plankton 10
water chem. 9.4
9.7

KICKAPOO LAKE

&

HUMMINGBIRD BOG

A study of two bodies of water on the U.N.D.E.R.C. properties

by
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The intention of this paper is to examine, individually and somewhat comparatively, two distinctively different bodies of water with respect to their physical, chemical and populational characteristics. While the two bodies of water, Kickapoo Lake and Hummingbird Bog, are located within several miles of each other and are both among the numerous bodies of water on the property belonging to the University of Notre Dame near Land-O-Lakes Wisconsin, they differ in several respects.

I Lake Description:

A Kickapoo Lake

This is a moderately sized lake having a surface area of 5.3 hectares or $5.3 \times 10^4 m^2$. The lake is roughly circular in shape and relatively shallow with a bottom depth of 3.25m recorded at the sampling site in the approximate center of the lake.

It is a relatively dark watered lake. The bottom is a very murky one with several inches of muddy ooze covering the entire bottom. The line of the bottom gently slopes up to the shoreline with no abrupt changes in depth occuring. At the shore-water interface there are scattered clusters of water lilly plants floating on the surface. There are several meters of marshy grasses in back of the shoreline.before the actual hardground wooded area begins.

This lake has been affectionately been knicknamed "Tickapoo" by its student visitors in reference to the multitudes of ticks, *Dermacentor variabilis*, that await in eager anticipation in the tall grasses on the path from the dirt road down to the wooden dock on the lake's southside. These numbers of ticks suggests the extensive use of the path and the lake as a source of drinking water for the large Virginia White-tailed Deer population of the area.

Few large macrophytes besides the aforementioned grasses and water lilly plants exist around the lake.

The lake supports a small fish population comprised of Muskellunge, Yellow Perch, Crappie and Northern Pike.

The waterflow pattern is in a West-East direction with the influx occuring on the north and west ends from Emeline and Plum Lakes respectively. The drainage is out the southeastern corner through Brown Creek.

Brown Creek is a fairly wide slow moving creek with banks much like the shorline of Kickapoo with a larger number of water lillies in the water. Brown Creek carries the water from Kickapoo in a southeasterly direction and eventually into the Cisco Chain System of Lakes.

B Hummingbird Bog

This is a small body of water with a surface area of one hectare or $1.0 \times 10^{4} m^{2}$. This bog is like other bogs in the respect that it is ringed by the usual shrubberies and dead and decaying trees and it even has similar chemical characteristics. However this bog differs from other bogs in that it lacks the characteristic sphagnum bog mat encircling the perimeter of the lake. There is very little of any bog mat on this lake. This bog so closely resembles a small lake that there has been some confusion on maps in the past as to whether this body of water is a lake or a bog.

The bog is dumbell shaped and relatively deep. A depth of

5.0m was recorded at the sampling site in the center of the narrow neck. The bottom is several inches of mud and debris. The bottom line doesn't gently slope up to the shore line but forms a rather steep drop-off about one and a half meters from the shore.

A small fish population of stunted Yellow Perch thrives in the bog although they are purportedly unable to reproduce in the low pH acidic water.

The proximity of the bog to Bay Lake forms a lowland isthmus that may be flooded in Spring highwater conditions thus forming a water influx point and also a channel for fish population migration. It might be this channel that prevents this bog from becoming a total bog and that sustains the fish population.

II Water Chemistry

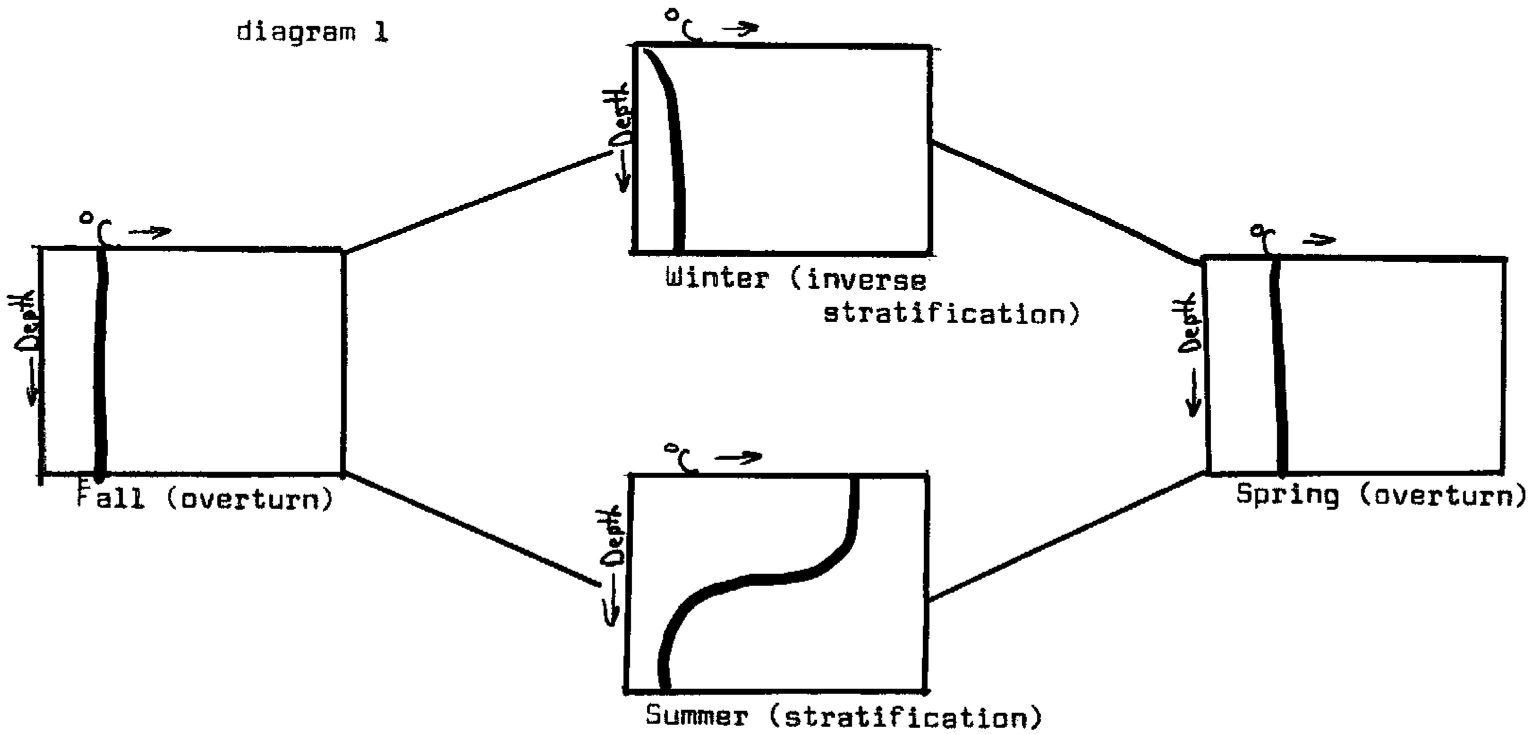
A Introduction

One of the most important physical parameters that can be studied about any body of water is an oxygen temperature profile. This profile is easily constructed by plotting depth of reading against either O_2(in ppm) or temperature(in °C).

The construction of this profile is important in relating many of the conditions or recent history of the body of water to the examiner.

It may be helpful to examine a complete seasonal cycle of depth-temperature graphs in order to understand where the body of water presently stands. (Diagram 1)

In the winter when there is no ice on the surface the temperature of the water is pretty uniform over the whole body of water, with some of it existing as ice and some as water. As diagram 1



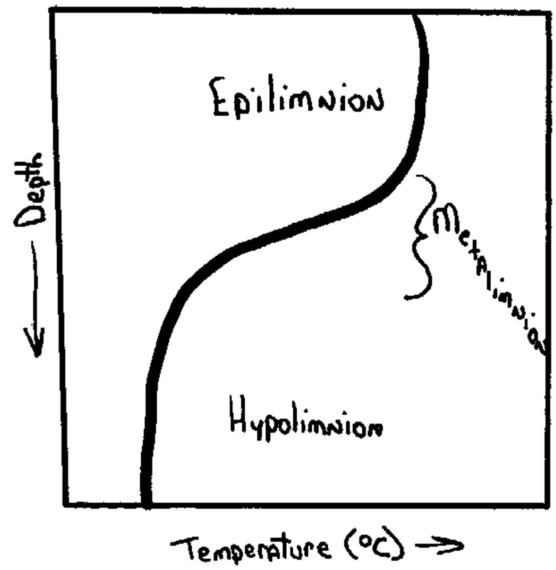
spring approaches the wind acts to circulate the water column. The circulation, aided to some extent by convection currents induced by cooling at night and by evaporation, can continue for varying periods of time. It is during this time that the body of water experiences a spring turnover where the entire water column is thoroughly mixed and the water temperature is uniform throughout. It is also quite possible for the actions of the winds impinging on the surface to mix oxygen into the water. It is during this time that most of the oxygen a body of water is to hold throughout the year is imparted to that water.

As spring progresses the surface waters are heated more rapidly than the distribution of heat by mixing. As these surface waters heat and become less dense the rise and their resistance to mixing increases drastically.

From that point on the water is divided into three regions of different temperatures which are exceedingly resistant to mixing with each other.

The period of summer stratification is characterized by an upper stratum of more or less uniformly warm, circulating, and fairly turbulent water, the epilimnion (Diagram 2).

diagram 2



The epilimnion overlies a deep, cold, and relatively undisturbed region, the hypolimnion. The stratum between the epilimnion and the hypolimnion exhibits a marked thermal discontinuity and is termed the metalimnion. This region has often also been termed the thermocline.

In late summer and fall, declining air temperatures result in cooling of the surface waters. The cooled surface waters become more dense and sink and mix by a combination of conversion currents and wind-induced epilimnetic circulation. This mixing continues into a period of fall overturns.

As winter sets in and the ice cover begins to form, the solar radiation may act to warm the waters just below the ice, resulting in a winter inverse stratification.

During this cycle it is quite possible for any number of conditions to occur to the dissolved oxygen concentration. As already mentioned, the oxygen concentration is highest and uniformly distributed during the spring and fall overturn periods. During summer stratification it is possible for the warmer epilimnetic waters to be low in oxygen content due to the decreased solubility of oxygen as temperature rises. It is also possible for the cooler hypolimnion to be deficient in oxygen due to respiration of the bottom dwelling organisms.

So, the resulting oxygen-depth curve much resembles the temperature-depth curve.

KICKAPOO LAKE

At first glance the oxygen-temperature profile for this lake (see Table i) seems to be severely out of line, but upon closer examination the temperature curve seems to be all right. There is a well established stratification with the epilimnion extending to 1.5m, the metalimnion between 1.5 and 2.5m, and the hypolimnion starting at 2.5m. This lake has seemed to go through spring turnover and is now into summer stratification.

The dissolved oxygen curve shows the beginnings of a discontinuity in the metalimnetic region; however, a sharp increase from 5.3ppm to 7.2ppm is seen followed by a steep drop off in the concentration back to 3.8ppm in the hypolimnion.There are several factors or parameters which could be used to explain this protrusion on the graph. It could have been that this oxygen curve would have closely followed the temperature curve but something was producing oxygen at the two to three meter depth. Just as there are some zooplankton that may rest on top of the much denser hypolimnetic water and produce an exygen reduction through respiration, so may it also be that phytoplankton, or another photosynthetic organism, could have been sitting on the hypolimnetic water increasing the oxygen levels through photosynthesis.

However, when a new oxygen-temperature profile and a water sample were taken in this region on the following evening the same type of protrusion was seen, but no organisms were found in the sample.

Another uninvestigated possible explanation was that there may have been a richly oxygenated, more dense body of water either sitting or running through the lake. Without the point of entry or dyes it was impossible to determine this.

The most plausible of all explanations might be that during the spring turnover the oxygen level might have reached around the 7.3ppm level and that during stratification the epilimnetic waters were warmed and lost oxygen due to the increased temperature-decreased solubility relationship. This type of oxygen profile is known as an orthograde oxygen curve characterized by the layered epilimnetic oxygen level. The sharp drop off in deeper waters may be due to heavy bacterial respiration in the murky bottom waters.

<u>HUMMINGBIRD BOG</u>

The oxygen-temperature profile for this bog is much easier than that of Kickapoo Lake. (See Table ii). The temperature profile shows somewhat of a stratification but there is very little of any epilimnion and a wide metalimnetic region. This serves to make the epilimnion-hypolimnion ratio very small.

This lack of epilimnion might be due to the fact that this bog didn't go through spring overturn and as such the heat is less evenly distributed and only occurring in the surface water. The wind may have a greater whipping effect on this smaller body of water, causing the long, stretched out metalimnion.

Table v

KICKAPOO LAKE

Plankton Tow Count

AM

Organism	Organisms/ml
Dinobryon sp.	6300
Keratella cochlearis	2200
Asterionella	960
Oedogonium sp. (filaments)	500
Asplanchna sp.	260
Anabaena sp. (filaments)	220
Cyclops vernalis	120
Polyartha trigla	120
Volvox sp. (colonies)	60
Bosmina coregoni	60
Kellicotta longispina	20
Ceratium hirundinella	20

also seen but not counted; *Coelosphaerium sp.*

PM

Organism	Organisms/ml
Dinobryon sp.	8750
Asterionella	1600
Oedogonium sp. (filaments)	1400
Keratella cochlearis	1200
Asplanchna sp.	500
Cyclops vernalis	400
Peridinium sp.	40
Volvox sp. (colonies)	40
Diaptoma	20
Pinnularia	20

Table vi

HUMMINGBIRD BOG

Plankton Tow Count

AM

Organism	Organisms/ml
Asterionella	123984
Dinobryon sp.	7560
Peridinium sp.	581
Keratella cochlearis	540
Polyartha trigla	297
Bosmina coregoni	68
Cyclops sp.	54
Diatoma	54
Ceratium hirundinella	27
Canthocampus sp.	14

PM

Organism	Organisms/ml
Asterionella	254016
Dinobryon sp.	13162
Keratella cóchlearis	743
Peridinium sp.	189
Holopedium gibberum	162
Bosmina coregoni	135
Diatoma	68
Cyclops sp.	68
Tabellaria	14

IV General Discussion

When one looks at the two bodies of water, Kickapoo Lake & Hummingbird Bog, being studies, one immediately notes that they are not as totally different as their names imply. They are both fairly unproductive bodies of water, low in nutrient levels, conductivity, and alkalinity. They are also relatively soft watered bodies.

They could both be termed Oligotrophic, low productivity, bodies of water with, perhaps Kickapoo Lake bordering, because of its sloping bottom and surrounding macrophytes, on being an Eutrophic, high productivity, lake.

If one examines the plankton counts of the two bodies, then it is apparent that they are relatively similar by witness of the fact that they contain virtually the same organisms with little variance.

As to the future; I invision that Hummungbird Bog will gradually become a more characteristic bog and ultimately will develop the encircling sphagnum mat. But this process will be slowed down by the influx of water that Hummingbird receives from Bay Lake in the early spring across the lowland between them. Kickapoo Lake will eventually fill in with sediments and the grasses will choke off the lake to form a marsh.

But as to the real future, only time and a detailed, prolonged study will tell.

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Table 1

KICKAPOO LAKE

Oxygen-Temperature Profile

Depth	Temperature	Dissolved Oxygen
Surface	20.3°C	5.5 ppm
1m	20°C	5.5 ppm
1.5m	19.5°C	5.3 ppm
2m	14.5°C	7.1 ppm
2.5m	11°C	7.2 ppm
3m	11°C	3.8 ppm
3.25m	Bottom	

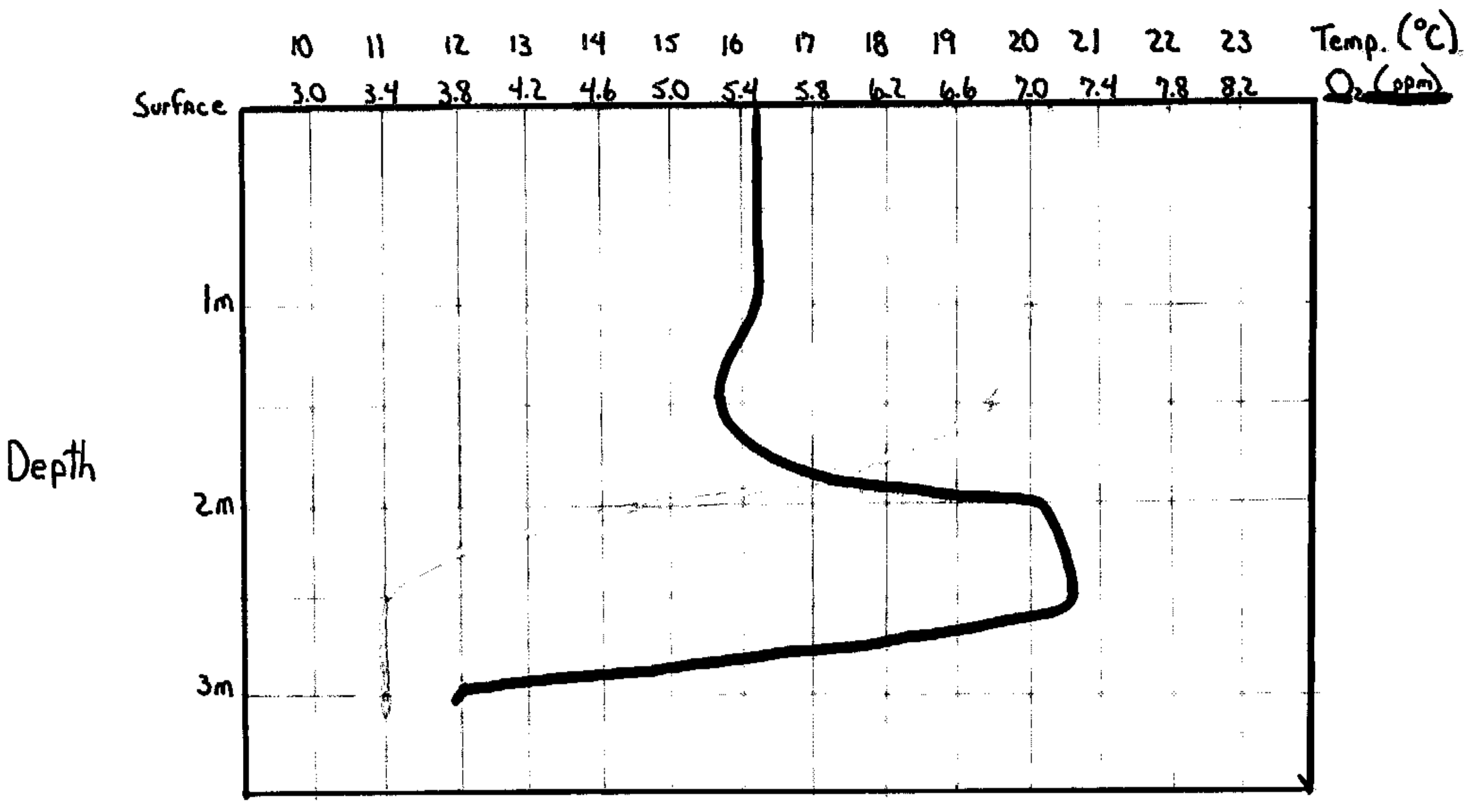
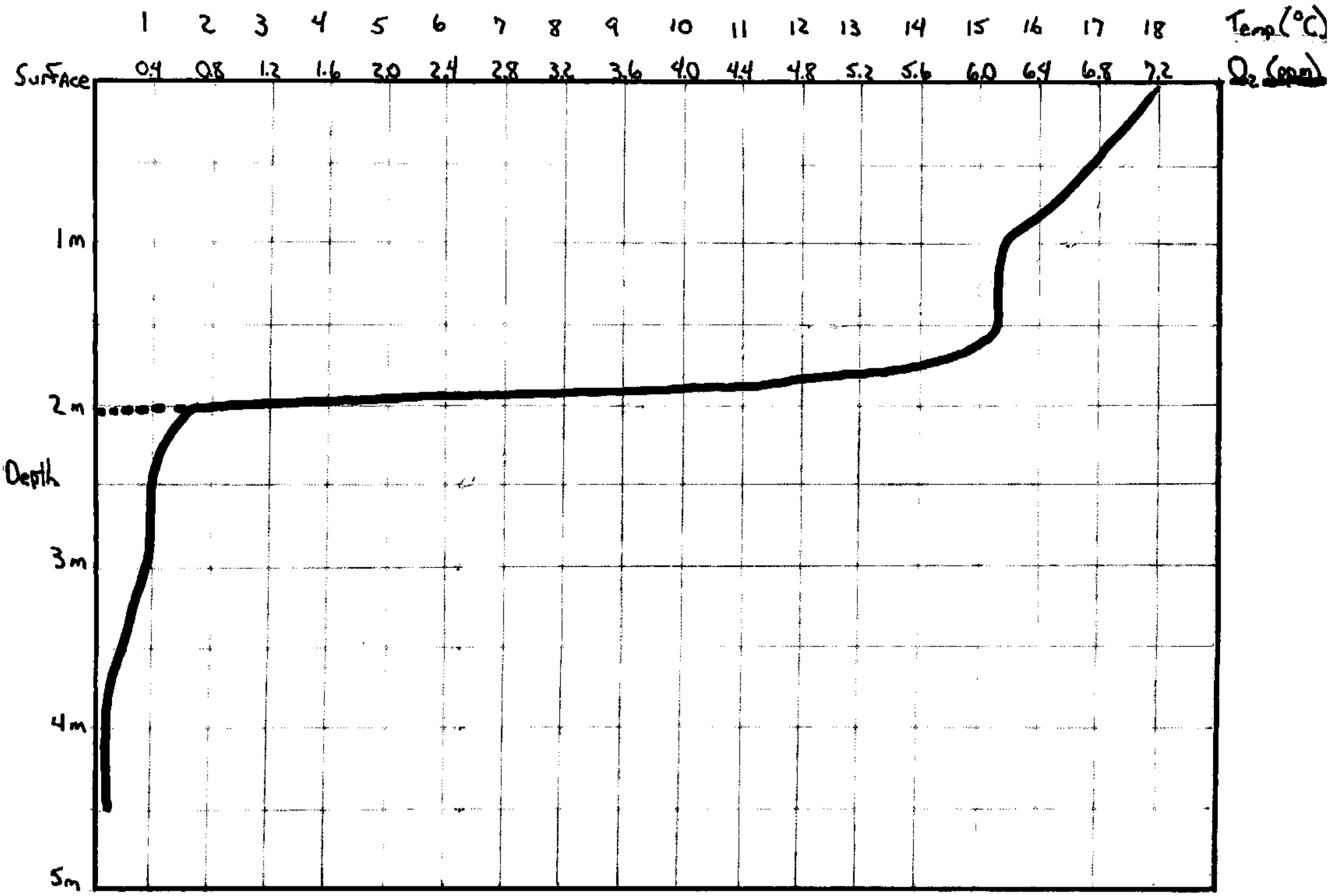


Table ii

HUMMINGBIRD BOG

Oxygen-Temperature Profile

Depth	Temperature	Dissolved Oxygen
Surface	18°C	7.2 ppm
1m	16.5°C	6.2 ppm
1.5m	12.1°C	6.2 ppm
2m	9.4°C	.7 ppm
2.5m	6.3°C	.4 ppm
3m	6.2°C	.4 ppm
3.5m	6.2°C	.2 ppm
4m	6.2°C	.1 ppm
4.5m	6.2°C	.1 ppm
5m	Bottom	



B Tests

In order to supplement our knowledge of the water chemistry of the bodies of water, it was necessary to perform the following chemical tests in addition to the oxygen-temperature profiles:

pH- This is a very self evident test for the hydronium ion concentration and is performed as soon as possible on the sample in order to prevent any equilibration with the carbon dioxide in the atmosphere. This is also why it is essential that when a sample is taken it be sealed with no air bubbles in the bottle.

It is an important test because it can give a general indication as to what type of body of water is being studied and what type of organisms can be expected to be found in it. The lethal pH limits are 4.5& 9 for most aquatic organisms, although some organisms are known to thrive at levels either higher or lower than these limits.

Acidity- Although closely associated with pH, the overall acidity is measured by titration with phenolphthalein as an indicator. Overall acidity is due to many factors; humic, tannic and uronic acids, and mineral acids.

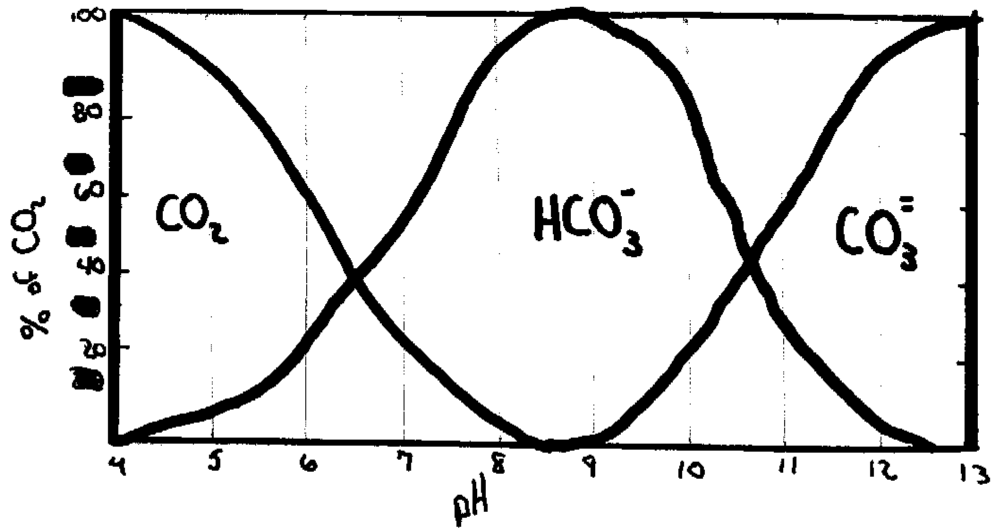
Alkalinity- The alkalinity of a sample is the measure of the buffering capacity of that water due mainly to the presence of bicarbonates, carbonates and hydroxides. The tests were performed as titrations to measure the presence of free HCO_3^-. However this test is misleading due to the pH affected equilibrium between the measured carbonate states(dig. 3). It can be seen that the buffering of a sample is due to the different states of the

$$H_2O + CO_2 = HCO_3^- + H^+ \underset{+OH^-}{\rightleftharpoons} CO_3^= + H_2O$$

reaction; at pH's lower than 6.5 the buffering capacity is due to

CO_2, at pH's between 6.5 & 10.5 it is due to HCO_3^- and at pH's greater then 10.5 the buffering capacity is due mainly to $CO_3^=$.

diagram 3



Since our methods a measuring alkalinity stem from the detection of HCO_3^- presence, it is quite possible to see how alkalinities of 0mg/1 are obtained in strongly acidic or strongly basic water samples.

Hardness- The term hardness is often used as an assesment of the quality of the water sample. The hardness of the water is governed by the content of calcium and magnesium salts.

In our test for total hardness, the calcium and magnesium were dyed and then precipitated out with a chelating agent. To determine the calcium hardness (the hardness due to calcium alone) the magnesium ions were first precipitated out using potassium hydroxide.

The magnesium hardness is calculated by the subtraction of the two predetermined quantities. There are several falacies in this method. Among them are that if one quantity (either the total or calcium hardness) is erroneously determined, the magnesium hardness is off as well.

Nitrate- The measure of nitrogen in a lake as nitrate is spectophotometrically determined. Nitrogen is important in lakes as a major constituent of much of the protoplasm of cellular material. and as such may act in a limiting capacity in lakes rich in phosohates.

Phosphate- The determination of total phosphate by titratable methods is an important segment of the determimation of the total nutrient supply of the entire body of water. It is quite often that it is phosphate that acts as the limiting quantity for various forms of life. Phosphate, in its varying forms, is utilized in a great variety of biological processes; respiration and photosynthesis.

The phosphate levels are also important in giving a somewhat general indication of what organisms will be able to exist in the waters being studied (e.g. Asterionella has a low phosphate tolerance level)

Specific Conductance- The specific conductance is measured as µmhos/cm by placing a probe directly in the sample. It is a measure of the ion content in the water and is temperature dependent because the release of ions into the water is increased with increased temperature.

Color- The color of a water sample is measured as specific units in a spectophotometer and is indicative of the amounts of particulate matter and chemical dyes in the water.

This test is useful in the indication of humic acids in the water. Humic acids are characteristic of bogs and stain the water a dark tea brown.

There are two measures of color. There is an apparent and true color measurements. The apparent is the measure taken directly off the sample while the true color is a measurement after the sample has been centrifuged to remove the particulate matter.

Secchi Disc- This test is performed at the sampling site and consists of lowering an alternately black and white, four segmented, weighted disc off the shaded side of the boat and measuring the depth at which the junction between adjacent segments can no longer be distinguished.

This test is closely correlated with the color test since it is the color and particulate content of the water that controls the depth of light penetration.

The Secchi Disc is designed to measure the depth of light penetration and is useful as an indicator of the presence of bottom macrophytes. The general rule-of-thumb is that at twice the depth of a Secchi Disc reading, 10% of incidence light or the photosynthetic threshold occurs.

H_2S- This test can be chemically done, but was actually performed by taking a bottom sample and sniffing for the characteristic hydrogen sulfide "rotten egg" smell.

The presence of this smell is indicative of bodies of water that don't experience overturn and is responsible for many very low level readings on an O_2 meter.

<u>KICKAPOO LAKE</u>

From the results (Table iii) it is apparent that this lake is only slightly acidic, with a pH of around 6.3 and low acidity readings of 40mg/l and 55mg/l. It is not uncommon to see the pH and acidity lower in the upper oxygenated waters because the high oxygen levels affect the hydronium ion release. It may also be that the mineral acids responsible for the high acidity readings are dense and settled out.

It is a relatively dark lake with apparent color readings of

60 and 40 and a Secchi Disc reading of 1.75m. It is interesting to note that the apparent color reading was higher in the first sampling depth. A possible explanation might be that there is more particulate matter or even more organisms suspended in the more turbulent epilimnetic water.

The fairly low alkalinity readings may be in part due to the fact that the pH is slightly below 6.5 and thus is on the lower portion of the HCO_3 curve of diagram 3 and the measurement is only of this lessened portion.

The Specific Conductance and Hardness tests show that this is a relatively ion rich soft water sample. The nutrient levels remain low in phosphate and nitrate with phosphate still the limiting nutrient.

HUMMINGBIRD BOG

As can be seen from the results of all the tests (Table iv), this bog is like other bogs in the respect that it displays a low pH of roughly 5.5. However, this is not as strongly acidic as some of the bogs investigated on the property whose pH may range down to 3.5.

The lowered pH is supported by the relatively high acidity levels of 70 and 80mg/l. If we examine the color levels we see that this bog is not as dark as it has been in past years, or as dark as other bogs are. One can interpret from the relatively low color readings of 40 and 30 and the deep Secchi Disc reading of 3.75m that this is a relatively clear bog and must not contain much humic acids, as darker bogs may. If it is not the humic acid content that is contributing to the high acidity readings, it must be other factors: possibly uronic or mineral acids.

There is little HCO_3 in the water due to the pH readings below 6.5, so any alkalinity measurement will come out to about 0mg/1, since most carbon is in the CO_2 form at these lower pH's.

Overall, the Specific Conductance and Hardness tests show this bog to be low in ions as well as the phosphate and nitrate nutrients.

Table iii

KICKAPOO LAKE

Sampled May 30,1978 from 10:00 am to 12:00 on a slightly overcast day. The air temperature was 21°C. Samples were taken at one and two meters from approximately the center of the lake.

Test	1m	2m
pH	6.2	6.4
Phenophthalein Acidity	40 mg/l	55 mg/l
Alkalinity	30 mg/l	20 mg/l
Hardness		
Calcium	30 mg/l	30 mg/l
Magnesium	15 mg/l	15 mg/l
total	45 mg/l	45 mg/l
Nitrate	.5 mg	.6 mg
Phosphate	.095 mg/l	.14 mg/l
Specific Conductance	73 µmhos/cm	69 µmhos/cm
Color	60	40
Secchi Disc	1.75 meters	
H_2S	Negative	

Table iv

HUMMINGBIRD BOG

Sampled June 1,1978 from 10:00 to 11:00 am on a sunny, clear day. The air temperature was 13°C. Samples were taken from one and three meters at the approximate center of the lake.

Test	1m	3m
pH	5.5	5.4
Phenophthalein Acidity	70 mg/l	85 mg/l
Alkalinity	0 mg/l	0 mg/l
Hardness		
Calcium	10 mg/l	10 mg/l
Magnesium	15 mg/l	15 mg/l
total	25 mg/l	25 mg/l
Nitrate	.4 mg	.6 mg
Phosphate	.1 mg/l	.175 mg/l
Specific Conductance	15 µmhos/cm	16.8 µmhos/cm
Color	40	30
Secchi Disc	3.75 meters	
H_2S	Negative	

III Plankton Study

Having investigated the physical and chemical compositions of these two bodies of water, we now turn our attention to how these chemicals and nutrients are assimilated into biological processes. Here we are primarily concerned with the primary producers in the food chain, the plankton. By definition the plankton are organisms that have weak swimming abilities and as such are subject to the whims of the currents. There are two primary classifications of plankton; those that are plant-like, phytoplankton, and those that are animal-like, zooplankton.

The planktons are by far the most numerous organisms in any body of water, inhabiting virtually every available niche. Because of the wide variety of niches inhabited by the planktons, special names habe been derived to label those organisms according to which space they occupy.

A number of specialized organisms, the pleustons, are adapted to inhabiting the air-water interface. The microscopic components of the pleuston are collectively termed neuston and are separated into those organisms adapted to living on the upper surface of the interface film (the epineuston) and those organisms living on the underside of the surface (hyponeuston).

There are also organisms adapted to growing or living in the sands of the bottom, the psammon.

The word periphyton originally was used to describe those organisms that lived on the plants inhabiting the bottom, but it now has been used to describe organisms that inhabit any part of the substrata. This general term has been subdivided into those organisms living on; a) the plant life (epiphytic) b) the rocky bottom (epilithic) c) the bottom sediments (epipelic) and

d) the water animals (epizoic).

It was our concern in this investigation to study over a twelve hour period those organisms that were planktonic or free floating in the waters of the body of water.

In examining the phytoplankton it can be seen that there is a definite relationship between the light intensity of the surrounding waters and the photosynthetic production expressed as mg C $_{fixed}/_{gFW/hr}$. This relationship shows that at the lower levels of light intensity the photosynthetic productivity increases expodentially as the light intensity increases to a point where the productivity levels off regardless of any increase in light intensity.

It can be seen that it is important for the phytoplankton to remain in the upper waters where the light intensity is greater. To remain suspended in the upper waters the phytoplankton must develop some form of buoncy mechanism. Among these mechanism. developed are; a) the formation of oil droplets b) gas vacuole formation and c) morphological changes such as spines and size adaptation and d) motility.

Although in a lot of cases the zooplankton exhibit a slightly greater motility than the phytoplankton, the still must adapt similar floatation mechanisms to keep them also in the upper waters. Since the phytoplankton are often found in the upper waters, so too will the zooplankton be found there feeding off the phytoplankton.

It was the object of our study to determine not only which types of phytoplankton and zooplankton are found in each of the two bodies of water, but also to establish their relative numbers relationships.

In order to accomplish this we took two samples of water, one in the morning and one at night, by doing an approximately two minute tow behind a boat with either a Wisconsin Net or a one and a half foot diameter plankton net at a moderate pace. One ml of the samples were then placed in Sedgwick-Rafter counting cells and placed under a phase microscope. In counting the organisms, one horizontal strip across the cell was counted and the numbers of organisms expressed as organisms/ml by multipling by the number of vertical fields of view in each cell.

Kickapoo Lake

If we examine the species lists for the a.m. and the p.m. plankton tows (Table v), we can see that there is not much variation in the organisms/ml for each species between the two samples. In taking an a.m. and a p.m. sample we had hoped to detect any diurnal migration of the organisms. However, only slightly higher numbers of organisms was found in the p.m. sample. There also is a disappearance of several organisms from the a.m. sample on the p.m. sample counting but they are not closely related and only occur in low numbers in the a.m. sample so they may have been uncounted in the p.m. counting.

In general it can be seen that the most abundant five or so organisms in the a.m. sample also occur as the most abundant five organisms in the p.m. sample with only slight changes in the order.

It is hard to draw any great relationships between the relative numbers of organisms becuase this study was only done over a twelve hour period and it is not unusual to see really high numbers of a particular organism over a short period of time. Some organisms experience these high bloom periods due to many conditional factors. In order to make this study more qualitative it would be necessary to have made the sampling over a more extended period of time to detect such factors as temperature-growth relationships. As an example, at 5°C the photosythetic productivity of the diatoms is greatest so there is a bloom of diatoms in the early spring just after the ice has left the water but as the water begins to warm to about 20°C the diatoms can't compete and the drop off and the blue-green alga flourishes. Then in the fall as the water begins to cool off , the blue-greens dwindle and another bloom of diatoms is seen.

An extended survey of the plankton community might also help detect any cyclomorphosis in organisms over the entire summer. The Cladocera experience cyclomorphosis more conspicuously than any other group. Cyclomorphosis is a gradual and sometimes quite drastic change in appearance of the organism over a seasonal period of sucessive generations. The exact cause, whether to increase buoncy as the water temperature rises or as a purely defensive measure as the predator population increases, is not exactly known.

Hummingbird Bog

When forst looking over the plankton tow counts for Hummingbird Bog (Table vi), they at first appear to be very similar to the counts for Kickapoo Lake. However, there is a marked dominance in the counts for the diatom Asterionella and the algae Dinobryon. The presence of these two organisms is indicative of bodies of water low in phosphorous levels as both of these organisms have low phosphorous tolerance abilities.

It is interesting to note that both of these organisms occur in almost doubled numbers/ml in the p.m. sample as in the a.m. sample, possibly suggesting they have a daily vertical migratory pattern.

The very interesting addition to the p.m. sample is the presence of the Cladocera _Holopedium gibberum_ which is found almost exclusively in bogs.

In general the plankton counts seem to have a relatively few species but they appear to be in pretty numerous quantities.

A –

Fishery Question

Stephen Durso
June 30, 1978

The task of doing a both quantitative and qualitative fish population study of Tenderfoot Lake near Land-O-Lakes Wisconsin is complex because of the public accessability to the lake. The fact that this lake has long been a favorite fishing spot for both the local and vacationing fisherman increases the difficulty of the task. Because of these facts, the placement of any collection gear must becarefully planned. The equipment itself must be well marked and easily visible from boat level. Another good suggestion might be a constant or at least prolonged surveillance of the equipment.

As monumentous as the task may seem at first, it becomes quite routine if properly undertaken. After obtaining the right permits from the proper authorities for the use of seining equipment, one is ready to begin.

For any type of population studies it is necessary to become acquainted with the area to be studied and even the population itself. This can best be done by making a semi-detailed search of the lake and its surrounding shorelines to determine the possible niches of the lake. It might be wise to do some preliminary selective sampling of the niches to determine their extent of population of the specific species inhabiting them. Of course timing the entire study is very important also. It does little good to do the study during nesting periods for there is little chance of catching numbers of fish during these periods as most of the sampling methods depend upon fish movement.

depth survey
Temp + DO survey

After studying the lake and selecting the sampling sites it might be wise to obtain background information that will be helpful in the final analysis. Among this collected information it would be well advised to do a complete water chemistry study of several different depths and sites around the lake.

A study such as this would be helpful in determining such parameters as pH, nutrient levels, and buffering capacities. Along with this water chemistry information, phytoplanktonic and zooplanktonic studies would be useful in determing the overall productability of the lake. This will tell if the lake is capable of sustaining a large population or not.

Before any placement of sampling equipment can be performed the perhaps single most important piece of background information should be obtained. That is to determine a temperature-oxygen profile at each selected site. The usefulness of this would be to give you a good indication of where the epilimnion and hypolimnion limits were.

In Tenderfoot Lake, I would begin the sampling with the placement of three experimental seine nets of fairly long lengths. (See map references). The first of the three nets would be placed in an east-west direction off the west side of Kilarney Point, almost on the Michigan-Wisconsin border, across the mouth of the cove, to determine any movement either into or out of the cove.

The second seine net would run in a north-south direction off the end of the point across the southwestern cove entrance to once again determine any movement into or out of the cove; it would also, hopefully, give a north-south population comparison with the first net.

The third net would be placed across the mouth of Tenderfoot Creek to determine the migration of any fish into or out of the creek. Another good spot would have been across the mouth of the Ontanogon River, but the heavy use of that river by the fishermen moving up from Palmer Lake would make that site impractical.

All seine nets would be placed just below the surface of the water, while still above the thermalcline because the lack of O_2 in the hypolimnion would make the chances of finding numbers of fish there minimal. The ends of these nets would be marked off with standing buoys and floating buoys would be placed at intervals along their lengths.

Along with these three seine nets I would propose to use four fyke nets. Two of these nets would be placed off Kilarney Point: one southerly and one easterly to utilize the grass and lilly beds there. The third and fourth nets would be placed in the grass beds to the north and south of the Notre Dame laboratory.

It would be a possibility to substitute a beach seine for either the third or fourth fyke net in one of the grass beds.

The nets would all be cleared of fish, or "ran", twice a day; in the morning and at dusk for three consecutive days.

Once the fish are brought in for analysis they should be treated separately for each net. The weight, fork and total lengths of each fish should be taken and recorded. In addition to determining this information for each fish, scale samples and intestinal tracts of approximately 30% of the fish gathered should be taken.

It would be possible to age the fish from the scale samples by counting the annular growth rings to determine an age-length relationship. This relationship could be compared to the relationships obtained for the same species of fish from the other nets or even to nationally published figures to determine how the fish from each area sampled fare. Another method of telling how the population under study is doing is to determine a condition factor for a representative form other nets or other sources. The method for determining the condition factor is:

$$c.f. = \frac{wt \times 10^5}{l^3}$$

where wt. is in grams and l is in mm.

The stomach analysis will tell you what your fish have been eating. Perhaps, why they are in the condition they are in.

In addition to these characteristics determined for each group of fish a bargraph can be constructed from length-numbers relationships to try to determine age groupings on the fish.

From the knowledge of where the nets were placed and what fish were caught in them, you should be able to determine what areas each species of fish prefer.

Ultimately you should be able to compare the population differences of the fish from one area to another and also see any migratory trends from the "running" of the nets at dawn and dusk. The cumulative knowledge gathered will tell you how the areial populations fare, how the entire lake fish population fares and how the entire aquatic community itself fares.

Tenderfoot Lake

(not to scale, nor Accurate)