	7.6	7.6	7.2	---	---	---
	7.2									
Alkalinity mg/1										
Station I	28	60	76	80	56	60	68	60	68	68
	48	56								
Station II	36	60	64	76	60	56	64	68	76	72
	56	56								
Station III	52	56	72	68	60	56	68	68	--	--
	60	56								
Temperature										
Station I	11.11	11.11	13.33	12.78	16.11	14.44	14.50	14.50	13.00	----
Station II	11.11	11.11	13.06	12.78	16.11	15.00	14.50	14.00	11.50	----
Station III	11.11	11.11	13.32	12.78	16.11	15.00	14.50	14.00	-----	----
Organisms per/1*										
Station I	11237		11917		7197		6272		8255	
Station II	3750		4777		5340		4580		----	
Station III	3092		5553		6935		6113		5429	

* Combined sample

Table 20. Johns Lake-Raw Data

	June 25		July 11		July 23		August 7		Sept 4	
Ammonia nitrogen ppm.	S	4	S	4	S	4	S	4	S	4
Station I	0.00	0.00	0.05	----	0.08	0.09	----	----	0.04	0.06
	0.00	0.00								
Station II	0.00	0.00	0.02	0.02	0.06	0.06	----	----	0.06	0.08
	0.00	0.00								
Station III	0.00	0.00	0.02	0.02	0.05	0.04	----	----	0.08	0.06
	0.00	0.00								
Nitrite nitrogen ppm.										
Station I	0.000	0.000	0.000	0.000	0.002	0.002	0.005	0.003	0.002	0.002
	0.000	0.000								
Station II	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.002	0.000
	0.000	0.000								
Station III	0.000	0.000	0.000	0.002	0.000	0.002	0.002	0.006	0.002	0.002
	0.000	0.000								
Nitrate nitrogen ppm.										
Station I	0.000	0.000	0.000	0.000	0.018	0.048	0.035	0.037	0.048	0.058
	0.000	0.000								
Station II	0.000	0.000	0.000	0.000	0.030	0.030	0.027	0.035	0.058	0.050
	0.000	0.000								
Station III	0.000	0.000	0.000	0.000	0.000	0.018	0.018	0.034	0.048	0.058
	0.000	0.000								
Orthophosphate ppm.										
Station I	0.20	0.05	0.08	----	0.09	0.02	0.05	0.05	0.00	0.00
	0.02	0.00								
Station II	0.06	0.18	0.08	0.00	0.05	0.03	0.00	0.02	0.00	0.00
	0.09	0.02								
Station III	0.03	0.05	0.15	----	0.02	0.05	0.05	0.10	0.00	0.00

Johns Lake-Raw Data (Cont.)

	June 25		July 11		July 23		August 7		Sept. 4	
	S	4	S	4	S	4	S	4	S	4
pH										
Station I	7.8	7.8	7.4	7.4	7.4	7.4	7.2	6.9	6.8	6.8
	7.9	7.8								
Station II	7.8	7.9	7.4	7.3	7.3	7.2	7.0	6.8	6.8	6.9
	7.7	8.0								
Station III	7.3	7.5	7.1	7.1	7.2	7.2	6.9	6.9	6.8	6.8
	7.9									
Alkalinity mg/1										
Station I	36	20	12	--	20	20	24	24	20	20
	36	28								
Station II	16	24	32	20	16	20	20	20	20	16
	24	20								
Station III	12	36	24	--	16	20	20	20	20	16
	20									
Temperature										
Station I	22.5	----	18.0	----	24.44	-----	19.2	----	15.5	----
Station II	22.5	22.5	17.5	17.5	25.56	23.33	19.2	17.3	14.4	13.2
Station III	22.5	----	20.0	----	25.00	-----	18.2	----	14.0	----
Organisms per/1*										
Station I	1124		1874		3050		10419		1499	
Station II	3469		1780		1970		6279		3894	
Station III	1874		526		4961		5432		937	

* Combined sample

Table 21. Lake McDonald-Raw Data

	June 26		July 11		July 24		August 8		Sept. 4	
Ammonia nitrogen ppm.	S	15	S	15	S	15	S	15	S	15
Station I	0.00	0.00	0.00	0.00	0.02	0.02	0.15	0.08	0.00	0 00
	0.00	0.00								
Station II	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.00
	0.00	0.00								
Station III	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.14	0.00
	0.00	0.00								
Nitrite nitrogen ppm.										
Station I	0.000	0.000	0.000	0.001	0.005	0.005	0.000	0.000	0.002	0.000
	0.000	0.000								
Station II	0.000	0.000	0.001	0.000	0.005	0.005	0.000	0.000	0.000	0.002
	0.000	0.000								
Station III	0.000	0.000	0.005	0.002	0.004	0.004	0.002	0.002	0.000	0.000
	0.000	0.000								
Nitrate nitrogen ppm.										
Station I	0.000	0.000	0.020	0.029	0.015	0.015	0.050	0.040	0.058	0.080
	0.000	0.000								
Station II	0.000	0.000	0.029	0.030	0.025	0.035	0.000	0.020	0.080	0.058
	0.000	0.000								
Station III	0.000	0.000	0.035	0.038	0.046	0.046	0.018	0.098	0.120	0.150
	0.000	0.000								
Orthophosphate ppm.										
Station I	0.10	0.05	0.05	0.08	0.05	0.10	0.03	0.02	0.00	0.00
	0.10	0.05								
Station II	0.18	0.09	0.00	0.00	0.05	0.15	0.02	0.02	0.00	0.08
	0.20	0.08								
Station III	0.05	0.08	0.00	0.00	0.06	0.08	0.03	0.02	0.00	0.00
	0.00	0.15								

Lake McDonald-Raw Data (Cont.)

	June 26		July 11		July 24		August 8		Sept. 4	
pH	S	15	S	15	S	15	S	15	S	15
Station I	7.6	7.4	7.2	7.5	7.5	7.5	7.2	7.1	7.2	7.2
	7.5	7.6								
Station II	7.3	7.7	7.4	7.4	7.6	7.8	7.3	7.1	7.5	7.2
	7.3	7.4								
Station III	7.7	7.5	7.5	7.5	7.5	7.7	7.1	7.1	7.2	7.1
	7.6	7.3								
Alkalinity mg/1										
Station I	44	48	56	56	48	48	60	60	56	56
	52	48								
Station II	48	48	56	52	52	48	60	60	52	52
	44	52								
Station III	52	48	56	52	44	48	56	56	60	52
	48	48								
Temperature										
Station I	14.4	15.0	17.7	15.5	18.3	16.1	17.2	17.2	14.0	14.4
Station II	11.1	12.2	14.4	13.8	18.3	17.7	16.5	16.5	15.5	14.4
Station III	7.7	8.8	15.0	14.4	17.7	17.2	16.5	16.5	15.5	15.0
Organisms per/1*										
Station I	1124		1874		3959		10419		1499	
Station II	3469		1780		1970		6279		3282	
Station III	-----		562		4961		5432		937	

* Combined sample

SUMMARY

The algal taxonomy and ecology of a transcontinental divide transect was studied during the summers of 1961 and 1962. A checklist of algae was compiled along with the location, range of altitude, temperature, pH, total alkalinity, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and orthophosphate for each species collected. Six lakes were sampled about every two weeks from June 20, to September 3, 1962, to determine the net phytoplankton forms, quantitative counts of phytoplankton, and the water chemistry. The community coefficient 2w/a+b was used to estimate the biological similarity between lakes, times, and different stations sampled at the same time in one lake. Further, the possible interaction between phytoplankton and environmental factors has been discussed.

APPENDIX

Hach Company Chemical Procedures for the D R Colorimeter

Ammonium Nitrogen Nessler's Method

The direct Nesslerization procedure will determine ammonia nitrogen as low as 0.02 ppm. when carried out with a photoelectric colorimeter.

Procedure

1. Measure a 25 ml. water sample by filling a clean 25 ml. graduated cylinder to the 25 ml. mark. Pour the sample into a clean colorimeter bottle.
2. Measure a 25 ml. sample of demineralized water by filling another clean 25 ml. graduated cylinder to the 25 ml. mark. Pour it into a clean colorimeter bottle.
3. Add to each sample 1.0 ml. of Nessler's Reagent. Swirl to mix. If ammonium nitrogen is present a yellow color will develop. Allow ten minutes for full color development.
4. Place the colorimeter bottle which contains the prepared sample of demineralized water in the light cell. Insert the ammonium nitrogen meter scale in the meter and use the 5543 color filter. Press the light switch and adjust the light control for a meter reading of zero ppm.
5. Place the colorimeter bottle that contains the prepared unknown sample in the light cell. Press the light switch and read the ppm. Ammonium Nitrogen.

Nitrate Nitrogen Brucine Method

Procedure

1. Measure a 10 ml. water sample by filling a clean 25 ml. graduated cylinder to the 10 ml. mark.
2. Measure a 10 ml. sample of demineralized water by filling another clean 25 ml. graduated cylinder to the 10 ml. mark.
3. Add to each graduated cylinder 0.1 gram of NitraVer powder.
4. Carefully add concentrated sulfuric acid to each cylinder to the 25 ml. mark. Carefully swirl to mix. Allow ten minutes for color development.
5. Fill a colorimeter bottle with the prepared sample of demineralized water. Insert the nitrate Brucine Method meter scale in the meter and use the 5543 color filter. Press the light switch and adjust the light control for a meter reading of zero ppm.
6. Fill a colorimeter bottle with the prepared unknown sample and place it in the light cell. Press the light switch and read the ppm. nitrate nitrogen.

Nitrite Nitrogen

Procedure

1. Measure a 25 ml. water sample by filling a clean 25 ml. graduated cylinder to the 25 ml. mark. Pour the sample into a clean colorimeter bottle.
2. Add 0.25 grams of NitriVer. Swirl to mix. Allow the color to develop for thirty minutes.
3. Fill a colorimeter bottle with some of the original water sample and place it in the light cell.

4. Insert the nitrite nitrogen meter scale in the meter and use the 4445 color filter. Press the light switch and adjust the light control for a meter reading of zero ppm.
5. Place the prepared sample in the light cell. Press the the light switch and read the ppm. nitrite nitrogen.

Orthophosphate

Procedure

1. Measure two 25 ml. water samples by filling two clean 25 ml. graduated cylinders to the 25 ml. mark. Pour each into two clean colorimeter bottles. The temperature of the samples should be close to 75° F. for best accuracy.
2. Add to each colorimeter bottle 1.0 ml. of ammonium molybdate solution and swirl to mix.
3. Add 0.1 gram of StannaVer powder to one of the colorimeter bottles. Swirl to mix. If phosphate is present a blue color will develop.
4. Place the colorimeter bottle, to which StannaVer was not added, in the light cell. Insert the phosphate meter scale in the meter and use the 5330 color filter. Press the light switch, adjust the light control for a meter reading of zero ppm.
5. Place the prepared sample in the light cell, press the light switch and read the ppm. phosphate.

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