

1979

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A COMPARATIVE STUDY OF RASPBERRY AND TENDERFOOT LAKES

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The purpose of this study was to develop a general idea of the productive and destructive processes involved in the energy flow of northern glacial lakes. The lakes selected were of different stages of lake development, so as to construct a contrasting view of energy flow. If we are to preserve and restore ^{are} valuable inland water resources, then we must understand the energy flow of these lakes and all the factors that contribute or disrupt this delicate balance of energy flow. Two of the major factors which can supply valuable information about the fauna and natural balance of a lake are the chemistry of the water and the plankton types which inhabit the lake. In this study of the chemistry of the water of these lakes, we explored many aspects of the water including: temperature, pH, acidity, alkalinity, color, light penetration, specific conductance, hardness, presence of hydrogen sulfide, phosphate content, and nitrate content.

Stratification of a lake is very important in determining what organisms can survive in the lake, and thus the state of the lake. Temperature is an indicator of the density of water at different depths. The density of the water is a very vital part of an organism life within that water. A temperature profile curve portrays this stratification and can provide vital information about the lake being studied. The temperature profile was made with an O₂/temperature meter.

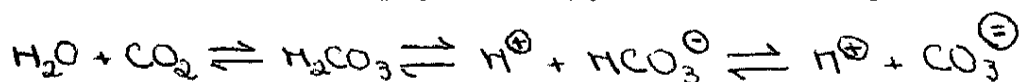
A temperature curve can also provide vital information about pH, gas solubility, and metabolism in the lake.

The pH of a sample of water is an important measure, it indicates the water sample's tendency to accept or donate hydrogen ions.¹ The pH values of this study were measured by standard electrometric pH procedure. The pH value represents the instantaneous hydrogen activity rather than the buffering capacity or the total reserve as in acidity and alkalinity tests. The pH is significant because many aquatic plants and animals have optimal hydrogen ion concentration levels on which their survival may be based. Thus, if the hydrogen ion concentration of a lake changes, then so will its natural fauna and energy flowage. However, pH only measures one type of proton donors, the strong acids that are highly or completely ionized. To obtain a full measure of both proton donor types, the completely ionized and the undissociated types in the presence of the highly ionized types a total acidity test must be performed. The total acidity includes both the free protons that cause the ambient pH and the bound protons.² The acidity was determined by NaOH titration past the phenolphthalein end point to pH 9.0. Associated closely with both pH and acidity is alkalinity. Alkalinity refers to the capability of a water sample to neutralize

¹Cole, Gerald A., Textbook of Limnology, St. Louis, The C.V. Mosby Company, 1979. Page 271

²Cole, Page 275.

acids. In natural waters alkalinity most commonly occurs when carbonates, bicarbonates, and hydroxides of calcium, magnesium, and sodium metals are present. Alkalinity was determined by direct titration of the water sample with sulfuric acid in the presence of suitable indicator. At the complete neutralization of alkalinity the indicator changed color. An equation which shows the close correlation between pH, acidity, and alkalinity is:



This equation is very important in drawing conclusions from chemical water data.

In this study, two types of color tests were performed on the water samples. One of these color test evaluated the apparent color, which is the result of many factors, the most important being both living and non-living particulate matter. This test can sometimes give indications of the different phytoplankton and zooplankton populations. True color was also measured. True color results were obtained by filtering out the entities that contribute to apparent color. This test can give some insight into the dissolved organic materials that a lake may contain. Related to the color of the water is the light penetration. Light penetration values can be obtained by analyzing the Secchi disc readings. From this data, information about the euphotic zone and the depths to which pondweeds and other macrophytes extend can be determined.³ It is also some value in determining what types

³Cole, Page 171.

of phyto- and zooplankton might be found in the lake, and at what depths they might be found.

Total dissolved solids or filterable residue is a measure of solids in the water sample which includes the salts and organic residue. In 1951, Rawson showed a positive correlation between total dissolved solids and lake productivity. However, total dissolved solids are very inconvenient to measure. A shortcut in analyzing for TDS is testing for specific conductance.⁴ A conductivity meter tests the flow of electrons through the water sample. The electron flow, thus the conductivity, is heightened in the presence of electrolytes. In 1966, Williams showed there was an excellent correlation between TDS and conductance. However, when correlating conductance and productivity one must be careful and not misinterpret the data. Thus, other productivity conclusion should be given priority over the conductance productivity implications.

In the chemical survey of the lakes a water hardness test was performed. Calcium and magnesium ions are the principal causes of hardness in natural waters, though iron, aluminum, manganese, strontium, zinc, and hydrogen ions are capable of producing the same effect. High concentrations of H^+ are not commonly found in natural waters and total hardness of water is defined as the amount of calcium and magnesium

⁴Cole, Page 301.

present, expressed as mg/l calcium carbonate (CaCO_3).⁵ Total hardness was determined by titration with ethylenediamine-tetraacetic acid. A second titration was performed on the sample that was treated with strong KOH, which precipitated $\text{Mg}(\text{OH})_2$. The result yielded calcium hardness. The difference between total and calcium hardness is magnesium hardness.

The presence of hydrogen sulfide in the hypolimnion can signify whether or not a certain lake has been having spring or fall turnovers. This can be helpful in determining the status of the lake. Hydrogen sulfide is a very soluble gas which results from decaying protein releasers. One of the methods used in this study for testing for hydrogen sulfide was not scientific, but it was effective. The presence was determined positive, if the water sample had a rotten egg odor. This was more effective than a regular test in some cases, because the water sample may give off the H_2S rotten egg odor while little or no sulfate can be detected for the reason that it has been chemically reduced.

Interest in phosphorus stems from its major role in biological metabolism, and the relatively small amounts of phosphorus in the hydrosphere. Phosphorus is absolutely necessary to all life, it functions in the storage and transfer of a cell's energy and in genetic systems. The universality of adenosine triphosphate as an energy carrier and the presence of phosphate groups in nucleotides shows living

⁵Cole, Page 328.

organisms great need for phosphorus. In comparison to the rich natural supply of other major nutritional and structural components of the biota--carbon, hydrogen, nitrogen, oxygen, sulfur--phosphorus is least abundant, and most commonly limits biological productivity. Thus, the rates of biological productivity of a great number of lakes are governed to a large extent by the rate of phosphorus cycling.⁶ Recently, input loading of phosphorus from external sources have cause a concern about too much phosphorus. With the rapid cycling of phosphorus, most of which is within the particulate phase of living biota, algae blooms can take place. This can deplete the nutrients within the lake, thus causing lower future primary production, and therefore lower fish yield. In this study, we tested for total phosphate content, because with the speed with which phosphorus is whisked back and forth between the abiotic and biotic worlds, it was concluded that this was the best way for quantifying the phosphorus in a body of water. The total phosphorus content of unfilter water consists of phosphorus in suspension, in particulate matter, and phosphorus in dissolved form.⁷

Nitrogen, although absolutely necessary for life, does not command the attention that phosphorus does, because nitrogen is more abundant and has more sources for living

⁶Wetzel, Robert G., Limnology, Philadelphia, W.B. Saunders Company, 1975. Page 215.

⁷Cole, Page 348.

organisms. The major source of nitrogen of the biosphere originates from fixation of atmospheric molecular nitrogen. The nitrogen cycle is a biochemical process in which the concentration of molecular nitrogen occurs by nitrogen fixation, assimilation, and denitrification in which nitrate is reduced to N_2 . Nitrate represents the most completely oxidized state of nitrogen commonly found in water. Nitrate-forming bacteria convert nitrites into nitrates under aerobic conditions and lightning converts large amounts of atmospheric nitrogen directly to nitrates. For all practical purposes the nitrogen cycle of lakes is microbial in nature, bacterial oxidation and reduction of nitrogen compounds are coupled with photosynthetic assimilation and utilization by algae and larger aquatic plants.⁸ If nitrate concentrations become too great the water quality will be degraded by excessive amounts of algae growth.

In this study of water chemistry, it must be noted that even though each test has some importance, the major significance of these tests can only be realized by analyzing them as a whole or with some regard to one another. For example, although phosphorus content and nitrogen content have some indicative value, many other factors such as the ratio of nitrogen to phosphorus, the pH, and the temperature must also be considered, if a full realistic view of the lake is to be obtained. Also, it should be noted

⁸Wetzel, Page 186.

that the water samples were taken at appropriate sites in the lake from row boats. A water sampling technique was used so that an epilimnion and hypolimnion sample could be taken, and the depth at which the sample was taken recorded. The pH was taken while out on the lake, so to avoid contamination of the water sample. However, at some sites the pH had to be taken at the lab, because of equipment problems. It should also be noted that the procedures followed for the acidity, alkalinity, color, specific conductance, hardness, presence of hydrogen sulfide, phosphate content, and nitrate content tests were performed by using a Hach Water Chemistry kit.

Plankton is a general term used for drifting organisms. These organisms drift about either because they are nonmotile or because they are too small or too weak to swim effectively against a current. Thus, plankton is distinguished from the nekton, which is composed of strong swimming animals, and the benthos, which includes sessile, creeping, and burrowing organisms at the bottom of the lake. Plankton are usually divided into two groups the phytoplankton, plant-like, and the zooplankton, animal-like. This is not a clear distinction though, because many planktonic organisms are neither clearly plant nor animal but are better described as protists.⁹ Plankton can also be classified into groups by using size as the characteristic feature. Macroplankton are larger than 500 μm ; microplankton are from 50 to 500 μm ; nanoplankton

⁹Grey, Peter, The Encyclopedia of the Biological Sciences, New York, Reinhold Publishing Corporation, 1961. Page 779.

are from 10 to 50 μm or capable of passing through a net made of No. 20 bolting cloth; ultraplankton are from 0.5 to 10 μm .¹⁰

Fresh-water phytoplankton, usually rich in green algae, also includes diatoms, blue-green algae, and true flagellates, are the primary producers in a lake. The productivity of an area is dependent upon the availability of nutrients and water stability conditions. Most of the phytoplankton serves as food for zooplankton, but some of it is carried below the light zone. After death, this phytoplankton undergoes chemical mineralization, bacterial breakdown, or transformation into sediments. Phytoplankton production usually is greatest from five to ten meters below the surface of the water.¹¹ Too high light intensity and the lack of nutrients in the upper regions may be causes for the sub-optimal photosynthesis.

The zooplankton is divided into two groups: Temporary plankton consists of planktonic eggs and larvae of members of the benthos and nekton; permanent plankton includes all animals that live their complete life cycles in a floating state. There is a pronounced tendency for zooplankton to perform diurnal vertical migrations in lakes. Generally, the animals ascend toward the surface at sunset from daytime depths. At midnight, if there is no optical stimulus, the moon,

¹⁰Greene, Richard W., "Some Definitions Relating to Freshwater Biota"; Notes from Aquatic Biology Practicum, University of Notre Dame, 1979.

¹¹Grey, Page 780.

some of the animals return to the daytime depths, then approach the surface once again just before dawn. As the sun arises, all descend to their daytime level.¹² The zooplankton are the primary consumers, and are used directly as food by fish.

Both the phyto- and zooplankton can act as indicator species to reveal the state of the lake. For example, Williams generalized that a eutrophic lake would have different groups of diatoms, a mixed crop of blue-green algae, filamentous diatoms, and Fragilaria. Whereas, a oligotrophic lake would have desmids, the Chrysophyte Dinobryon, and diatoms Tabellaria and Cyclotella. In this study, two different techniques were used to collect the plankton. One sample was taken at each level a water sample was taken. The other sample was taken by towing a standard plankton net or a Wisconsin net. These tows were done twice on Raspberry Lake, during the day and at night. On Tenderfoot Lake only a day tow was taken. The samples were preserved on the same day they were taken. The analysis of the samples were performed at a later date.

Raspberry Lake is located in the southern part of the Upper Peninsula of Michigan. It is a kettle lake which was left behind when the glaciers receded. Raspberry Lake is a drainage lake which has its outflow of water through the

¹²Grey, Page 781.

ground. The water flows from Raspberry Lake and joins the Peter and Paul Lakes drainage, which then drains into the Cisco chain. Raspberry Lake has a rich supply of fish; both largemouth and smallmouth bass (Micropterus salmoides and Micropterus dolomieu) are found here as well as blue gill (Lepomis macrochirus). The lake is surrounded by a bog mat with hardwoods farther from the lakes edge. The main component of the bog mat is Sphagnum, also found in the mat are leather leaf (Andromeda glaucophylla), sundew (Drosera rotundifolia), pitcher plants (Sarracenia purpurea), bladderwort (Utricularia), and tamaracks (Larix). The terrain surrounding the lake is small rolling hills and there is a slight slope toward the lake. The lake is small with a surface area of only 2.9 hectares.

Raspberry Lake

Data:

Temperature Profile

| | |
|----------|--------|
| Air | 15.2°C |
| Surface | 16.5°C |
| 1 meter | 16.5°C |
| 2 meters | 16.5°C |
| 3 meters | 12.2°C |
| 4 meters | 8.6°C |
| 5 meters | 7.5°C |
| 6 meters | 7.0°C |
| 7 meters | 6.8°C |

pH 5.7

| Test | 2 meters | Depth | 6 meters |
|------------|------------------|-------|------------------|
| Acidity | 133 ppm | | 140 ppm |
| Alkalinity | less than 10 ppm | | less than 10 ppm |

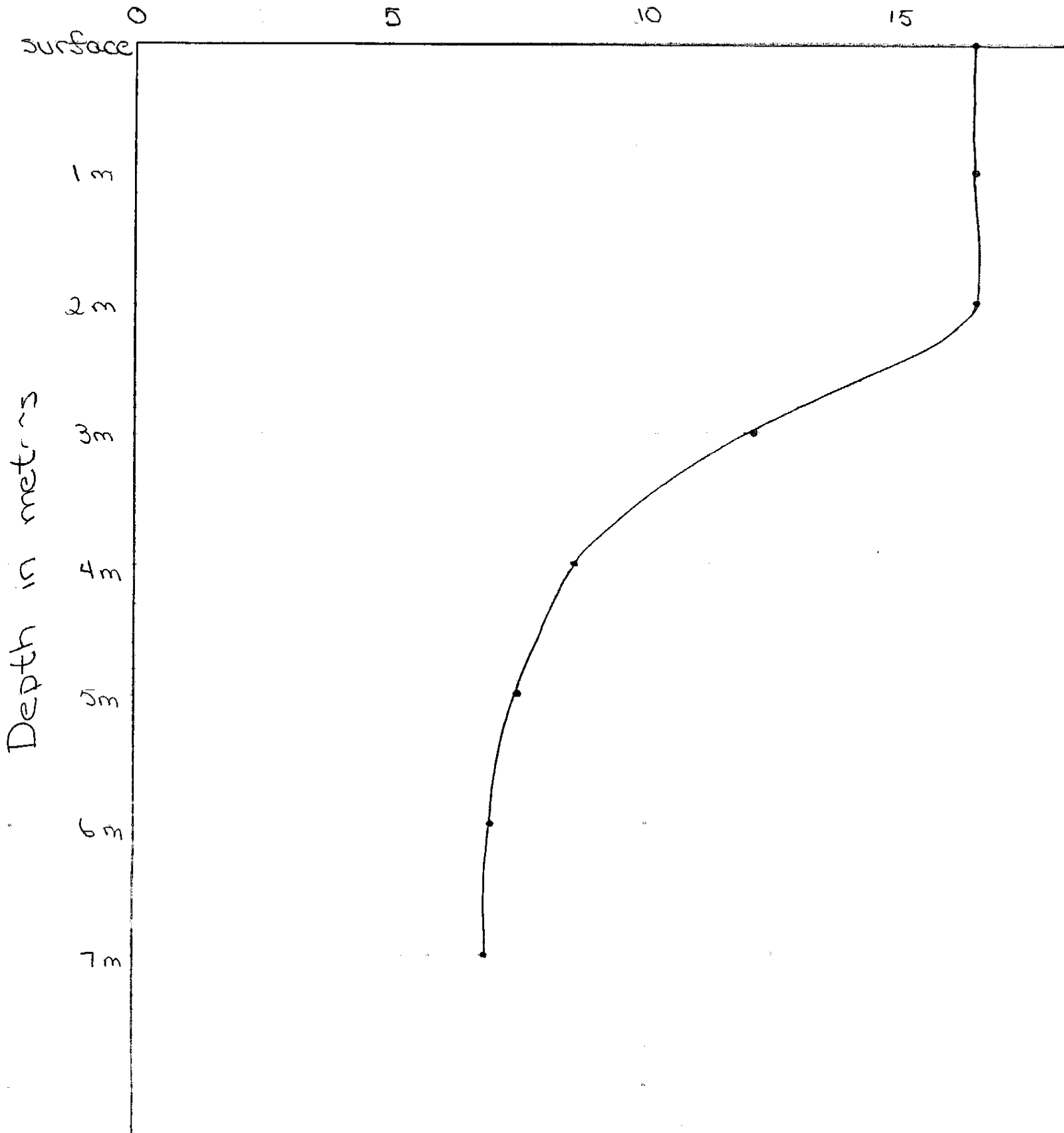
| Test | 2 meters | Depth | 6 meters |
|----------------------|----------------------------|--|----------------------------|
| Color | | | |
| Apparent | 45 units | | 50 units |
| True | 15 units | | 20 units |
| Specific Conductance | 21 μ hos/cm Range 3 | | 20 μ hos/cm Range 3 |
| Hardness | | | |
| Ca ⁺⁺ | 5.0 ppm | | 5.0 ppm |
| Mg ⁺⁺ | 2.5 ppm | | 2.5 ppm |
| Total | 7.5 ppm | | 7.5 ppm |
| Phosphate | 0.27 ppm | | 0.31 ppm |
| Nitrate | 0.50 ppm | | 0.47 ppm |
| Hydrogen Sulfide | absent | | absent |
| N/P ratio | 1.8 | | 1.5 |
| Secchi disc | 1.7 m | Day: overcast & raining wind 10-15 mph waves small | |

Discussion: From the water chemistry data, I concluded that Raspberry Lake is between a eutrophic and a dystrophic lake stage. The dystrophic lake stage is supported by the surrounding bog mat. The sphagnum combined with the SO₂ in the atmosphere account for the high acidity. Also, since the lake has a low alkalinity, thus low buffering power; this could account for the low and dropping pH. In 1975, the pH was 6.4; now it is 5.7. Thus, there is probably a high amount of SO₂ being brought into the lake. The low Ca⁺⁺ and total hardness also agree with the pH and alkalinity findings. The eutrophic lake stage is supported by the nitrate concentrations. The phosphates are very high suggesting an

Vertical temperature profile of Raspberry Lake

Date: 6-5-79

Temperature
°C



external input. The lake seems to show a spring overturn, because of the lack of H_2S . However, from the rest of the data and previous history, this lake is probably oligomictic and heading toward a bog amixis. The lake was stratified with a rather large thermocline. The epilimnion and hypolimnion seem to be about the same size, which slightly supports the eutrophic hypothesis.

PHYTOPLANKTON

Blue-Green Algae

- ① Anabaena
- ② Anacystis
- ③ Merismopedia
- ④ Oscillatoria

Desmid

- ⑤ Arthrodesmus
- ⑥ Micrasterias

Diatoms

- ⑦ Melosira
- ⑧ Navicula
- ⑨ Tabellaria

Green Algae

- ⑩ Tribonema
- ⑪ Volvox

ZOOPLANKTON

Amphipoda

- ⑫ Hyalella

Chironomidae

Genus A

Cladocera

- ⑬ Bosmina
- ⑭ Daphnia

Copepoda

- ⑮ Cyclops

Rotifer

- ⑯ Asplanchna
- ⑰ Keratella cochlearis
- ⑱ Kellicottia longispina
- ⑲ Rotaria
- ⑳ Trichocera

The diatoms and blue-green algae were the most abundant phytoplankton. The rich supply of phytoplankton seems to contradict the dystrophy hypothesis. The eutrophic lake stage hypothesis though is supported by the diatoms and blue-green algae found. The rich supply of blue-green

algae also coincides with the high phosphorus levels. Since phosphorus is the limiting factor for blue-green algae; as they are able to fix nitrogen from the atmosphere.

The two most abundant zooplankton were the Cladocera Daphnia and the Rotifer Asplanchna. The finding of a Chironomidae is also support for the eutrophic lake stage. It should also be noted that the nighttime tow had a much greater volume of zooplankton than the daytime tow.

Tenderfoot Lake is located in the southern part of the Upper Peninsula of Michigan near the Wisconsin border. It is a very large lake with a surface area of 181.9 hectares. The lake has five small type bays and several islands. Tenderfoot Lake is a drainage lake, which has inflow and outflow through established streams. The water flows from Palmer Lake via the Ontagon River into Tenderfoot Lake, and drains through Tenderfoot Creek. There are many large weed beds through the lake, and surrounding shore. Within these beds can be found water milfoil (Myriophyllum), waterweed (Elodea), cattail (Typha), duckweed (Lemna minor), and fragrant waterlily (Nymphaea odorata). The shore line is surrounded by a mixture of conifers, hardwoods, and pines. The lake has a rich fish fauna, which include muskellunge (Esox masquinongy), Northern Pike (Esox lucius), walleye (Stizostedion vitreum), yellow perch (Perca flavescens), Crappie (Pomoxis), sunfish (Enneacanthus), Rock bass

(Ambloplites rupestris), largemouth bass (Micropterus salmoides), and smallmouth bass (Micropterus dolomieu). The terrain around the lake is variable; on the northern and eastern shores the terrain is rather hilly, whereas on the southern and western shores it is more plain-like.

Tenderfoot Lake

Data:

Temperature Profile

| | |
|----------|--------|
| Air | 19.0°C |
| Surface | 17.9°C |
| 1 meter | 17.8°C |
| 2 meters | 17.0°C |
| 3 meters | 16.0°C |
| 4 meters | 15.2°C |
| 5 meters | 13.5°C |
| 6 meters | 12.0°C |
| 7 meters | 11.5°C |
| 8 meters | 11.0°C |
| 9 meters | 10.5°C |

pH 6.0

| Test | Depth | Depth |
|------------|---------|---------|
| Acidity | 1 m | 5 m |
| Site 1 | 85 ppm | 105 ppm |
| | 1 m | 7 m |
| Site 2 | 80 ppm | 125 ppm |
| | 1 m | 7 m |
| Site 3 | 90 ppm | 85 ppm |
| | 2.5 m | |
| Site 4 | 87 ppm | |
| | 3 m | |
| Site 5 | 96 ppm | |
| | Surface | 7 m |
| Site 6 | 86 ppm | 87 ppm |
| Alkalinity | 1 m | 5 m |
| Site 1 | 40 ppm | 40 ppm |
| | 1 m | 7 m |
| Site 2 | 50 ppm | 45 ppm |
| | 1 m | 7 m |
| Site 3 | 40 ppm | 40 ppm |
| | 2.5 m | |
| Site 4 | 37 ppm | |

Vertical temperature profile of

Tenderfoot Lake

Date: 6-8-79

Temperature °C

surface

5

10

15

1m

2m

3m

4m

5m

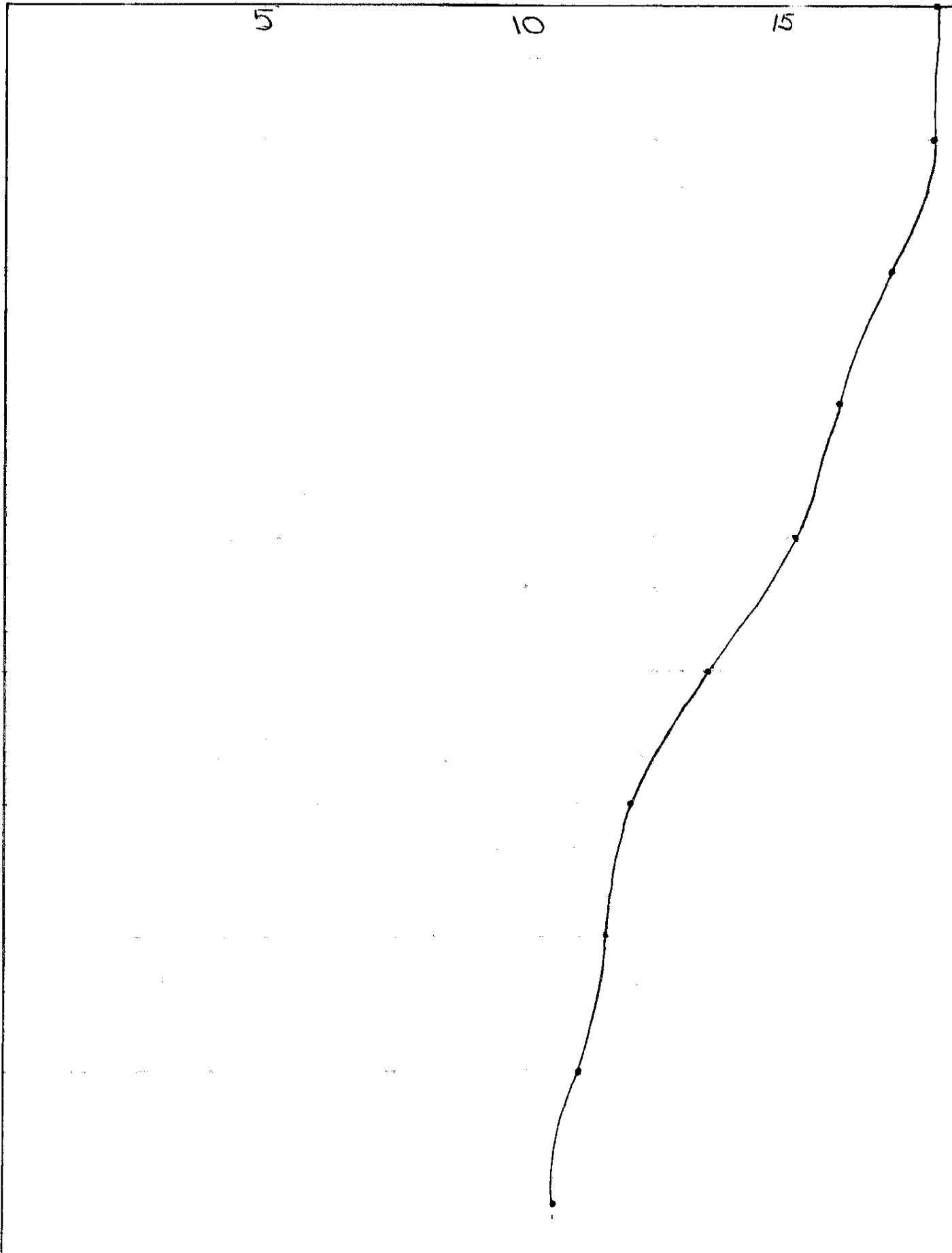
6m

7m

8m

9m

Depth in meters



| Test | Depth | |
|----------------------|-------------------|------------------|
| Alkalinity | 3 m | |
| Site 5 | 33 ppm | |
| | Surface | 7 m |
| Site 6 | 32 ppm | 29 ppm |
| Color | | |
| Site 1 | 1 m | 5 m |
| Apparent | 57 units | 67 units |
| True | 50 units | 53 units |
| Site 2 | 1 m | 7 m |
| Apparent | 47 units | 65 units |
| True | 25 units | 50 units |
| Site 3 | 1 m | 7 m |
| Apparent | 50 units | 73 units |
| True | 40 units | 47 units |
| Site 4 | 2.5 m | |
| Apparent | 50 units | |
| True | 45 units | |
| Site 5 | 3 m | |
| Apparent | 50 units | |
| True | 45 units | |
| Site 6 | Surface | 7 m |
| Apparent | 60 units | 50 units |
| True | 45 units | 45 units |
| Specific Conductance | | |
| Site 1 | 1 m | 5 m |
| | 100 μ mhos/cm | 85 μ mhos/cm |
| Site 2 | 1 m | 7 m |
| | 85 μ mhos/cm | 85 μ mhos/cm |
| Site 3 | 1 m | 7 m |
| | 85 μ mhos/cm | 82 μ mhos/cm |
| Site 4 | 2.5 m | |
| | 85 μ mhos/cm | |
| Site 5 | 3 m | |
| | 89 μ mhos/cm | |
| Site 6 | Surface | 7 m |
| | 86 μ mhos/cm | 85 μ mhos/cm |
| Hardness | | |
| Site ₁ | 1 m | 5 m |
| Ca ⁺⁺ | 25 ppm | 30 ppm |
| Mg | 20 ppm | 17 ppm |
| Total | 45 ppm | 47 ppm |
| Site ₂ | 1 m | 7 m |
| Ca ⁺⁺ | 30 ppm | 30 ppm |
| Mg | 10 ppm | 13 ppm |
| Total | 40 ppm | 43 ppm |

| Hardness | Depth | |
|------------------|---------|--------|
| Site 3 | 1 m | 7 m |
| Ca ⁺⁺ | 33 ppm | 30 ppm |
| Mg | 7 ppm | 10 ppm |
| Total | 40 ppm | 40 ppm |
| Site 4 | 2.5 m | |
| Ca ⁺⁺ | 40 ppm | |
| Mg | 10 ppm | |
| Total | 50 ppm | |
| Site 5 | 3 m | |
| Ca ⁺⁺ | 40 ppm | |
| Mg | 20 ppm | |
| Total | 60 ppm | |
| Site 6 | Surface | 7 m |
| Ca ⁺⁺ | 40 ppm | 40 ppm |
| Mg | 20 ppm | 20 ppm |
| Total | 60 ppm | 60 ppm |

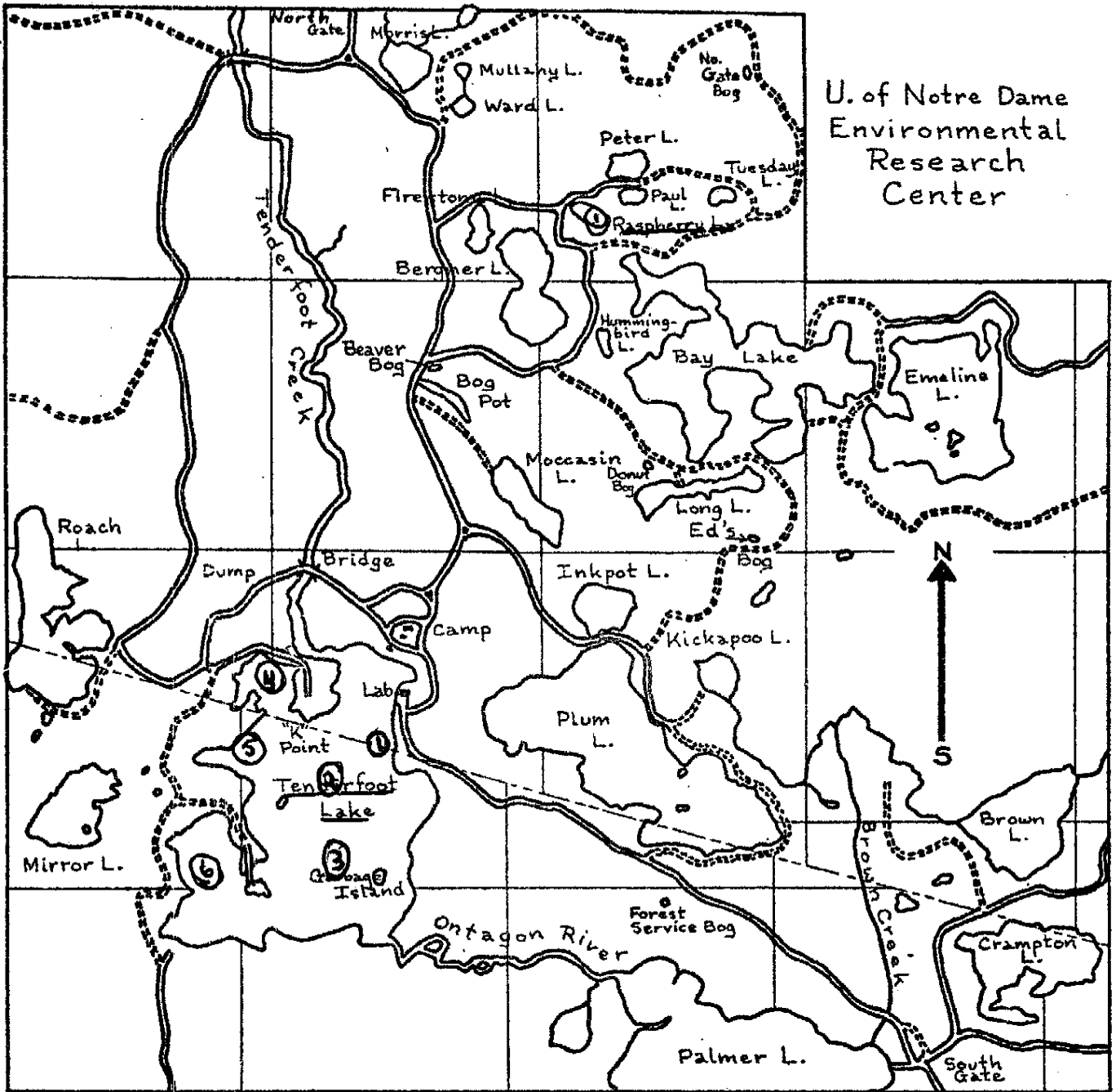
| | | |
|-----------|----------|----------|
| Phosphate | 1 m | 5 m |
| Site 1 | 0.08 ppm | 0.16 ppm |
| | 1 m | 7 m |
| Site 2 | 0.09 ppm | 0.06 ppm |
| | 1 m | 7 m |
| Site 3 | 0.08 ppm | 0.09 ppm |
| | 2.5 m | |
| Site 4 | 0.25 ppm | |
| | 3 m | |
| Site 5 | 0.31 ppm | |
| | Surface | 7 m |
| Site 6 | 0.33 ppm | 0.36 ppm |

| | | |
|---------|----------|----------|
| Nitrate | 1 m | 5 m |
| Site 1 | 0.45 ppm | 0.55 ppm |
| | 1 m | 7 m |
| Site 2 | 0.70 ppm | 0.65 ppm |
| | 1 m | 7 m |
| Site 3 | 0.70 ppm | 0.60 ppm |
| | 2.5 m | |
| Site 4 | 0.25 ppm | |
| | 3 m | |
| Site 5 | 0.45 ppm | |
| | Surface | 7 m |
| Site 6 | 0.50 ppm | 0.50 ppm |

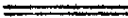



H₂S absent at all sites

Secchi Disc 3.2 m Day: overcast
wind--none
waves--small

N/P East 1,2,3. West 4,5,6.
7.2 1.5



Legend

- Improved Light duty road 
- Unimproved dirt road 
- Section Line, U.S. land survey 
- WATER SAMPLE SITES 

SCALE

1 : 31248



Discussion: From the water chemistry data, I concluded that Tenderfoot Lake is in an intermediate stage of development between a mesotrophic and eutrophic lake stage. This conclusion is supported by the high phosphate and nitrate concentrations. There is also support, in that, the lake has some alkalinity and a rather high calcium, magnesium, and total hardness. The pH is low for a eutrophic lake, but the SO_2 in the atmosphere could be lowing the pH a significant amount, because of the lake's large surface area. The lake is capable of buffering low concentrations of acid, but the SO_2 must be being absorbed by the water in great quantities. The SO_2 mixed with the water forms the strong acid, H_2SO_4 . With the large surface area, the lake probably has both a spring and fall overturn. This is reinforced by the lack of H_2S . Thus, Tenderfoot Lake is a dimictic lake. From the temperature profile, it can be seen that the lake is only slightly stratified, and that it is a rather warm lake.

PHYTOPLANKTON

Blue-Green Algae

- ① Anabaena
 - ② Anacytis
 - ③ Arthrospira
 - ⑦ Entophysalis
 - ⑩ Oscillatoria
 - ⑪ Rivularia
- Diatom
- ④ Astrionella

Dinoflagellate

- ③ Ceratium

Green Algae

- ① Coelastrum *Coelastrum*
- ② Fragellaria
- ③ Hydrodictyon ?
- ② Sphaerocystis schroeteri
- ⑥ Tribonema
- ④ Volvox

ZOOPLANKTON

Cladocera

② Bosmina④ Daphnia⑦ Moina

Copepoda

③ Nauplii

Rotifera

① Asplanchna② Brachionus⑤ Kellicottia⑥ Keratella⑧ Trichocera

In Tenderfoot Lake, there is a rich fauna of phytoplankton. The most abundant were the Anacytis, Ceratium, and Astrionella. There were also fairly many Anabaena, Sphaerocystis, and Coelâstrum. This abundance of phytoplankton supports the eutrophic lake stage hypothesis. The large quantities and number of groups of blue-green algae suggests that the lake was going through a blue-green algae bloom, which is common in eutrophic lakes.

The most abundant zooplankton were the Cladocera Daphnia. There were also many Rotifera Asplanchna and Keratella. In a dredge taken near site 3, Chaoborus were found. This is also support for the eutrophic lake stage hypothesis.

In this study, two northern lakes were analyzed. The two lakes were Raspberry and Tenderfoot. One of the major

distinguishing characteristics of Tenderfoot Lake was its much larger surface area. Another notable distinguishing feature was the bog mat surrounding Raspberry Lake. The bog mat around Raspberry Lake led to the conclusion the lake was past the eutrophic stage and near a dystrophic stage. However, the water chemistry and plankton data from the lake suggested that the lake was nearer to the eutrophic stage than the dystrophic stage. The water chemistry and plankton data from Tenderfoot Lake seemed to imply that the lake was in a eutrophic stage. However, a low pH and a high acidity seemed to support an oligotrophic stage hypothesis. Thus, Tenderfoot Lake is probably in a mesotrophic stage nearer to a eutrophic stage than an oligotrophic stage.

One common element in both lakes was a dropping pH, which is most likely due to SO_2 in the atmosphere coming from industry. Low alkalinity was also found in both lakes. This is probably due to the same factor as above, and to the geological aspects of the lakes. The phosphorus levels in both lakes were high, which implies an influx of phosphorus from some source. A rich fish fauna was characteristic of both lakes. However, the depth and size of Tenderfoot Lake supplied more ecological niches, and thus allowed more different species to occupy the waters. The phytoplankton and zooplankton data were similar. Both lakes seemed to be experiencing blue-green algae blooms, which were probably due to the high levels of phosphorus.

One major difference in the lakes was that Raspberry

Lake had a much greater stratification of temperature between the epilimnion and the hypolimnion. The hypolimnion in Tenderfoot Lake was fairly warm, which seems to suggest strong mixing of the lake. Another difference was that the water of Tenderfoot Lake was slightly harder than the water of Raspberry Lake. To reiterate, the major difference was that Raspberry Lake had a bog mat. This will slowly change Raspberry Lake into a bog with a very different water chemistry and fauna than the eutrophic lake, it once was. Tenderfoot Lake is just reaching the eutrophic stage, and it will be many years before a bog mat will invade its shores.

From this study, it can be seen that the energy flow of a lake is very complicated with many factors that interact with one another. These factors, like water chemistry and plankton analysis, are not just complicated, but are difficult to study. In this study, no actual conclusion were formulated about the energy flow. Thus, more research is needed, so that we may better understand energy flow in our freshwater lakes.

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A Study of Bass in Long Lake

In this study, two species of bass were found the largemouth bass (Micropterus salmoides) and the smallmouth bass (Micropterus dolomieu). The fish were collected with nets, which were checked twice a day and were set for two days.

The bass were weighed and measured. They were measured for standard length, body length, and total length. Condition factors for each fish were also calculated. The age of the fish were determined by scale analysis. With regard to length, age, and condition factors, these fish were compared with typical standards of fish for the area from the literature.

The bass found in this area seemed to be large or about standard size for the area. Most of the fish caught were in the 2 to 3 year age category. It was noted, in a five year old fish, that it had a very bad growth year in 1975. This suggests that there was probably a drought or a food deficiency in the lake that year. Although, this fish had a bad growth year in 1975, it was about standard size for its age category.

Long Lake has rather nutrient poor water, however, it does support a fair size phytoplankton population. The phytoplankton support a smaller zooplankton population, which supports the fish population. The bass caught in this study did not feed on the zooplankton, but on small yellow perch (Perca flavescens) and a variety of insects, mostly mayflies. The perch eaten by the bass probably do depend

on the zooplankton as a food source. The bass are probably the largest fish in the lake, and are fed upon by mammals around the lake like the beavers and the otters.

For the mangement of this lake, I would not tamper with the balance within the lake now. The lake should be monitored every few years, however, the bass are standard or large for the area. Thus, I would not tamper with success.