plankton 8.5
fish – A

LAKE REPORTS

water chemistry and plankton analysis

Beaver Bog   Tenderfoot Lake

FISHERY REPORT

minnows, dace, stickleback, *Umbra*

Bolger Bog

UNDERC

Gogebic County, Michigan

May 28 to June 21, 1979

James Elser

Beaver Bog

General Description: Beaver Bog is typical of the bogs situated on the Notre Dame property. It lies relatively low with slight protecting hills to the north and south. The outer perimeter of the bog is heavily forested with evergreens (spruce) and deciduous trees (maples, aspen). Beaver's spaghnum mat is quite extensive; at the point of access, it extends for nearly forty yards. This bog mat supports a sizeable secondary plant population; pines of respectable size can be found on its outer limits, with tamarack being of much importance. The characteristic bog shrubs are present: bog rosemary, leatherleaf, and Labrador Tea. These extend very close to the open water in the center of the bog. Also prominent among the flora are pitcher plants and sundews.

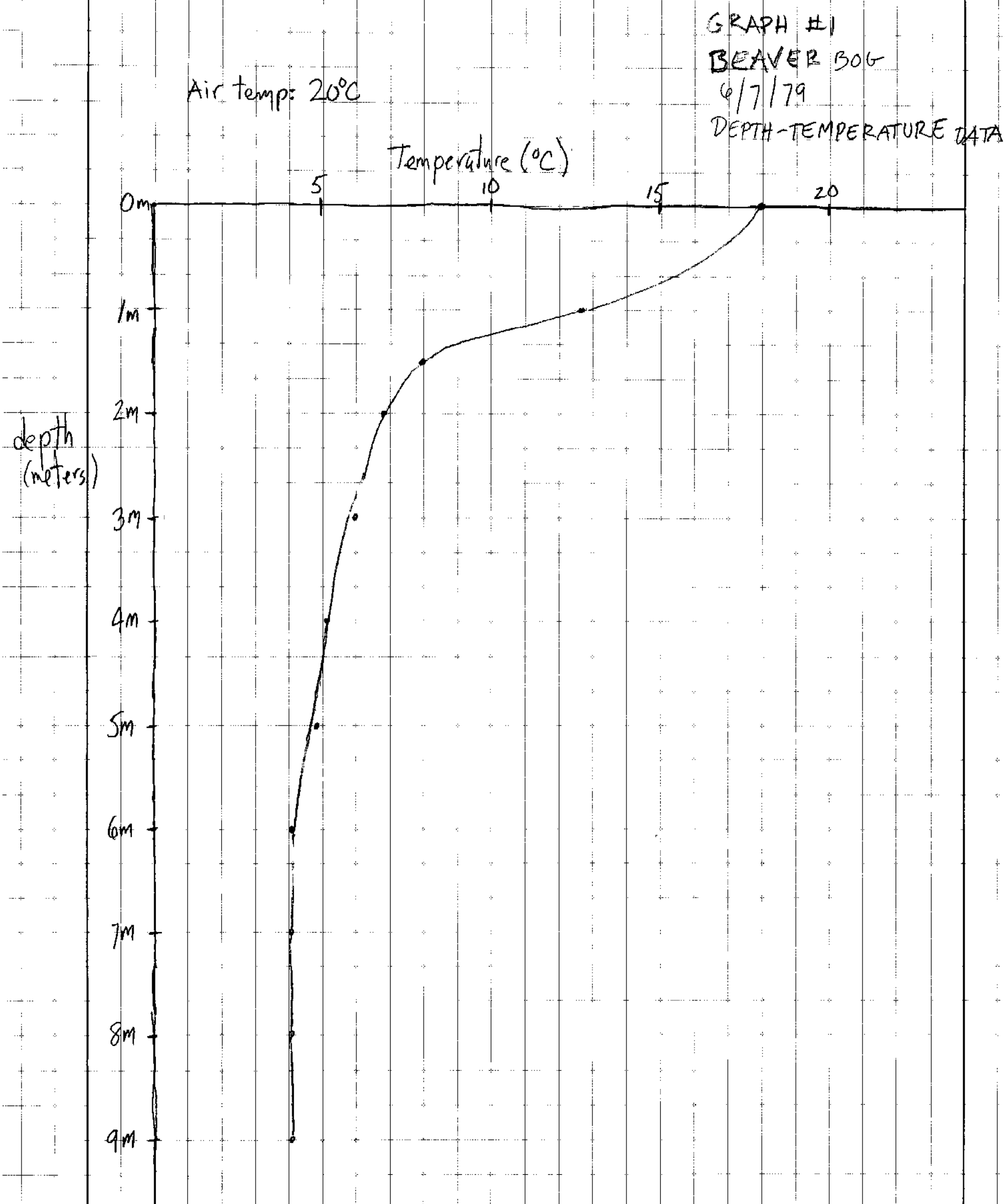
Beaver Bog, like most bogs, is not directly fed or emptied by any stream. It receives seepage and runoff water from its surrounding hills, and perhaps loses some water to Bog Pot to the south.

BEAVER BOG WATER ANALYSIS DATA
6/7/79

	surface	6 meters
Acidity:	155 mg/l	185 mg/l
Methyl Orange:	10 mg/l	<10 mg/l
Alkalinity:	<10 mg/l	<10 mg/l
pH:	3.2	3.7
Z_{SD}:	1 meter	
Color true:	125 units	225 units
apparent:	150 units	230 units
Conductance:	29 μmhos/cm	41 μmhos/cm.
Hardness Ca^{++}:	7.5 mg/l	7.5 mg/l
Mg^{++}:	2.5 mg/l	10.0 mg/l
total:	10.0 mg/l	17.5 mg/l
Nitrate:	0.9 mg/l	1.5 mg/l
Phosphate:	0.3 mg/l	0.73 mg/l
H_2S:	+	+++

Temperature Profile:

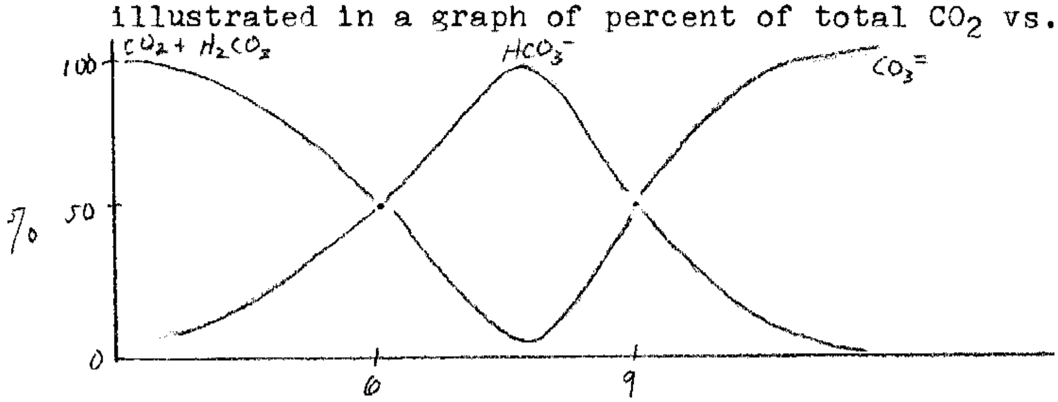
air:	20°	4m:	5.2°
surf:	18°	5m:	4.9°
1m:	12.7°	6m:	4.2°
1.5m:	8.0°	7m:	4.1°
2.0m:	6.9°	8m:	4.2°
3.0:	6.0°	9m:	4.1°


GRAPH #1
BEAVER BOG
6/7/79
DEPTH-TEMPERATURE DATA
Air temp: 20°C
Temperature (°C)
5
10
15
20
0m
1m
2m
3m
4m
5m
6m
7m
8m
9m
depth (meters)

Discussion: The water chemistry of Beaver Bog shows most of the characteristic features of bog ecosystems. Most prominent among these are two inter-related characters: low pH and low water hardness (particularly Ca^{++}). The low values for these two parameters can be explained by reference to the spaghnum uronic acid ion exchange mechanism. When runoff water enters a bog, it first percolates through the spaghnum mat. There, the spaghnum uronic acids exchange protons for the Ca^{++} ions present in the runoff as calcium sulfate. ($2COOH + Ca^{++}SO_4^{=} \rightarrow 2COO^{-}Ca^{++} + H_2SO_4$) Thus, Ca^{++} ions become bound up in the bog mat, and protons are donated to the water. In a bog which has a large spaghnum growth, such as Beaver, this reaction takes on great importance. Even dead spaghnum has been shown to act as an ion exchanger. H_2SO_4 can depress the pH of a bog so far that neither carbonic acid nor humic acids can disassociate.

The data support this explanation. The acidity (proton donating capability) is rather high- 155, 185 mg/l and the calcium concentration is quite low (under 10 mg/l).

However, the acidity of a water sample is not solely responsible for the pH. The presence of buffering agents in the water is a key factor in the resultant pH. Carbonates formed by the reaction of water and carbon dioxide: $H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + \underline{HCO_3^-} \rightleftharpoons H^+ + \underline{CO_3^=}$ are crucial as buffers, binding free protons and driving the equation to the left. This relationship is well illustrated in a graph of percent of total CO_2 vs. pH.



Note that at a low pH, most of the CO_2 is present as that or as undisassociated carbonic acid. Thus, in a highly acidic bog, there is a high concentration of free CO_2 and a low concentration of bound HCO_3^-, and $CO_3^{=}$. Beaver Bog has both a low pH and a low alkalinity.

A water sample, thus, can have a high acidity but still have a high pH if the sample has a large buffering capacity. Beaver Bog, as well as many of the other bodies of water on the property, does not have a large buffering capacity (alk.< 10 mg/l). This is reflected in the low calcium hardness (little calcium carbonate). Geological factors are important in explaining the low buffering capacity of these bodies of water. The upper Wisconsin-Michigan peninsula area is underlaid mainly by a bed of granite. This contributes little to the buffering capacity of the ground water. On the other hand, an area with a limestone underlayer would be populated by lakes with large alkalinity readings. In addition to the proton sources of H_2SO_4 and carbonic acid, bog pH can be lowered by humic acids, resultant of decomposition of plant materials and present in the runoff.

Beaver Bog has a Secchi disk reading of only one meter and relatively high color readings of 125 and 225 units (true color). These properties, along with its tea-colored appearance, are also typical of bog systems. Both low pH and low Ca^{++} concentrations have been shown to be severe limiting factors in microbial breakdown of organic matter. Therefore, in a bog, much undecomposed organic substance remains in suspension, greatly limiting light penetration. This is partly responsible for the Secchi disk reading. In addition, the peat deposists of the spaghnum mat contribute much to the colloidal suspension of organic matter.

The tea-like color of the water samples taken from Beaver Bog is partly the result of this colloidal suspension and partly the result of humic acids in solution, (mentioned earlier with respect to pH). Humic acids are produced from plant materials by bacterial enzymes. They are polymeric mixtures of phenols, quinones, and amino compounds, with an abundant distribution of the carboxyl radical. As Beaver Bog is fed by runoff, and is low in bacterial efficiency, these acids accumulate and lend a brown tint to the water.

When the depth and temperature data are graphed (graph #1), a sharp thermocline curve is described. The epilimnion is very shallow, extending perhaps to only one meter. After one meter, the temperature drops rather rapidly to a minimum of 4.1°. This is a pronounced example of thermal stratification, and a classic characteristic of a bog ecosystem.

Thermal stratification in a bog is primarily a result of the encroaching bog mat. In the winter, when open water is frozen, a fairly constant temperature is found at all depths (or perhaps inverse stratification occurs). In the spring, when the ice melts and air temperature rises, the upper layers of water become warmer. Because water becomes more dense approaching 4° from above (and less dense thereafter), the upper layers continue to warm, while the lower layers remain cold. Eventually, a temperature profile similar to graph #1 results. In the fall, however, as the air temperature cools, the wind removes heat from the upper layers, cooling and stirring them, and thus increasing their density. The upper layers and lower layers can then mix, and the event known as the fall turnover occurs.

However, in a bog with an extensive spaghnum mat, not much water surface is exposed to the wind. It has been shown that a set of water samples at 27° and 26° require more work to be mixed than a set at 5° and 4°. So, in a bog, the heat removed by the wind is not sufficient to mix the water. This phenomenon is encouraged if the bog pond is well protected by surrounding hills and trees, as Beaver Bog is. A further difficulty preventing bog turnover is the small epilimnion/hypolimnion ratio. There is simply too much water to be mixed for the small area available for heat loss. Thus, bogs rarely, if ever, turn over.

Thermal stratification has great effects on the bog's water chemistry. Since the water is never mixed, the lower layers of water never receive contact the atmosphere and cannot become oxygenated. This problem is compounded by the low photosynthetic activity in the bog resultant of its high acidity and low light penentrance- severe limiting factors for algal growth. As a result, there is no oxygen in the bog water other than in the uppermost parts of the epilimnion. Obviously, aerobic bacteria cannot function due to the low O_2 concentration, pH, and Ca^{++} concentration. Dead vegetable and animal matter sinks to the bottom, where it remains or is decomposed by inefficient anaerobic bacteria, also somewhat limited by the pH and $[Ca^{++}]$. In this process, hydrogen sulfide (H_2S) is produced, which is responsible for the strong rotten egg odor given off by the samples, particularly the six meter sample. Thus, because of the lack of turnover and aerobic bacterial action, nutrients remain tied up and unused in the bottom of the bog (c.f. peat deposits). This is reflected somewhat in the nitrate and phosphate data, in which the concentration of each in the hypolimnion is seen to be nearly double that of the epilimnion. Because of this lack of nutrient recirculation, bogs are allotrophic.

In Beaver Bog, low pH, low buffering capacity, high acidity, soft water, and pronounced thermal stratification are all present. These characteristics are typical of the dystrophic ecosystem.

Plankton Analysis

Phytoplankton

Genus List:

Diatoms-	Cycotella	Fragilaria	Cymbella
	Astrionella	Melosira	Navicula
Desmids-	Cosmarium	Penium	
Blue Green-	Anabaena	Raphidiopsis	
Green-	Ulothrix	Microspora	Staurastrum
	Chodatella	Spyrogyra	Vaucheria
Flagellated-	Dinobryon (very many)		

Discussion: Conditions in a bog are not favorable for algal growth. The high acidity and low concentration of free ions (Ca^{++}, Mg^{++}, etc.) all place limitations on the extent to which algae can survive. In addition, light penetration is severely limited by suspended solids and solvated substances. Algae can receive sufficient light to conduct photosynthesis only in the uppermost layers of the water; in the case of Beaver Bog, perhaps at most the upper two meters. In addition, the algae is restricted to the small area of water actually exposed in the center of the spaghnum mat. Thus, algae are not only limited by harsh chemical factors but also by the physical parameter of poor light penetration. Primary production is severely limited, and, in fact, much of it probably occurs in the spaghnum mat itself.

These harsh conditions are reflected in the relative sparcity of algae in both kind and number in Beaver Bog. Green algae were found very infrequently; of these Ulothrix and Chodatella were most common, but even these were limited in number. The Cyanophyta, or blue green algae, were somewhat more common, but still were rather scattered. Of the Cyanophyta, Raphidiopsis was most frequent. Two genera of desmids, Cosmarium and Penium, were observed somewhat frequently. In general, desmids seem to fare better in dystrophic waters than other algal families, due to their ability to cope with low concentrations of calcium and magnesium. Several genera of diatoms were seen, though not in tremendously great numbers. Of these, Astrionella was most common. However, by far the most common algal type present in Beaver Bog was the colonial, flagellated algae, Dinobryon. It was seen in rather large numbers in every sample examined, far outnumbering all other types.

Thus, in Beaver Bog, it is apparent that primary productivity is severely limited. Harsh chemical and physical conditions are responsible for this deficiency, which, of course, has a subsequent effect on the zooplankton and higher animal populations.

Zoolankton

Genus List:

Rotifers-	Polyarthura	Keratella cochlearis
	Asplanchnopus	Keratella quadrata
	Brachionus	
Copepods-	Diaptomus and larvae	
	Cyclops	
Cladocera-	Pleuroxus	Bosnia (only in P.M. sample)

Malacostraca, Isopod: Lirceus

Chaoborus larvae- found in A.M. 6 meter sample and P.M. surface tow only.

As with the algae, the bog ecosystem is not favorable for the existence of zooplankton, which includes the rotifers, cladocerans, copepods, malacostracans, and various insect forms such as Chaoborus larvae. It is severely limited by the harsh chemical factors, particularly the low oxygen concentration. The very low primary productivity is also crucial in limititing the zooplankton population. Because most of these organisms feed on algae or on the algae feeders, a sparse algal population leads only to a sparser zooplankton population. It is typical of bogs that phytoplankton far outnumber the zooplankton.

Only one Malacostracan was observed, an isopod: Lirceus. Copepods were likewise scarce, though less so, and only Diaptomus and Cyclops were discovered, as well as their larvae.

The Cladocera and Chaoborus were also scarce, but exhibited an interesting phenomenon of zooplankton. Cladocera (such as Bosnia and Pleuroxus), were found only in the night sample. The Chaoborus were found only in the morning 6 meter sample and in the P.M. surface tow. These observations are manifestations of diurnal migration of zooplankton. During the day, certain organisms, such as some of the Cladocera and Chaoborus, remain in the lower reaches of the hypolimnion. After sunset, they rise to the upper layers to feed on microcrustaceans, rotifers, and algae. Chaoborus accomplish this journey by an expansion of the pigment cells that constitute the walls of their gas bladders. This enlarges the sacs, lowers their density, and allows them to rise.

By far, the most common type of zooplankton found in

Beaver Bog was the rotifer. Four genera were observed, the most common being Polyarthra. Keratella (both cochlearis and quadrata) were also found in rather high numbers. The predaceous genus Asplanchnopus, which, because of its greater size, can feed on other rotifers, was also discovered. This relatively high number of rotifers in the zooplankton samples is typical of bog microfauna.

Tenderfoot Lake

General Description: Tenderfoot Lake is the largest lake on the Notre Dame property, with a surface area of 181.9×10^4 m^2. It has a fairly long shoreline with several bays and peninsulas. For the most part, however, it is a broad, open lake, as opposed to Bay Lake which is much narrower and limited by its peninsulas and inlets.

Tenderfoot Lake is varied in depth. Samples were taken near the bottom of all sites, with sample depths varying between 2.5 meters (site 4) and 9.5 meters (site 5). This variation of depth is manifested by reed beds which line the northeast corner of the lake, often extending quite a distance from the shore. Despite these reeds beds, the deepest sites sampled were on the eastern half of the lake.

The shoreline of Tenderfoot Lake is lined with varied vegetation. In some areas, pine are most common, in others, maples are prevalent, and in others, birch. In all areas, however, the surrounding forest extends right up to the shore line.

The lake is fed from the southeast by the Ontagon River, which arises from Palmer Lake. Tenderfoot Creek drains the lake to the north. The lake supports many fish, including walleye, pike, crappie, perch, bass, sunfish, and assorted minnows and smaller types.

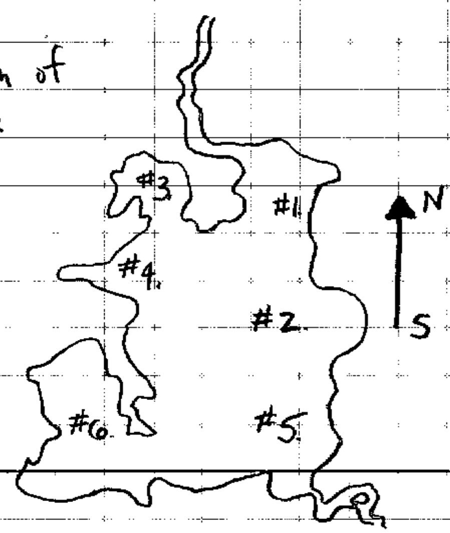
TENDERFOOT LAKE DATA
6/8/79

site:	#3, 4m	#4, 2.5m	#6 surf.	#6 4m	#1 surf.	#1 7m	#2 surf.	#2 9.5m	#5 surf.	#5 9.5m	
Acidity	96	87	86	87	85	105	80	125	90	85	(mg/l)
Alkalinity	33	37	32	29	40	40	50	40	40	40	(mg/l)
Color true:	45	45	45	45	50	50	25	50	40	50	(units)
apparent:	50	50	60	50	60	70	50	60	50	70	(units)
Conductance:	89	85	86	85	100	85	85	85	85	82	(µmhos/cm)
Hardness Ca^{++}:	40	40	40	40	25	30	30	30	35	30	(mg/l)
Mg^{++}:	20	10	20	20	20	15	10	15	10	10	↓
total:	60	50	60	60	45	45	40	45	45	40	
Nitrate:	0.45	0.25	0.5	0.5	0.4	0.5	0.7	0.6	0.7	0.6	(mg/l)
Phospate:	0.31	0.25	0.33	0.36	0.1	0.08	0.17	0.06	0.08	0.09	" "

pH: 6.3

H_2S: none

location of sites:



Tenderfoot Lake (cont'd.)

Temperature Profile: (6/3/79)

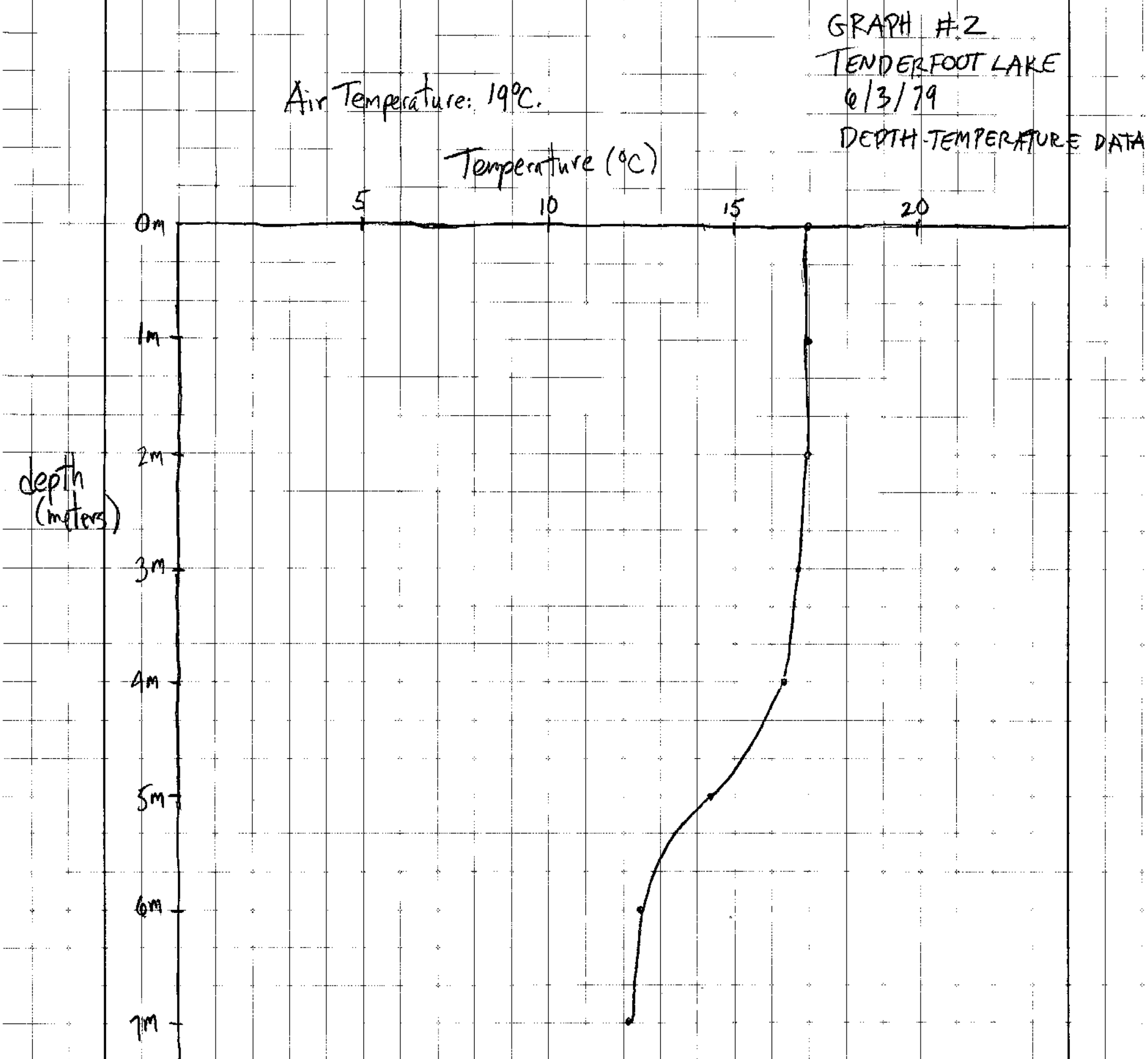
air:	19°	6m:	12.0°
surf:	17.9°	7m:	11.5°
1m:	17.8°	8m:	11.0°
2m:	17.0°	9m:	10.5°
3m:	16.0°		
4m:	15.2°		
5m:	13.5°		

Chlorophyll Study:

depth	[chlorophyll]
0.5m	3.2 mg/m³
3.0m	1.68 mg/m³
4.0m	9.925 mg/m³
5.0m	80.4 mg/m³
6.0m	142.9 mg/m³

Productivity Study:

depth	P (mg/m³/hr)
0.5m	1.446
3.0m	1.95
4.0m	0
5.0m	3.5
6.0m	0


GRAPH #2
TENDERFOOT LAKE
6/3/79
DEPTH-TEMPERATURE DATA
Air Temperature: 19°C.
Temperature (°C)
5
10
15
20
0m
1m
2m
3m
4m
5m
6m
7m
depth (meters)

Discussion: Tenderfoot Lake was sampled in various areas and at various depths. The pH of the lake was taken at various times between June 3 and June 14, and was found to have an approximate value of 6.3. This value is easily substantiated by the acidity and alkalinity data. The most common acidity value of the samples taken was 90 mg/l, with a low of 85 and a high of 125. These values are not especially high, and when viewed in light of the alkalinity data (30-40 mg/l), indicative of the sample's buffering capacity, the intermediate pH value is easily understood. This milder pH is more hospitable to both planktonic populations and microbial activity.

When the pH of Tenderfoot was taken in 1975, it was a bit higher- 8.2. This lowering of pH is part of a general trend in many lakes both on the property and across the country. In industrial areas, particularly ones in which steel mills, refineries, and factories that burn coal are present, sulfur dioxide is a major component of air pollution. When SO_2 comes in contact with water, it reacts to form sulfuric acid. This acid then can return to earth in the form of rain and snow. Thus, bodies of water, even those far removed from industrial areas, can have their acidities increased in this manner. The manufacturing city of Duluth to the west of the property is perhaps responsible for some of Tenderfoot's pH change.

The Secchi disk reading for the lake was a reasonably clear 3.2 meters. The color data (50 units) are consistent with this reading. The relative clarity of the lake water is important in that light penetrance is perhaps as high as 6.5 meters, and, thus, in fairly shallow areas, light is available to algae at all depths, as well as to benthic vegetation. Primary productivity is much improved in these clearer waters.

The Tenderfoot samples showed total hardness values between 40 and 60 mg/l. This hardness is somewhat indicative of the higher alkalinity. More importantly, this calcium concentration facilitates microbial activity, allowing nutrients to be broken down and recycled. The hardness data are substantiated by the specific conductance value of 85 μ hmos/cm (a measure of the level of ionized material in the sample).

Graph #2 is the temperature profile drawn from readings taken on June 3. A fairly clear thermocline is observable, with the temperature dropping off fairly rapidly after four meters, to a minimum of 10.5° at nine meters. Because this minimum is much warmer than 4° (the normal minimum in a stratified body of water), Tenderfoot Lake can not be a lake that remains stratified for a very long time. In fact, it most likely turns over in both the spring and fall, an assertion supported by a temperature profile taken a week later, in which the temperature is nearly uniform at all depths.

The physical dimensions of the lake make it simple to explain its turnover pattern. It is a broad, open lake with much surface area from which heat can be removed. In addition, the lake's epilimnion/hypolimnion ratio is not small, as evidenced by the thermocline which breaks approximately at the midpoint.

Tenderfoot is a well-mixed lake, as is clear after examining the various data from surface samples and those at lower depths. There seems to be an even distribution of nutrients (see nitrate and phosphate values), as well as components that contribute to acidity, alkalinity, and hardness. This thoroughness of mixing is important with respect to oxygen levels in the lake, and it is likely that if O_2 concentration data could have been collected, oxygen would have been present throughout the water column, even at the bottom. The presence of oxygen at these depths allows the efficient aerobic bacteria to operate, and, thus, dead organic matter can be decomposed and recycled. Therefore, Tenderfoot is essentially autotrophic. The absence of H_2S in the samples is indicative that anaerobic bacteria are not operating.

On the whole, the chemical and physical conditions of Tenderfoot Lake are rather mild and favorable for the growth of organisms. This is evident in the planktonic populations in the lake.

Plankton Analysis

Phytoplankton

Genus List:

Blue Green- *Anacystis* *Anabaena*
Anthrospira *Rivularia*
Entophysalis *Oscillatoria*

Green- *Sphaerocystis schroeteri*
Coelastrum *Volvox*
Hydrodictyon ?

Diatoms- *Astrionella* *Fragilaria*

Flagellates- *Ceratium*

Discussion: The mild pH, relatively clear water, and more bountiful nutrient supply are all favorable for algal populations. This becomes clear when both the number and types of phytoplankton are examined.

Six genera of cyanophytes were observed. Of these, the coccoid form *Anacystis* and the filamentous *Anabaena* were most frequent. Green algae were very common. There were four genera of coccoid types in the samples; *Sphaerocystis schroeteri* and

Coelastrum were found most frequently. The filamentous *Tribonema* was also present. Diatoms were observable in high frequency, and the centric genus *Astrionella* was most common. In addition, to these non-motile types, the Dinoflagellate *Certium* was quite common.

Two studies were performed on Tenderfoot Lake to determine its primary productivity. The first, a quantitative chlorophyll determination, ascertained a high concentration of photosynthetic organisms at five and six meters. It is possible to explain this observation if the Secchi disk reading, the day's weather conditions, and the temperature profile are considered. The Z_{sd} was 3.2 meters, which means that light is available to perhaps almost seven meters. The samples were taken at noon on a cloudless day, a time of maximum light intensity. Algae have been shown to migrate vertically in response to varying light conditions in order to receive the optimum intensity and to avoid the damaging effects of ultraviolet light. Due to the high availability of light at the time the samples were taken, it is possible that the algae had migrated to the 5 meter depth. Also, the depth-temperature data indicate a thermocline at five and six meters. It is also possible that the algae were resting on a density gradient. These results were collaborated by the C^{14} study, in which water samples taken at various depths were supplied with radioactive carbon in the form of $Na^{+}{}^{14}CO_3^{=}$, and returned to their depths. The amount of radioactive carbon fixed was then determined. A peak of fixed carbon was found at five meters, similar to the results of the chlorphyll study.

Zooplankton

Genus List:

Rotifers- *Keratella cochlearis*

Brachionus

Asplanchnopus

Cladocera- *Daphnia pulex* (very many)

Bosmina

Copepods- *Nauplii* and larvae

Diaptomus

The high level of primary productivity in Tenderfoot Lake makes possible a large population of primary and secondary consumers. This is reflected in the abundance of zooplankton in the tow samples.

Rotifers were found in fairly large numbers, particularly *Keratella cochlearis*. Also observed was the secondary consumer *Asplanchnopus*. Copepods were found in high frequency, especially *Nauplii* and their larvae. However, the most bountiful zooplankton type was the Cladocera. *Bosmina* was seen often, but was far outnumbered by *Daphnia pulex*. The Cladocera were so concentrated that they nearly clogged the plankton net.

This profundity of zooplankton is very favorable for the existence of organisms that feed on them. This is reflected in the numbers and types of minnows and smaller fish, and subsequently, predatory fish such as pike present in the lake.

Lake Comparasions

After close examination of both sets of data, it is apparent that the quantitative differences in the water chemistries of the two bodies of water have led to qualitative differences in the types of ecosystems supported by them. In Beaver Bog, the low pH, soft water, and low O_2 concentration all contribute to making the water unfavorable for the existence of organisms. In addition, these conditions prevent the operation of aerobic bacteria. However, in Tenderfoot Lake, the conditions are much milder: a higher pH, harder water, and oxygenated water are all present. Because of the limited light penetration and inavailability of nutrients in Beaver Bog, primary productivity is severely limited. This is not true of Tenderfoot, where clearer water and more abundant carbon, phosphate, and nitrate sources are available. Tenderfoot Lake is therefore far more productive.

This disparity in water chemistry between the two sites produces a quantitative and qualitative differences in the life forms present in both. Algal species are much more abundant in both kind and number in Tenderfoot. Thus, more consumers can be supported, as indicated by the large numbers of Cladocera and other zooplankton present in Tenderfoot's tow samples.

This comparasion of the data from the two sites effectively demonstrates the differences between a dystrophic system (Beaver Bog) and a eutrophic lake (Tenderfoot). In Beaver Bog, low pH, harsh chemical stratification, and uncirculated nutrients all lead to low productivty and scarce amounts of zooplankton and higher animals. Tenderfoot Lake, on the other hand, with its mild chemical and physical conditions and higher nutrient availability, is characterized by high productivity and ample amounts of zooplankton, higher invertebrates, and fish.

Fishery Report

Bolger Bog

June 20, 1979

Minnows, Dace, Umbra, Sticklebacks

Species List:

		#
Pimphales notatus	(blunt-nosed minnow)	2
Eucalia inconstans	(brook stickleback)	5
Umbra limi	(central mudminnow)	5
Chrosomus eos	(Northern redbelly dace)	very many

Data: Eucalia inconstans (5 specimens)

K = condition factor
length = true length → ?

1. 50mm, 0.9 gms, K = 0.72
2. 60mm, 1.8 gms, K = 0.83
3. 49mm, 1.0 gms, K = 0.85
4. 47mm, 1.0 gms, K = 0.96
5. 56mm, 1.6 gms, K = 0.91

Umbra limi (5 specimens)

1. 80 mm, 4.7 gms, 3 yrs. old, K = 0.92
2. 76 mm, 4.5 gms, 3 yrs. old, K = 1.02
3. 78 mm, 4.9 gms, 3 yrs., K = 1.03
4. 100mm, 8.8 gms, 4 yrs., K = 0.88
5. 56 mm., 2.0 gms., 1 yr., K = 1.13

Chrosomus eos (11 specimens)

1. 50 mm 1.0 gm K = 0.8 age = 3 yrs.	2. 67 mm 2.6 gms K = 0.7 age = 5 yrs	3. 57 mm 1.9 gms K = 1.02 age = 4 yrs	4. 62 mm 2.1 gms K = 0.88 age = 4 yrs.	5. 62 mm. 2.2 gms K = 0.92 age = 4 yrs.
6. 49 mm 1.2 gms. K = 1.0 age = 3 yrs.	7. 48 mm 1.1 gms K = 0.99 age = 3 yrs.	8. 53 mm 2.2 gms K = 1.5 age = 4 yrs.	9. 49 mm 1.2 gms K = 1.02 age = 3 yrs.	10. 50 mm 1.3 gms. K = 1.04 age = 3 yrs.
11. 53 mm 1.4 gms K = 0.94 age = 4 yrs.				

Bolger Bog is fairly typical of the bog ecosystems on the property. It is surrounded by an extensive spaghnum (sp.?) mat, and the typical bog fauna are present (tamarack, leatherleaf, etc.). However, it seems to be a milder environment than some of the other bogs. Its pH (5.4) is somewhat less acidic than other bogs, most of which have pHs in the 3.7- 4.5 range. Thus, conditions seem to be more favorable for both algal and zooplanktonic populations, as well as for bacterial activity.

This fish examined in this report, blunt-nosed minnows, sticklebacks, mudminnows, and dace, are all smaller fish, and, in a complete food chain, would be a link between the micro-organisms and the higher consumers.

All of the fish observed are consumers of plankton. The dace are important consumers of algae and diatoms, while all four types feed upon the cladocera, copepods, and other components of the zooplankton. In addition, both the larval and adult forms of aquatic insects are important elements of the diets of these fish. Gut analysis of one of the stickleback specimens revealed a number of Trichoptera larvae.

As was stated before, these smaller fish would be important in the diets of predators such as pike, bass, and perch. However, the nature of Bolger Bog makes it impossible for such vigorous fish to survive. Oxygen concentration is too low, and the general inavailability of food due to low productivity characteristic of bogs prevent the survival of such fish. Reports of rather large shiners and suckers in Bolger Bog have been made. This is possible since these are less vigorous fish whose diet consists mainly of plant foods, plankton, and aquatic insects. While they occasionally feed on small fish, it is not likely that they are efficient enough to capture significant amounts of dace, sticklebacks, and mudminnows in the tangled bog mat. Thus, it is unlikely that the fish examined in this study face extensive predation in Bolger Bog.

That predation is not extensive in the bog is supported by the age data. Several four year old and one five year old dace were recorded. The dace's maximum life span is around five years. In addition, several three and four year old Umbra were captured, these also near the ends of their life spans. Younger fish (1-2 years) of all types were not observed, with one exception- a mudminnow. This is not because spawning had not occurred for two years, but merely that the openings in the trap were too large to contain the smaller fish.

Dace, stickleback, and mudminnows are all well-suited for the bog habitat. The chief items in their diets are present: algae and zooplankton, as well as aquatic insects. All three show a preference for boggy, heavily vegetated waters. This is reflected in the condition factors for the specimens, which are normal or above normal for these species in this area.

However, the presence of the blunt-nosed minnow in Bolger Bog is somewhat puzzling. The literature states that this minnow prefers the sand and gravel shallows of clear lakes and ponds. It is possible that the fish was incorrectly identified, but if it was not, it is possible that this fish could survive in limited numbers in Bolger Bog. In order to escape the large amounts of predators present in clearer waters, the blunt-nosed minnow could live in the upper layers of the bog, where a reasonable amount of food is available. The less harsh chemical conditions in this bog make this more possible. However, confirmation of identification of the specimens is actually in order, though impossible.

Thus, in Bolger Bog, the food chain is shortened. The small fish studied in this report are at its peak, feeding on the producers (algae), and the primary and secondary consumers (zooplankton and insects). However, due to the somewhat rigorous physical and chemical factors in the bog, these fish do not fall prey to larger predators, as they would in a normal lake or running stream.

Good job! Thanks, Dee Flagan