Fish B 9

ROACH AND TENDERFOOT LAKES

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Roach and Tenderfoot Lakes:
A Comparison

The lakes on which I am doing this report are Tenderfoot and Roach. Each lake was studied in essentially the same manner. Several sites were choosen on the lakes and water samples were taken from the epilimnion and hypolimnion. Various tesets were performed on these samples in order to understand the chemistry of the lakes. Daytime plankton tows were taken in each lake and a night time tow was taken at Roach Lake. The plankton were identified in each tow.

In this report I shall first discuss the yearly cycle of a lake; then I will discuss the various characteristics of each lake (including water chemistry and plankton). In conclusion I will compare the two lakes on the basis of this data.

Generally a lake goes through several cycles throughout the year. These cycles include winter stratification, spring overturn, summer stratification and autumn overturn. In winter lakes stratify with water around 4^{o}C at the bottom of the lake since water is densest at this temperature. Colder water remains at the surface leading eventually to the formation of ice. In spring the ice melts and numerous storms cause the water to mix and leads to a uniform temperature distribution in the lake. In summer the sun heats the upper layer of water while the lower layer remains cold. This is summer stratification (5). The upper waters (the epilimnion) are warmer and the lower depths (the hypolimnion) are colder. In general the temperatures of the epilimnion and the hypolimnion are uniform, but there is a certain depth where a thermocline occurs. This is the transition point between the warm and cold waters. In order to obtain water samples ~~form~~ from the epilimnion and the hypolimnion we took temperature readings at various depths and found the thermocline. Then we took water samples above and below this point.

Roach Lake

Roach Lake is located on the south-west part of the Notre Dame property. It has a surface area of $38.4 \times 10^4 m^2$ and it is a seepage lake. (2) A seepage lake is one where loss of water occurs by seepage into the ground water through the basin walls. This loss usually occurs from the upper portions of the basin since deposition of clays and silts usually seals the deeper parts of the lake. (9) Roach Lake was mostly surrounded by hardwoods among which were some stands of white birch. The trees came up to the shore and along the water's edge were some grassy plants. ?

We took water samples from two sites (see map) and obtained the following data:

	Site #1		Site #2	
	epilimnion	hypolimnion	epilimnion	hypolimnion
Acidity	126mg/l	125mg/l	110mg/l	75mg/l
Alkalinity	<10mg/l	<10mg/l	<10mg/l	<10mg/l
Hardness				
Ca^{++}	10mg/l	10mg/l	10mg/l	10mg/l
Mg^{++}	0mg/l	0mg/l	0mg/l	0mg/l
Total	10mg/l	10mg/l	10mg/l	10mg/l
Specific Conduct.	24µmhos/cm	19µmhos/cm	20µmhos/cm	18µmhos/cm
Color				
Apparent	35units	25units	20units	15units
True	15units	15units	15units	10units
Nitrate	0.85mg/l	0.70mg/l	0.65mg/l	0.80mg/l
Phosphate	0.175mg/l	0.23mg/l	0.30mg/l	0.36mg/l

pH	4.6
H_2S	not present
Secchi Disc	3.3m at Site #1 and 2.9 at Site #2; the day was partly cloudy with only a slight breeze, readings taken between 11:30am and 12:00am.

All the samples showed a low pH, a high acidity and a low alkalinity in Roach Lake water. The alkalinity is determined by titrating with a strong acid and finding the amount of acid necessary to neutralize it. Conversely the acidity is found by titrating with a base. Alkalinity is usually imparted by the presence of bicarbonates, carbonates, hydrozides and sometimes borate, silicate and phosphates.(9) These compounds are involved in the buffering capacity of the lake. The chemical equation of this capacity is:

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^=$$

The presence of various compounds can drive this equation either to the right or to the left. Acidity is defined as the capcacity of a compound to donate hydrogen ions to another compound. Pure water dissociates weakly into H^+ and OH^-, but natural water contains many salts and other compounds (such as tannic, humic, uronic, and mineral acids) which contribute to the acidity. The pH of the water is closely related to the interaction of H^+ ions from the dissociation of H_2CO_3 and OH^- ions from the hydrolysis of bicarbonate.(9)

From our data we found that Roach Lake does not have a high buffering capacity because of the low alkalinity readings. This means that acids which enter into solution are not readily neutralized. This accounts for the low pH and high acidity.

Another aspect of water quality is found by taking hardness measurements. This measurement is governed by the calcium and magnesium salt content of the water. The presence of calcium is dependent on CO_2 which when combined with carbonate forms H_2CO_3; this in turn reacts with calcium to form $Ca(HCO_3)_2$.

Large amounts of this compound causes hard water and also shows that the lake has a high bicarbonate buffering capacity.(10) The fact that the water from Roach Lake is not hard also accounts for the low pH. In hard water the following reaction takes place upon addition of sulfuric acid:

$$Ca(HCO_3)_2 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$$

As one can see the sulfuric acid is replaced by a weaker carbonic acid, so the pH does not change as much as it would if $Ca(HCO_3)_2$ were not present.(10) Roach Lake is therefore effected by the addition of acids since its calcium measurement is very low.

Correlated with the hardness measurement is the specific conductance of the water. This is a measure of the resistance of a solution to electrical flow. The resistance of a water solution is reduced with increasing content of ionized salts. Therefore purer water will have more resistance to electrical flow.(9) The specific conductance is measured as the reciprical of specific resistance, so water with fewer ions will have a small specific conductance. This is the case with Roach Lake. It does not have a high specific conductance. This result would be expected since calcium was present only in small amounts in the lake water and magnesium ions were not even detected.

The depth to which light penetrates the lake water is also very important. We took measurements of the water color and Secchi disc readings to determine the clarity of the water. The color of a lake is the result of light scattered upward from the lake after some of it has been absorbed. The color of the water (actually the color of anything) has two properties: color intensity (brightness) and light intensity (lightness). These are tested in a standardized manner.(10) The clearer the water the less color it will have. In our case we tested both apparent color and true color. The latter consisted of a reading taken after the water had been centrifuged to remove particulate matter. We found that Roach Lake water did not have much color. The true color was slightly different than the apparent color. This difference is due to the particles which were spun out of solution by centrifugation.

The other reading we took was with a Secchi disc. This instrument was a black and white disc which was lowered into the water until it was no longer visible. The depth to which the disc can be seen is a function of the reflection of light from its surface and so it is influenced by dissolved and particulate matter in the water. An approximate depth to which light travels in the water can be obtained from the Secchi disc reading. Light penetrates approzimately twice the distance at which the disc disappears. This is important to know when studying phytoplankton since their existance is dependent on the amount of light which reaches them. Roach Lake was relatively transparent and we could see the disc at a depth of 3.3 meters. This meant that light penetrated almost to the bottom of Roach Lake. It is also important to note that our readings were taken near mid-day, because it has been found that Secchi disc readings become erratic near dawn and dusk.(9)

The nitrogen and phosphate contents of a lake are important to the organisms living in that environment. Both are essential to living matter and both can be limiting factors for the growth of organisms. Nitrogen is a component of nucleic acids which compose all the proteins and amino acids in an organism. In freshwater most ~~the~~ of the nitrogen, especially in the form of nitrate, is utilized by algae. Nitrogen enters the water mostly through run-off, precipitation and nitrogen-fixing bacteria. Once in solution it is incorporated into living systems and eventually ends up in the hypolimnion when organisms die or excrete nitrogenous wastes. Here the decomposers utilize the nitrogen and most of it remains at the lake bottom. Here it is not usable to organisms living in the epilimnion. During summer stratification the amount of nitrogen is much greater in the hypolimnion. When overturn occurs, the nitrogen is cycled back to the epilimnion.(9) In Roach Lake we found the nitrate content of the epilimnion to be slightly higher than in the hypolimnion. This means that more nitrogen is available to the algae and that a significant number of organisms had not died. It could also mean that the lake had not bee stratified for a long time so alot of nitrogen had not accumulated in the lower depths yet.

Phosphorus is also present in freshwater. A correlation between the amount of phosphorus and productivity has been found. For example if more algal growth is desirable in a lake then phosphorus fertilization is used to obtain this end.(10) Phosphates do dramatically increase the amount of algal growth. Roach Lake did not contain high amount of phosphate in either the hypolimnion or epilimnion. This would mean that there should not be a large algal growth in Roach, especially if phosphorus is the limiting factor.

The only other measurement that was taken was for the presence of hydrogen sulfide. The tests for this compound were not that sensitive, so we tested for it with our noses. Hydrogen sulfide smells like rotten eggs. It is found near the bottom of lakes when the oxygen content has been depleted.(10) There are several types of bactera which are anaerobic and can utilize the H_2S. It was important in our lake assay to determine if H_2S was present since the oxygen meter was not working. The presence of H_2S shows that there is very little oxygen in the hypolimnion and gives some evidence that the lake has not turned over. We did not detect hydrogen sulfide in Roach Lake, indicating that it had turned over.

In conclusion I will summarize the Roach Lake data. Roach Lake had high acidity and low alkalinity reading, and therefore did not have a good buffering capacity. It also had a low specific conductance and was not very hard. The water had very little color and was fairly transparent. The lake did not have high amount of either phosphorus or nitrogen leading one to the conclusion that there should not be much algal growth in the water. This absence of growth may account for some of the clarity of Roach water. Hydrogen sulfide was not found to be present either. From this and the phosphorus and nitrogen data one could conclude that Roach did turnonver in spring. Summer stratification was beginning as shown by the temperature readings. There was a thermocline and the upper water was warmer than the lower water.

In each lake we identified phytoplankton and zooplankton. In Roach Lake we did both a night tow and a day tow. I identified the following phytoplankton in Roach:

Green Algae

Volvox
Fragellaria
Dinobryon

Diatoms

Asterionella

Dinoflagellates

Perdinium
Ceratium hirundinella

Desmids

Staurostrum

The green algae were fairly scarce. There was some Staurostrum but the most common phytoplankton were Asterionella and Perdinium. I did not find any blue-green algae present either. This data correlated somewhat with the water chemistry, though there did appear to be some idiosyncrasies. The presence of very few green algae and alot of Asterionella may be caused by several factors. The acidic environment may limit the growth of green algae, since they prefer more basic waters.(7) Green algae is also more predominant in warm summer water, while diatoms are abundant in spring. This is especially true for Asterionella. I also identified Staurostrum, a desmid, which is common in soft water lakes.(7) Roach does have very soft water so this correlates well with the chemistry. Asterionella and Ceratium hirundinella, though, are common in hard water lakes with more nutrients. This is somewhat of an idiosyncrasy. To reconcile this data with the water chemistry, it was true that Ceratium was not very abundant. Also Asterionella is a very common spring diatom and probably does well in most waters.

The following zooplankton were found in Roach Lake:

A.M. TOW

Rotifera	Copepoda
Karatella	Nauplii
Brachiones	

P.M. TOW

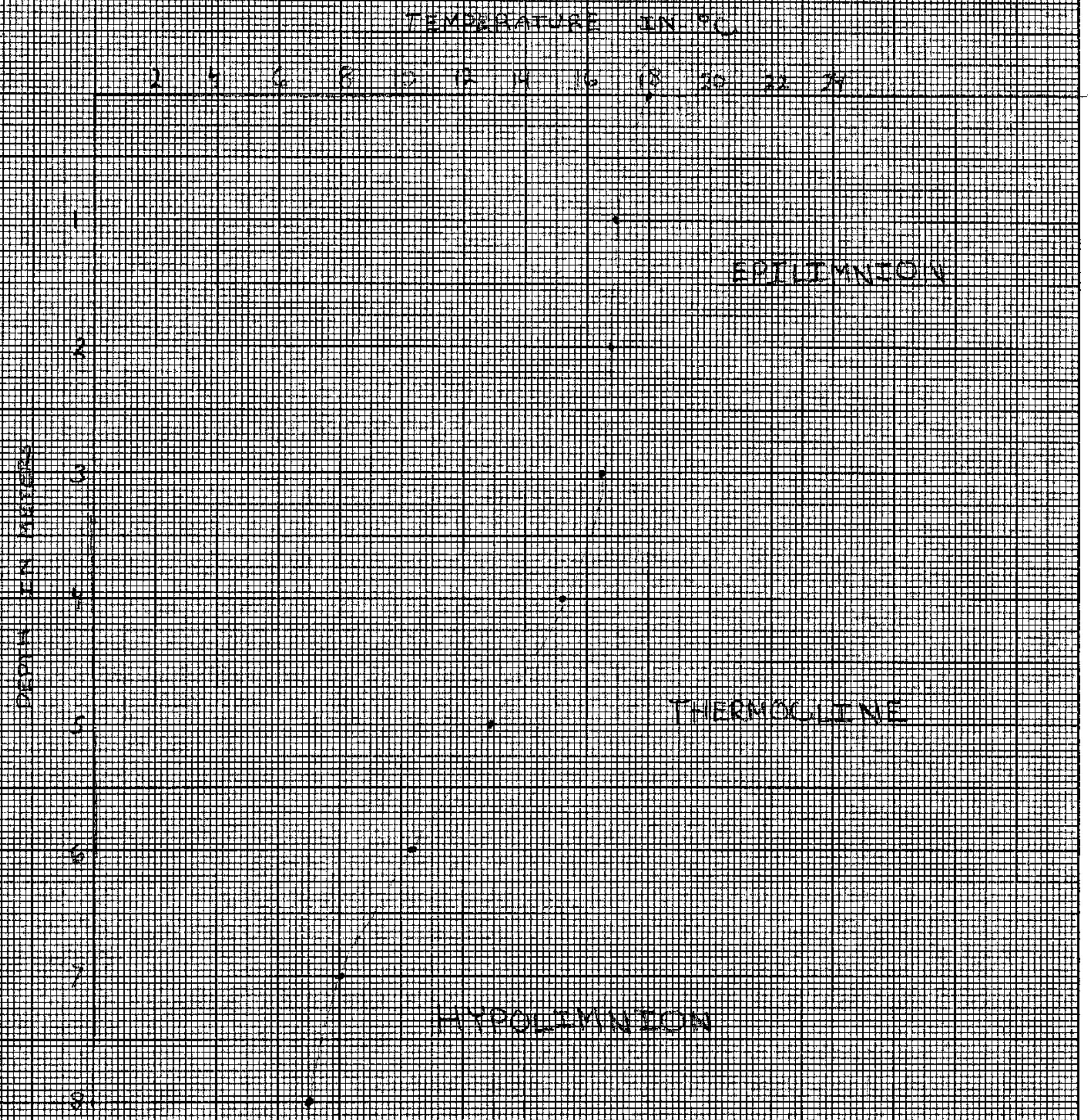
Rotifera	Copepoda	Cladocera
Keratella	Nauplii	Bosmina
Asplanchna	Cyclops	Ceriodaphnia

The Keratella and Nauplii were very abundant in the A.M. plankton tow. Every zooplankton identified is common in lakes and ponds throughout the United States. The only exception was Brachiones which is mostly found in hard water lakes.(1) Again this does not correlate with the water chemistry, but Brachionus was also not very abundant.

The most obvious fact as shown by this data is that the zooplankton exhibit diurnal movements. While the A.M. tow showed only rotifers and Nauplii, the P.M. tow also showed Cladocera and Cyclops. The difference between the two tows was very pronounced. Crustacean, Cladocera and Copepods are supposed to exhibit diurnal movements and this was definately shown by the data.(1)

Roach Lake was an acidic lake with low buffering capacity and without large amounts or numerous types of plankton. The lake was also inhabited by Yellow Perch, Large-mouth Bass, Pumkinseed and Muskellungs.(2) The types of organisms found in this lake probably vary with the seasons. The addition of acids to this lake will dramatically lower the pH and this would also cause a change in the organisms found present.

ROACH LAKE TEMPERATURE DATA



TEMPERATURES

AIR	19.0°C
SURFACE	18.0°C
1m	17.0°C
2m	16.8°C
3m	16.5°C
4m	15.2°C
5m	12.9°C
6m	10.2°C
7m	8.0°C
8m	7.0°C

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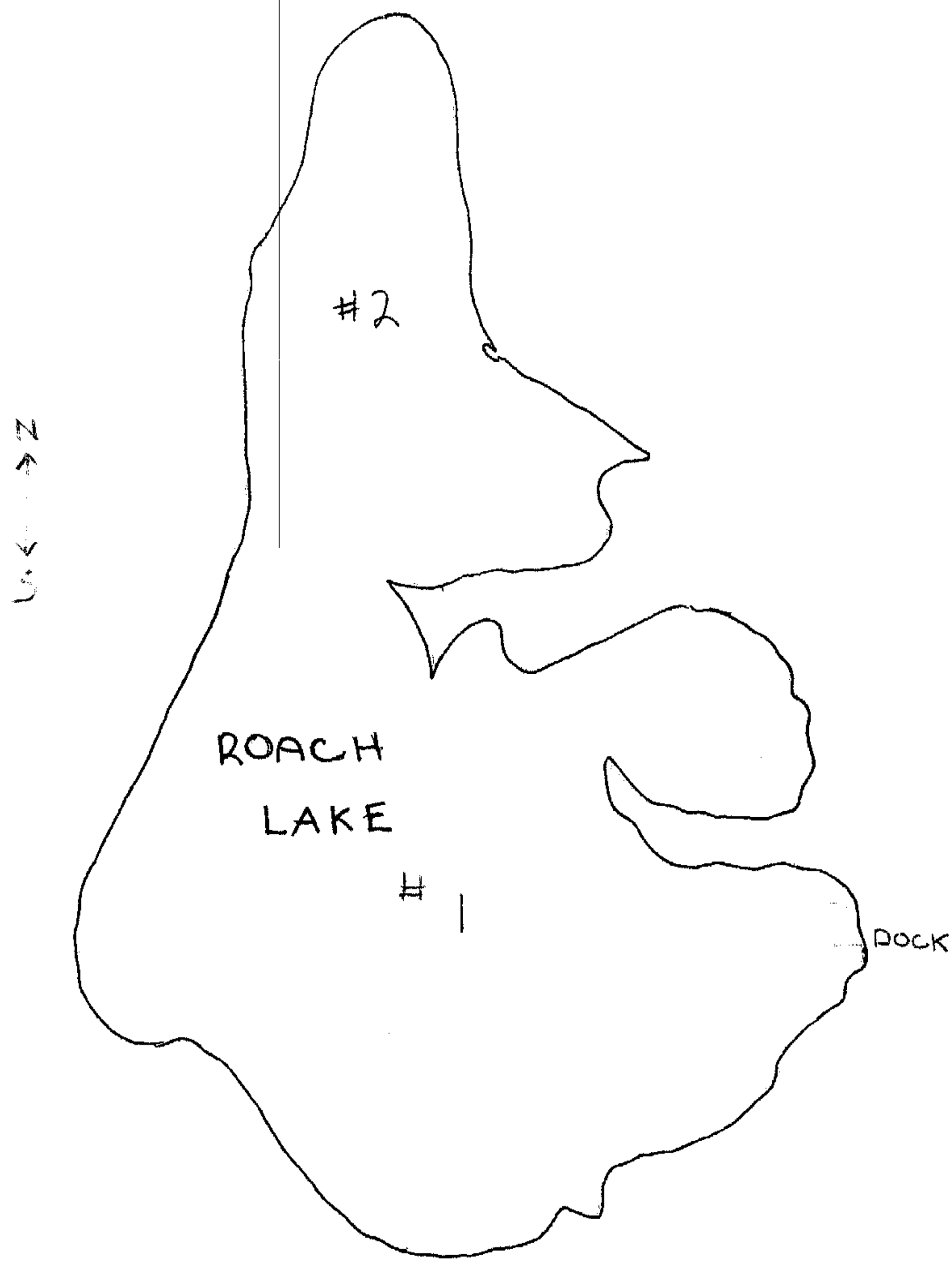

N
S
#2
ROACH
LAKE
#1
DOCK

Tenderfoot Lake

Tenderfoot Lake is much larger than Roach Lake. It has a surface area of 181.9 x $10^4 m^2$. It is surrounded by hardwoods and conifers. Water from Palmer Lake enters Tenderfoot via the Ontagon River and it leaves through Tenderfoot Creek.(2) Therefore Tenderfoot Lake is a drainage lake where water loss occurs through the Tenderfoot Creek outlet.

We took samples from 3 sites on Tenderfoot (see map) and the data can be found on the following page. The temperature readings were taken at the deepest site.

Tenderfoot Lake water had both acidity and alkalinity readings. ? The acidity was fairly high but since there was some alkalinity readings one can conclude that this lake has some buffering capacity. This conclusion is also indicated by the pH, which was 6.1. This was the least acidic pH of all the lake which we tested.

Magnesium and calcium were both found to be present in Tenderfoot water. The lake therefore is not extremely soft. The presence of both these compounds again shows that Tenderfoot Lake has some buffering capacity. Acidic compounds added to this lake will not dramatically lower the pH. Since the water does contain these two ions and showed some alkalinity one would expect a high specific conductance. The presence of these ions decrease the resistance to electrical flow of the water; therefore the specific conductance would be high since it is an inverse relationship. Indeed, the specific conductance was high and this correlates well with the other findings.

Tenderfoot Lake did have a high color reading, though the true color was slightly less than the apparent color. This color could be due to the presence of more plankton or perhaps certain compounds found in hard water impart this color. The Secchi disc reading did show that Tenderfoot water was fairly transparent and light penetrated to a great depth. This indicates that photosyn-

	Site #1		Site #2		Site #3	
	epilimnion	hypolimnion	epilimnion	hypolimnion	epilimnion	hypolimnion
Acidity	85mg/l	96mg/l	80mg/l	87mg/l	86mg/l	87mg/l
Alkalinity	40mg/l	33mg/l	50mg/l	37mg/l	32mg/l	29mg/l
Hardness						
Ca^{++}	40mg/l	40mg/l	40mg/l	40mg/l	40mg/l	40mg/l
Mg^{++}	20mg/l	20mg/l	20mg/l	10mg/l	20mg/l	20mg/l
Total	60mg/l	60mg/l	60mg/l	50mg/l	60mg/l	60mg/l
Specific Conduct.	85μmhos/cm	89μmhos/cm	85μmhos/cm	85μmhos/cm	86μmhos/cm	85μmhos/cm
Color						
Apparent	60units	50units	60units	50units	60units	50units
True	50units	45units	45units	45units	45units	45units
Nitrate	0.20mg/l	0.31mg/l	0.29mg/l	0.25mg/l	0.33mg/l	0.36mg/l
Phosphate	0.40mg/l	0.45mg/l	0.5mg/l	0.25mg/l	0.50mg/l	0.50mg/l
pH	6.1					
H_2S	not present					
Secchi Disc	3.2m, taken about mid-day; the sky was overcast and the water was very calm with only a slight breeze.					

thesis probably takes place at lower depths since light penetrates further.

There was not much phosphate or nitrate in Tenderfoot. Therefore one would not expect large amounts of algae if these compounds are limiting factors. There was also no significant difference between the amount of these nutrients in the epilimnion and the hypolimnion. This indicates that the lake has undergone overturn and the nutrients are well mixed. No hydorgen sulfide was found to be present giving further evidence that the lake had undergone spring overturn.

Tenderfoot Lake had a wider variety of plankton than Roach Lake. The following types of phytoplankton were identified:

Blue-green Algae	Green Algae
Anacystis	Sphaerocystis schroeteri
Arthrospira	Coelastrum
Anabaena	Hydrodictyon reticulatum
Rivularia	Volvox
Entophysalis	Tribonema
Oscillatoria	Fragellaria
Dinoflagellates	**Diatoms**
Ceratium hirundinella	Asterionella

Blue-green algae was very abundant in Tenderfoot Lake, the most common types being Anacystis and Anabaena. Blue-green algae is usually found in lakes with plentiful nitrates, phosphates and bicarbonates. Anabaena is especially common in eutrophic lakes. (8) The green algae identified are fairly common in the United States. Sphaerocystis schroeteri and Coelestrum were most abundant in our sample; of these Sphaerocystis schroeteri is common in eutrophic lakes. (7) The dinoflagellate, Ceratium, and the diatom, Asterionella, were also abundant in the water. These are plentiful in hard water lakes. All of these results indicate that Tenderfoot Lake should have hard water and alot of nutrients and bicarbonates. It is true that Tenderfoot had hard water and some bicarbonate, but the chemistry indicated small amounts of nitrate and phosphate. This result may have been because the tests were run inaccurately or some other error occured. Another reason may be that these nutrients were tied up in the phytoplankton since alot of nutrients would be needed to support their population.

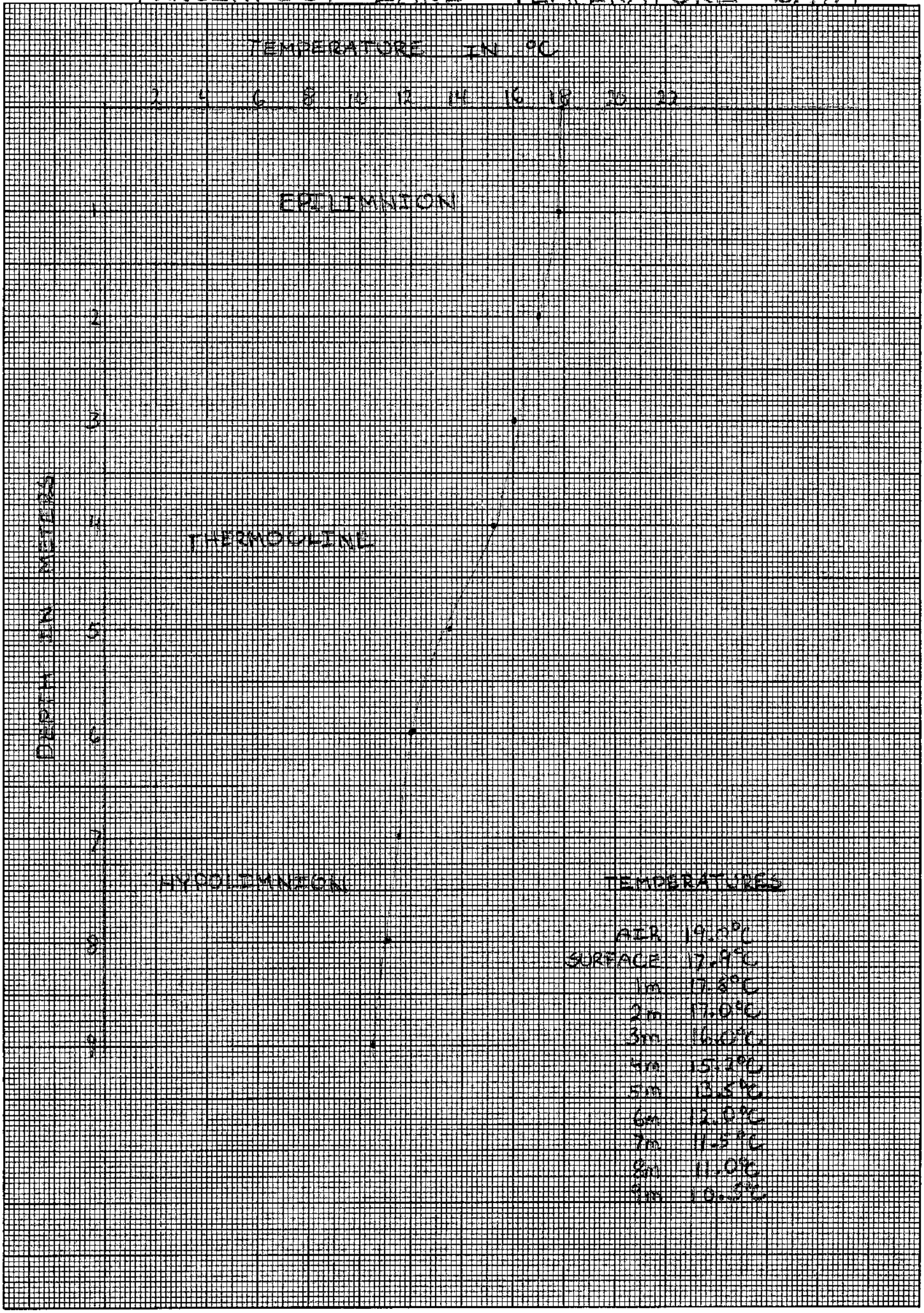
The following data are the zooplankton identified in Tenderfoot Lake:

Rotifera	Cladocera	Copepoda
Keratella	Daphnia	Nauplii
Polyarthra		Cyclops
Kellicottia		

All of these zooplankton are common in the United States. Keratella and Kellicottia were most predominant of the rotifers. Nauplii and Cyclops were common in the water samples; also there were quite a few Daphnia. Since we did not take a night tow on this lake, it is difficult to say what other zooplankton might be present. One would probably expect more Cladocera and Copepoda in the night tow. None of the zooplankton identified specifically inhabited hard or soft water (1), therefore no conclusions can be drawn about the water chemistry. These conclusions can best be obtained from the phytoplankton samples.

Tenderfoot Lake was not very acidic and it did have some buffering capacity. It did contain some nutrients along with being a hard water lake. The plankton, especially the phytoplankton, were abundant and varied. The lake was also inhabited by Muskellunge, Walleye, Northern Pike, Crappie, Yellow Perch, Rock Bass, Sunfish, Large-mouth Bass and Small-mouth Bass. (2) This varied fish population indicated that the lake is able to sustain many types of life.

TENDERFOOT LAKE TEMPERATURE DATA



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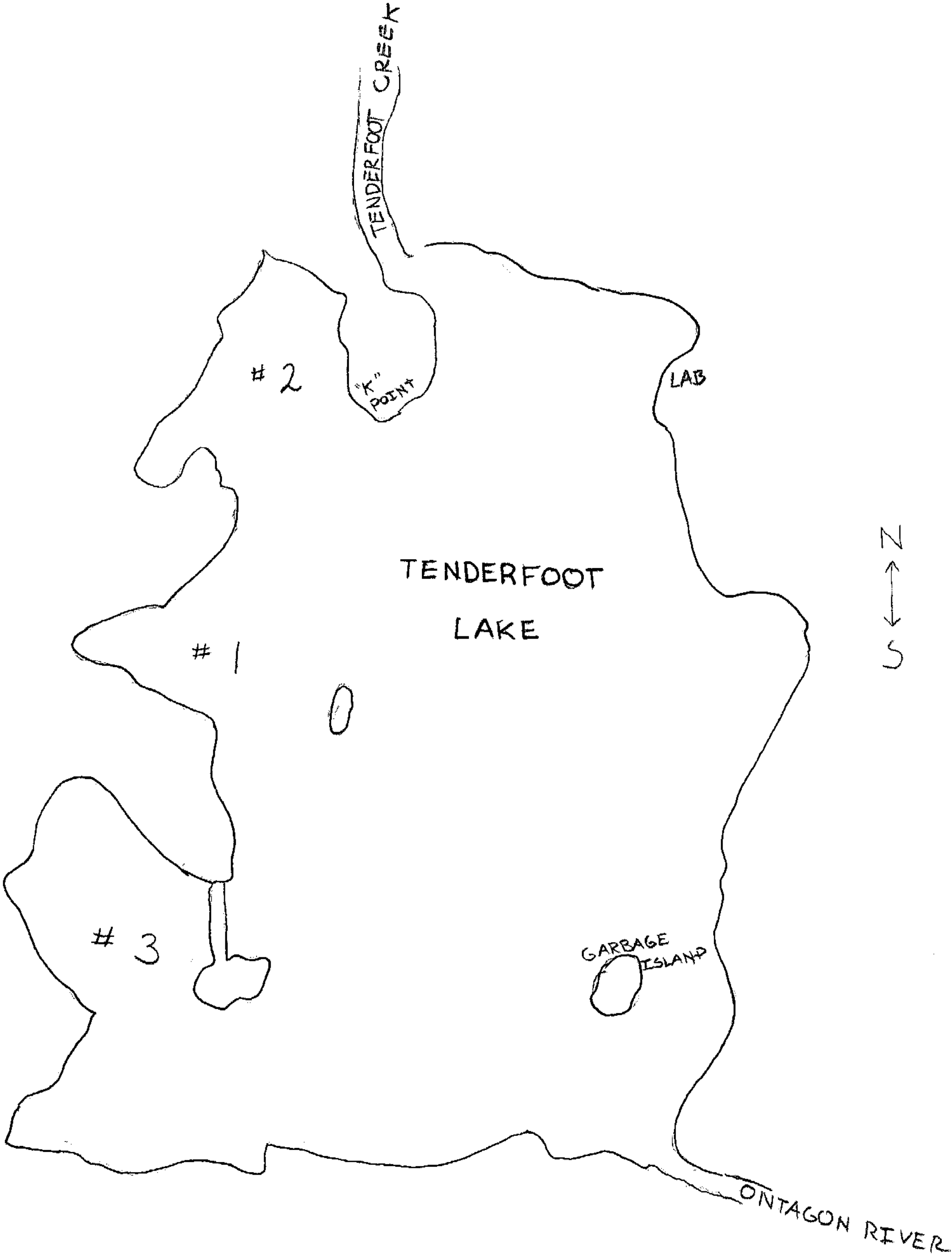

TENDERFOOT CREEK
#2
"K" POINT
LAB
TENDERFOOT
LAKE
#1
N
S
#3
GARBAGE ISLAND
ONTAGON RIVER

Roach Lake and Tenderfoot Lake Compared

The water chemistry and plankton data indicate that there are many differences between Roach Lake and Tenderfoot Lake.

Roach Lake was definately more acidic than Tenderfoot. Roach's buffering capacity was much less than Tenderfoot's. This means that Roach's pH will be affected to a greater degree than Tenderfoot's if acidic compounds are added to the water. Tenderfoot was also harder and had a higher specific conductance than Roach. This again points to Tenderfoot's greater buffering capacity.

Roach and Tenderfoot had very similar Secchi disc readings. Therefore they both had good light penetration. Tenderfoot's water, though had more color than Roach's. This could be due to different compounds which may be present in harder water. Also different kinds of plankton or different amounts may account for the color differences.

Roach Lake did have lower amounts of phosphate than Tenderfoot, but it also had greater amounts of nitrate. This data should be important in understanding the different types of plankton found in each lake, especially if phosphates and nitrates are limiting factors. For example one could conclude that neither lake should have large algal populations since neither contains alot of nutrients. Perhaps one lake has a larger phytoplankton population (as in the case of Tenderfoot and Roach) and alot of the nutrients are tied up in the organisms. Also this data and the fact that no hydrogen sulfide was found in either lake shows that both underwent spring overturn. It appeared from our data and other temperature readings which were taken in Tenderfoot Lake that this lake might still be undergoing overturn and no definate stratification had taken place. This may be due to the fact that Tenderfoot was much larger than Roach and its waters were probably more stirred up by the spring storms.

The plankton found in each lake also differed. Primarily there was alot more phytoplankton present in Tenderfoot Lake. There were especially large amount of blue-green and green algae in this lake, while in Roach, no blue-green algae was identified and green algae was scarce in comparison. Asterionella was prominant in both lakes. This is probably due to the fact that diatoms are predominant in spring. Ceratium was much more abundant in Tenderfoot than in Roach. This is probably due to Tenderfoot's harder waster; Ceratium is more common in hard water than in soft water. A comparison of the phytoplankton in the two lakes did indicate that each had slightly different water chemistry. Several organisms (Anabaena, Sphaerocystis schroeteri, etc.) which are common in eutrophic lakes were present in Tenderfoot and not in Roach Lake. Also present in Roach and not in Tenderfoot Lake was the desmid Staurostrum, which inhabits soft water. Some plankton which are indictive of eutrophic (hard,lots of nutrients, etc.) lakes were found in Roach. This lake had very little calcium and not alot of nutrients; therefore just identifying phytoplankton could lead to some erroneous conclusions about the water chemistry.

The zooplankton was also different in both lakes. All the organisms identified were common in the United States, but each lake did not have the exact same zooplankton. This shows that some organisms may not be tolerant of the acidic conditions found in Roach, while others can tolerate it. It was very interesting to note that the A.M. tow in Tenderfoot produced some Cladocera and Cyclops while these were only found in Roach Lake during the night tow.

Roach Lake and Tenderfoot Lake are definately two different lakes. The former is a seepage lake while the latter is a draingae lake. Tenderfoot appears to be more eutrophic in that is is much harder and less acidic than Roach. Its waters support a wider variety of plankton and fish. Roach Lake, on the other hand was very clear and did not have a large algal population. Of the two lakes I thought Roach was much prettier with its many stands of white birch, but Tenderfoot was real nice too.

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