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A STUDY OF THE CHEMISTRY AND PLANKTON
OF LONG LAKE AND BEAVER BOG
AT THE UNIVERSITY OF NOTRE DAME
ENVIRONMENTAL RESEARCH CENTER

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INTRODUCTION

Water chemistry and plankton were sampled and analyzed from Long Lake and Beaver Bog at the University of Notre Dame Environmental Research Center in an effort to obtain some information regarding the nature and productivity of these bodies of water, and to offer some basis for comparison between them.

Water samples were taken from Long Lake on May 30, 1978 and from Beaver Bog on June 1, 1978. A portable oxygen-temperature probe was used to record these values at one meter intervals, and the thermocline was determined. One liter water samples were taken above and below the thermocline with a Kemmerer sampler. Hach kits were used to analyze these water samples for hydrogen sulfide, acidity, alkalinity, color, calcium and magnesium hardness, nitrate, phosphate, and specific conductance. Secchi disk readings were taken to record turbidity and pH measurements were done on a laboratory pH meter approximately half an hour after the samples were collected.

Horizontal two minute plankton tows were taken in the morning and at night on the same days as the water samples. Planktonic organisms were preserved in formalin and samples were observed and identified to species where possible with a light microscope. One strip of a Sedgwick-Rafter chamber

was counted and the approximate number of organisms present per milliliter of sample were counted.

Calibration factor

Total area of slide: 1000 mm²

length of slide: 50mm.

number of fields: 52.5

radius of field: $50/52.5/2 = .48$

area of field: $3.14(.48^2) = .712$ mm²

total area viewed: $.712(52.5) = 37.4$ mm²

multiplication factor: $1000/37.4 = 27$ (approximate)

Beaver Bog

Beaver Bog is small, oval, and fairly deep (at least 11m.).

A heavy sphagnum mat surrounds it on all sides. Other bog vegetation, including leatherleaf, tamarack, and Labrador tea is also evident. The Central Mud Minnow, Umbra limi is the only fish species present in the bog.

Long Lake

Long Lake is roughly dumbbell shaped with two basins reaching a maximum depth of about 14m. and a shallower area of about 4m. connecting them. There is a fairly deep mud bottom and no inlets or drainage areas are present. Vegetation extends to the lake edge and very few hardwood trees are present. Tamaracks, pines, and shrubs are predominant, and a small amount of sphagnum moss is present along sections of the lake's periphery.

WATER CHEMISTRY-BEAVER BOG
DATA

pH

Surface	4.2
5m	4.8

Acidity

Surface	140 mg/l.
5m	160 mg/l.

Alkalinity

Surface	0
5m	0

Color

Surface	350 color units
5m	455 cocor units

Calcium Hardness

Surface	10 mg/l.
5m	10 mg/l.

Magnesium Hardness

Surface	0
5m	10 mg/l.

Total Hardness

Surface	10 mg/l.
5m	20 mg/l.

Specific Conductance

Surface	25 micromhos/cm.
5m	22 micromhos/cm.

Nitrate

Surface	3.52 mg/l.
5m	8.58 mg/l.

Phosphate

Surface	0
5m	0

Secchi Disk

disappeared at 3m.

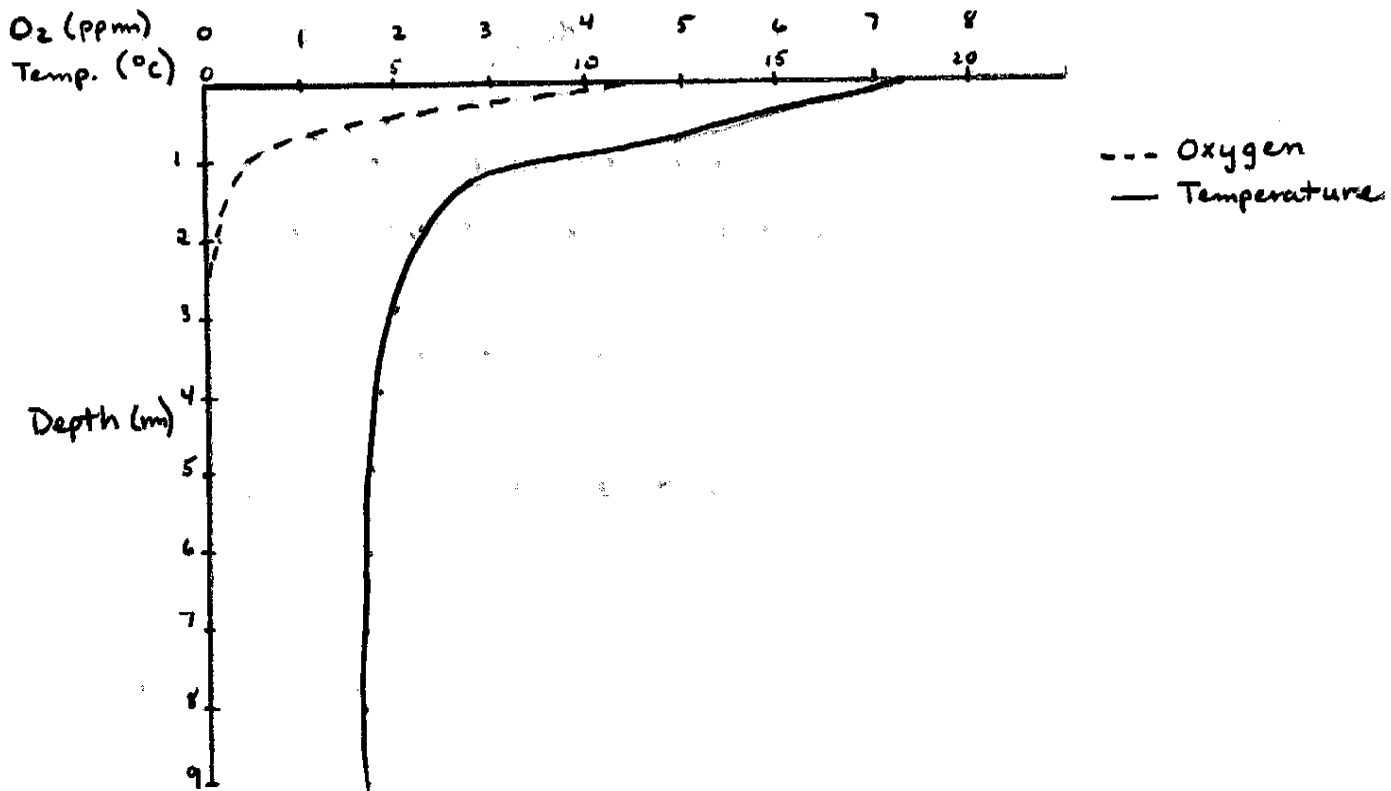
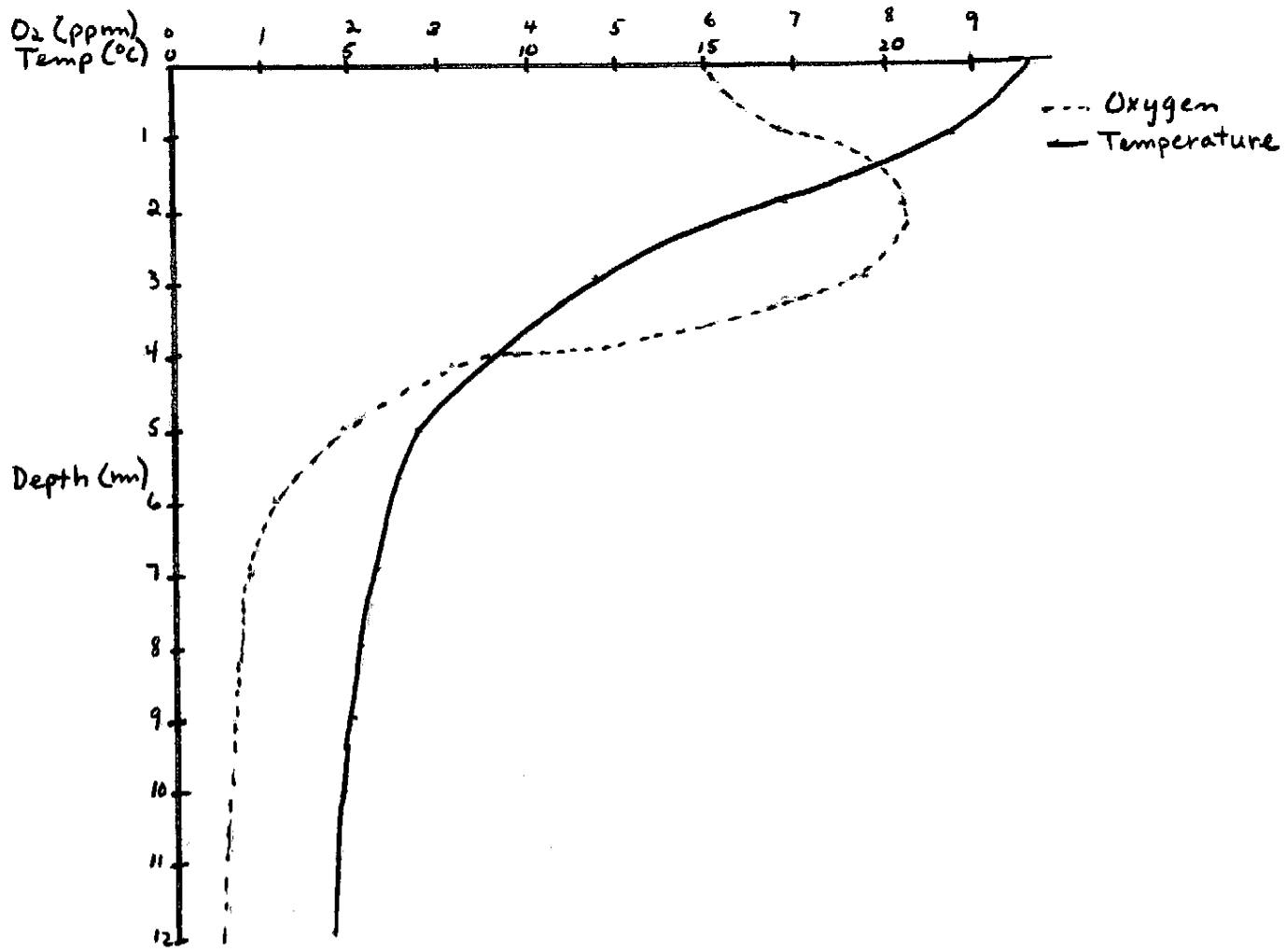
Hydrogen Sulfide

strongly present at 2m.

WATER CHEMISTRY-LONG LAKE
DATA

<u>pH</u>		
	1m	5.7
	7m	5.6
<u>Acidity</u>		
	1m	125 mg/1.
	7m	120 mg/1.
<u>Alkalinity</u>		
	1m	0
	7m	0
<u>Color</u>		
	1m	30 color units
	7m	45 color units
<u>Calcium Hardness</u>		
	1m	10 mg/1.
	7m	10 mg/1.
<u>Magnesium Hardness</u>		
	1m	0
	7m	5 mg/1.
<u>Total Hardness</u>		
	1m	10 mg/1.
	7m	15 mg/1.
<u>Specific Conductance</u>		
	1m	18 micromhos/cm.
	7m	18 micromhos/cm.
<u>Nitrate</u>		
	1m	3.96 mg/1.
	7m	4.4 mg/1.
<u>Phosphate</u>		
	1m	.05 mg/1.
	7m	.08 mg/1.
<u>Secchi Disk</u>		
	disappeared at 3m.	
<u>Hydrogen Sulfide</u>		
	.3 mg/1. at 9m.	

OXYGEN - TEMPERATURE PROFILE LONG LAKE



OXYGEN - TEMPERATURE PROFILE BEAVER BOG

are also possible. The fact that many of the chemical tests were not taken immediately after sampling must also be considered in an analysis of the data.

indication of sphagnum growth, it is possible to suggest that Long Lake is slowly in the process of becoming a bog, and that this body of water will turn more dystrophic with age.

The pH of both bodies of water were in the acid range, although that of Beaver Bog was more acidic. The fact that sphagnum moss accumulates sulfur^u from the atmosphere and releases it as sulfuric^u acid is probably partially accountable for the high^{Low} pH.

The high values obtained for acidity and the low alkalinity measurements indicate that these bodies of water have a very small buffering capacity. This low buffering capacity could allow for more fluctuations in pH, which might partially explain why the pH values obtained were low. The low buffering capacity is also consistent with the fact that the lakes in the area sampled were formed by glaciers, and were basically of granite rather than limestone or other material capable of dissolving in water. One study indicates that an alkalinity range between 100 and 120 mg/l. is the most beneficial for a diversity of aquatic organisms. (U.S. Dept. Agriculture Forest Service 1969). If this is the case, both Long Lake and Beaver Bog could provide an environment which was harsh or even unsuitable for a variety of aquatic species.

The fact that the values for calcium and magnesium hardness were so low are another indication of low alkalinity. These values also correlate with the composition of the basins. If the basins were limestone or another rock capable of leech-

ing, the hardness reading obtained would have been much higher.

Values obtained for specific conductance were also very low. Specific conductance estimates the amount of ionic material dissolved in the water, and thus indirectly the ability of the water to meet the requirements for certain physiological adaptations in aquatic organisms. One study showed that the greatest diversity of aquatic organisms could live in water with a specific conductance range of about 150-500 micromhos/cm. ^(Ellis, 1944) The fact that the values obtained were so much lower than these are another indication that the bodies of water examined are probably not in a eutrophic state.

Positive nitrate tests were obtained in both Long Lake and Beaver Bog. Average nitrate figures for most lakes appear to be well over 1mg/l. (Reid and Wood 1976). By these standards, the values obtained appear to be high or at least average. High values might be due to the release of nitrogen during the decomposition of organic material. It is probable that nitrogen is not a limiting factor in the bodies of water studied.

The phosphate values obtained in this study for Beaver Bog were too low to be recorded. One study indicated that concentrations below .05 mg/l. could decrease fish productivity. (Moyle 1949). The concentrations found in Long Lake were somewhat above this range, however; it is still probable that phosphorus is a limiting factor in both bodies of water.

There appears to be a fairly large difference in tur-

idity and color unit readings between Long Lake and Beaver Bog. Much of this is probably due to the large amount of allochthonous organic material from the sphagnum mat, which enters the water of Beaver Bog and decomposes.

Although the sources of error present in this investigation must be considered, it is still possible to suggest several trends apparent in the water chemistry data. On the basis of water chemistry, Beaver Bog appears to fit the necessary criteria for a true bog. Judging from a comparison of such measurements as alkalinity, pH, hardness, acidity, and oxygen-temperature profile, it is reasonable to project that the ecological succession in Long Lake will someday lead to bog formation.

An area which is predominantly of limestone or possesses another available mineral resource would be more alkaline and have a greater buffering capacity. Such a lake would have a much greater tendency to become eutrophic with possible ecological succession to marsh formation. However, the fact that Long Lake appears fairly low in several chemical variables and is located in an area of granite glacial rock basins, suggests a former oligotrophic state which is now in a period of transition.

DATA- PLANKTON
BEAVER BOG A.M.

A. PHYTOPLANKTON

<u>Species</u>	<u>Number (per ml.)</u>
<u>Dinobryon sertularia</u> (39/colony)	7960
<u>Mougeotia</u> sp.	1998
<u>Caelosphaerium</u> sp.	432
<u>Microcystis aeruginosa</u>	297
<u>Anabaena</u> sp.	297
<u>Synura</u> sp.	189
<u>Tabellaria</u> sp.	162
<u>Navicula</u> (species 1)	135
<u>Aphanocapsa</u> sp.	135
unid. filamentous blue green	81
<u>Bambusina</u> sp.	81
<u>Desmidium</u> (species 1)	54
<u>Chryso-sphaerella longispina</u>	27
<u>Diatoma</u> (species 1)	27
<u>Diatoma</u> (species 2)	27
<u>Desmidium</u> (species 2)	27
<u>Navicula</u> (species 2)	27
<u>Ceratium</u> sp.	27
<u>Terpsinoe</u> sp.	27
<u>Asterionella</u> sp.	
<u>Xanthidium</u> sp.	
<u>Staurastrum</u> sp.	
<u>Oedogonium</u> sp.	
Total	11610

B. ZOOPLANKTON

<u>Species</u>	<u>Number (per ml.)</u>
<u>Keratella cochlearis</u>	7047
<u>Bosmina coregoni</u>	3213
unid. rotifer	540
<u>Asplanchna</u> sp.	297
nauplius larvae	162
<u>Keratella quadrata</u>	108
<u>Polyarthra</u> sp.	
unid. cyclopoid copepods	
Total	11259

Approxomate ratio Phytoplankton/Zooplankton 1:1

BEAVER BOG P.M.

A. PHYTOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Dinobryon sertularia</u> (35/colony)	5562
<u>Mougeotia</u> sp.	1809
<u>Microcystis aeruginosa</u>	405
<u>Tabellaria</u> sp.	243
<u>Synura</u> sp.	135
<u>Anabaena</u> sp.	108
unid. colonial blue green	81
unid. filamentous blue green	54
<u>Bambusina</u> sp. (45 in chain)	27
<u>Aphanocapsa</u> sp.	27
<u>Frustulla</u> sp.	27
<u>Diatoma</u> (species 1)	
<u>Synedra</u> sp.	
<u>Chrysophaerella longispina</u>	
<u>Rhizoclonium</u> sp.	
<u>Staurastrum</u> sp.	
Total	8478

B. ZOOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Keratella cochlearis</u>	10854
<u>Bosmina coregoni</u>	5076
nauplius larvae	432
unid. rotifer	189
<u>Keratella quadrata</u>	81
cyclopoid copepod (species 1)	81
<u>Chaoborus</u> sp.	81
<u>Asplanchna</u> sp.	54
cyclopoid copepod (species 2)	27
Total	16875

Approxomate ratio Phytoplankton/Zooplankton .5:1

LONG LAKE A.M. (NANCY NOUSEK)

A. PHYTOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Dinobryon sertularia</u> (31/colony)	4320
<u>Aphanocapsa</u> sp.	486
<u>Microcystis aeruginosa</u>	216
<u>Dinobryon bavarium</u>	162
<u>Coelosphaerium</u>	135
<u>Synura</u> sp.	135
<u>Anabaena</u> sp.	108
<u>Volvox</u> sp.	54
<u>Botryococcus</u> sp.	54
<u>Anabaena</u> sp.	27
<u>Melosira</u> sp.	27
<u>Merismopedia elegans</u>	27
<u>Eudorina</u> sp.	
<u>Staurastrum</u> sp.	
<u>Stentor</u> sp.	
<u>Diatoma</u> sp.	
<u>Tabellaria</u> sp.	
colonial <u>Vorticella</u>	
Total	5724

B. ZOOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Anabaena rotifers</u>	594
<u>Keratella cochlearis</u>	135
<u>Daphnia pulex</u>	135
<u>Daphnia longispina</u>	54
<u>Bosmina coregoni</u>	27
<u>Keratella quadrata</u>	27
nauplius larvae	27
<u>Cyclops</u> sp.	27
<u>Philodina</u> sp.	
Total	1080

Approxomate ratio Phytoplankton/Zooplankton 5:3

LONG LAKE P.M. (NANCY NOUSEK)

A. PHYTOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Dinobryon sertularia</u>	2673
<u>Microcystis aeruginosa</u>	297
<u>Synura sp.</u>	270
<u>Anabaena sp.</u>	162
<u>Dinobryon bavarium</u>	135
<u>Aphanocapsa sp.</u>	108
unid. blue green	108
<u>Synedra sp.</u>	54
<u>Asterionella sp.</u>	27
<u>Chrysosphaerella longispina</u>	27
<u>Staurastrum sp.</u>	27
<u>Melosira sp.</u>	27
<u>Volvox sp.</u>	27
<u>Tabellaria sp.</u>	27
<u>Botryococcus sp.</u>	27
Total	3996

B. ZOOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
Anabaena rotifers	540
<u>Keratella cochlearis</u>	513
<u>Asplanchna sp.</u>	108
unid. rotifers	108
<u>Daphnia longispina</u>	54
<u>Cyclops bicuspidatus</u>	27
<u>Keratella quadrata</u>	27
<u>Daphnia pulex</u>	27
<u>Polyarthra sp.</u>	
<u>Philodina sp.</u>	
nauplius larvae	
Total	1404

Approximate ratio Phytoplankton/Zooplankton 2.8:1

LONG LAKE A.M. (BOB KERBY)

A. PHYTOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Dinobryon sertularia</u> (37/colony)	3321
<u>Dinobryon bavarium</u>	918
<u>Aphanocapsa sp.</u>	297
<u>Anabaena sp.</u>	297
<u>Volvox globator</u>	135
<u>Mougeotia sp.</u>	108
<u>Chrysosphaerella longispina</u>	27
Total	5130

B. ZOOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
Anabaena rotifers	432
<u>Keratella cochlearis</u>	351
unid. Cladoceran	135
unid. rotifer	135
<u>Daphnia pulex</u>	27
<u>Keratella quadrata</u>	27
<u>Asplanchna sp.</u>	27
<u>Polyarthra sp.</u>	27
Total	1161

Approximate ratio Phytoplankton/Zooplankton 4.4:1

LONG LAKE P.M. (BOB KERBY)

A. PHYTOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Dinobryon sertularia</u> (37/colony)	3051
<u>Dinobryon bavarium</u>	891
<u>Merismopedia sp.</u>	864
<u>Anabaena sp.</u>	243
<u>Tabellaria sp.</u>	108
<u>Asterionella sp.</u>	81
<u>Aphanocapsa sp.</u>	54
<u>Ankistrodesmus sp.</u>	27
<u>Staurastrum sp.</u>	27
<u>Volvox tertius</u>	27
<u>Launularia socialis</u>	27
Total	5400

B. ZOOPLANKTON

<u>Species</u>	<u>Number</u> (per ml.)
<u>Keratella cochlearis</u>	297
unid. rotifer	135
Anabaena rotifers	54
unid. Cladoceran	27
<u>Daphnia pulex</u>	27
<u>Kellicottia longispinia</u>	27
<u>Polyarthra sp.</u>	27
Total	594

Approximate ratio Phytoplankton/Zooplankton 9:1

PLANKTON RESULTS

Beaver Bog: The A.M. plankton sample showed 23 species of phytoplankton present with two very dominant species. Zooplankton showed 8 species, also with two dominant. In the P.M. sample, 16 species of phytoplankton were observed with two dominant, and nine species of zooplankton, with two dominant. The total A.M. count was 22,869 and the total P.M. count 25,353,

Long Lake: Two counts were done on Long Lake by different individuals for the sake of comparison. The first A.M. count showed 17 species of phytoplankton with one dominant, while the second count showed 8 species with one dominant. Zooplankton of Count 1 were of 11 species (one dominant) and in Count 2, 8 species (two dominant). In the P.M. sample, Count 1 showed 14 species of phytoplankton (one dominant) and 11 species of zooplankton (2 dominant). Count 2 showed 11 species of phytoplankton (one dominant) and 7 species of zooplankton (one dominant). In survey one, the total A.M. count was 6804 and the P.M. was 5400. Survey two showed an A.M. count of 6291 and a P.M. count of 5994.

Sources of Error

As a rough comparison between the two sets of data obtained from Long Lake indicate through their discrepancies, there is a significant margin of personal error present in the identification and counting of the plankton samples. However, the data is fairly similar in relation to major species present

in the samples, so some conclusions are able to be suggested.
Error might also have occurred in dilution and random sampling
of plankton.

DISCUSSION

Beaver Bog showed a great diversity in planktonic species and a much higher ratio of zooplankton to phytoplankton than Long Lake. A few species of desmids were present, although they were not dominant. Beaver Bog also appeared to have a much greater number of total planktonic organisms than Long Lake, although some of this variation could be due to errors in sampling and dilution.

Chemical analysis showed that Beaver Bog is acidic with soft water and low in such nutrients as phosphates. However, it is high in color and turbidity, possibly because of the organic input from the sphagnum mat.

Although the chemical conditions of Beaver Bog might provide a harsh or even detrimental environment for some planktonic organisms, this body of water still appears able to meet the requirements for many organisms. Some organisms, such as desmids, are often found in sphagnum bogs with soft water conditions. Hasler (1961) has indicated in one study that blue green algae appear to possess lower requirements for phosphates and calcium than other algal species. Therefore, some of these species could also be successful in the sampled conditions.

It is possible to suggest from the data observed in Beaver Bog that even though chemical conditions might be unfit for some larger aquatic species, several planktonic

species are capable of surviving there. If larger aquatic organisms were selected against in these bog conditions, a lack of predation might partially account for the large numbers of plankton present in the survey.

Bosmina sp. rather than Daphnia sp. appeared to be the predominant Cladoceran in Beaver Bog. This could be due to the fact that Daphnia sp. are selected against by the bog's mud minnow population because of their larger size.

Both Beaver Bog and Long Lake show a predominance of Dinobryon sertularia and Keratella cochlearis. It is possible that these species of plankton had reached an annual peak at the time the survey was taken.

The number of zooplankton counted in relation to the number of phytoplankton counted appeared larger in the night counts in the Beaver Bog sample and in one of the Long Lake tallies. In the Beaver Bog sample it was also noted that a larger number of nauplius larvae were present in the P.M. sample and that nearly half of the Bosmina coregoni counted were in the juvenile stage. Several Chaoborus sp. larvae were also observed in the P.M. sample from Beaver Bog. These results suggest that Beaver Bog and probably also Long Lake have a diurnal migration of plankton. It is possible that zooplankton forms, including the juveniles, are more active and rise to the surface at night as a defense against predation. Phytoplankton migration could also be occurring with the appearance and disappearance of the sun.

Fewer numbers of plankton were counted in Long Lake than

in Beaver Bog. Although chemical conditions might be less severe in Long Lake, there are smaller amounts of organic materials in the water which might be a factor contributing to plankton numbers. It is very possible that there is a greater amount of predation in LongLake if a larger number of plankton eating species are able to survive there.

Many of the planktonic species observed were fairly common in both Long Lake and Beaver Bog. It appears that water chemistry factors and physical conditions are similar enough in these two bodies of water to support many of the same species of plankton, even though the relative numbers of these plankton might differ. On the basis of plankton, both Long Lake and Beaver Bog appear fairly productive in numbers and species.

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