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Photo. of Hummingbird [illegible]

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Aquatic Research of Lake Environments

Hummingbird Lake
&
Raspberry Lake

Not eutrophic!

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U.N.D.E.R.C.

A broad definition of Limnology is the study of fresh water and its inhabitants. The data collected from two lakes, Hummingbird and Raspberry, will be discussed in accordance with this general definition. All data was recorded between July 25 and August 19, 1983, in Land O'Lakes, WI, the property of the University of Notre Dame. The data presented in a general format, consists of the Lake Environ, Water Chemistry, and Plankton Counts. A discussion on each lake will follow.

I. Environ

Hummingbird Lake:

a) Watershed:

- small round lake, no apparent inflow or outflow from adjoining streams
- water inflow mainly from rain and runoff from shore although not steeply banked
- drainage into Bay Lake (U.N.D.E.R.C. Guide)
- slight depressed area

b) Terrain:

- several dead conifers
- grasses, leatherleaf
- lilies around edge; not too dense
- Sphaganum plentiful in surrounding area
- blueberry bushes, pitcher plants, ferns

c) Additional Notes

- film seen across water surface
- water very stagnant
- wind can be heard in surrounding trees

Raspberry Lake:

a) Watershed:

- no straams that flow to or from the lake
- lake receives H_2O from rain; not in depressed area
- drains into Cisco Chain

b) Terrain:

- leatherleaf
- grasses and lilies near dock
- conifers along shore along with maple and birch
- west end has few trees

II. Water Chemistry

Hummingbird Lake

Conditions: calm, sunny
9:00 a.m.

		Epilimnion	Hypolimnion
Nutrients:			
Phosphorus (Total Phosphate)	a)	.18 mg/l	.27 mg/l
	b)	.19	.35
	c)	.20	.32
Nitrate		.2 mg/l	.8 mg/l
Sulfate		0 mg/l	31 mg/l
Iron		.35 mg/l	1.1 mg/l
Sulfide			positive
Conductance		47 umhos	30 uhmos
pH - lab		5.3	5.5
Hardness:			
Calcium		5 mg/l	7.5 mg/l
Magnesium		5	7.5
Total		10	15
Phenopthalien			
Acicidity		25 mg/l	30 mg/l
Alkalinity		5 mg/l	5 mg/l
Secchi disc		.7 meters	

Oxygen-Temperature Profile

depth (m)	O_2(ppm)	temperature (*C)
air	7	36
surface	6.8	26
.5	6.1	24.5
1	.6	21
1.5	.4	16.5
2	.4	12
3	.4	6
4	.4	4.5
5	.4	4.5

Raspberry Lake

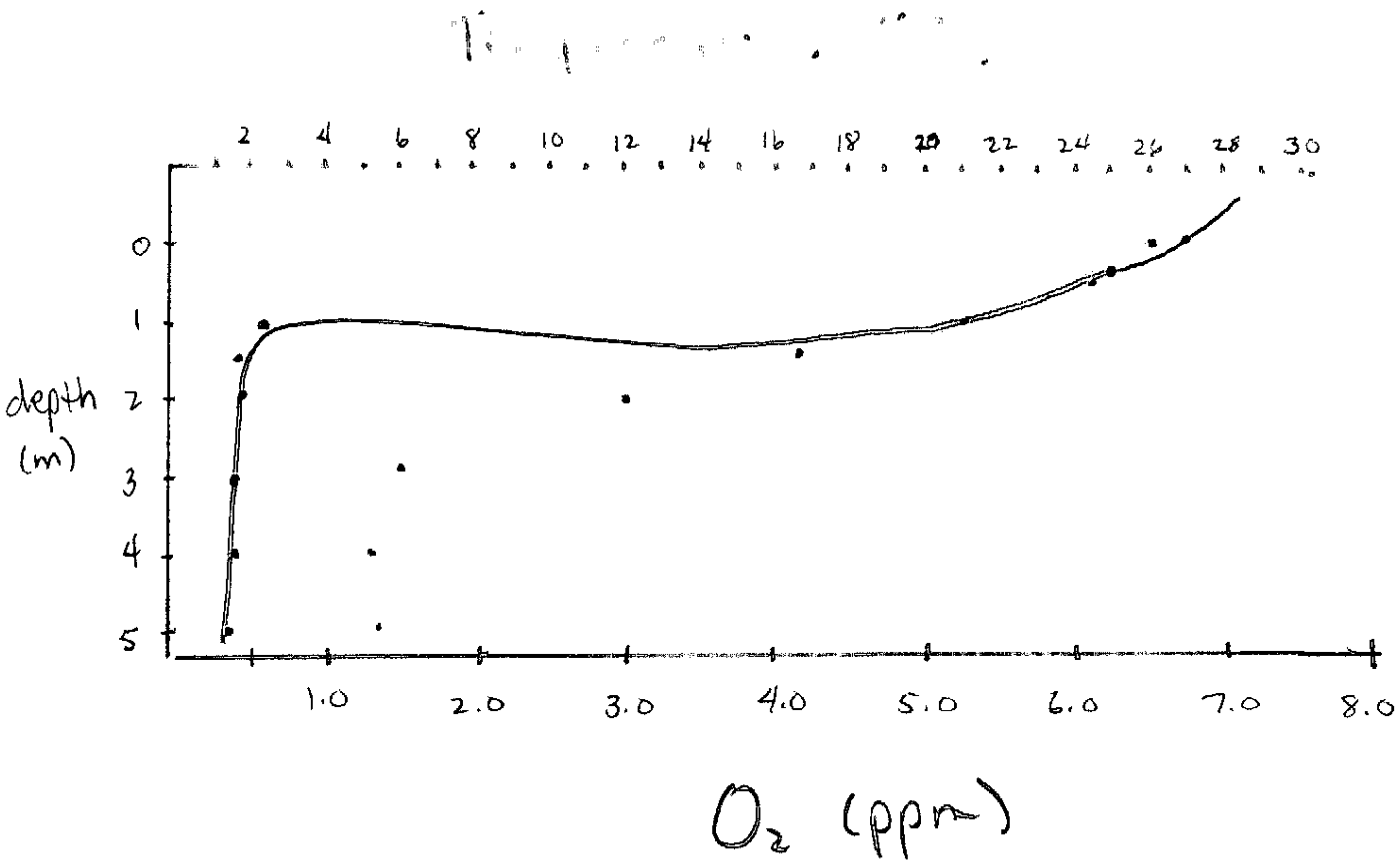
Conditions: calm, few clouds
10:30-12:15 p.m.

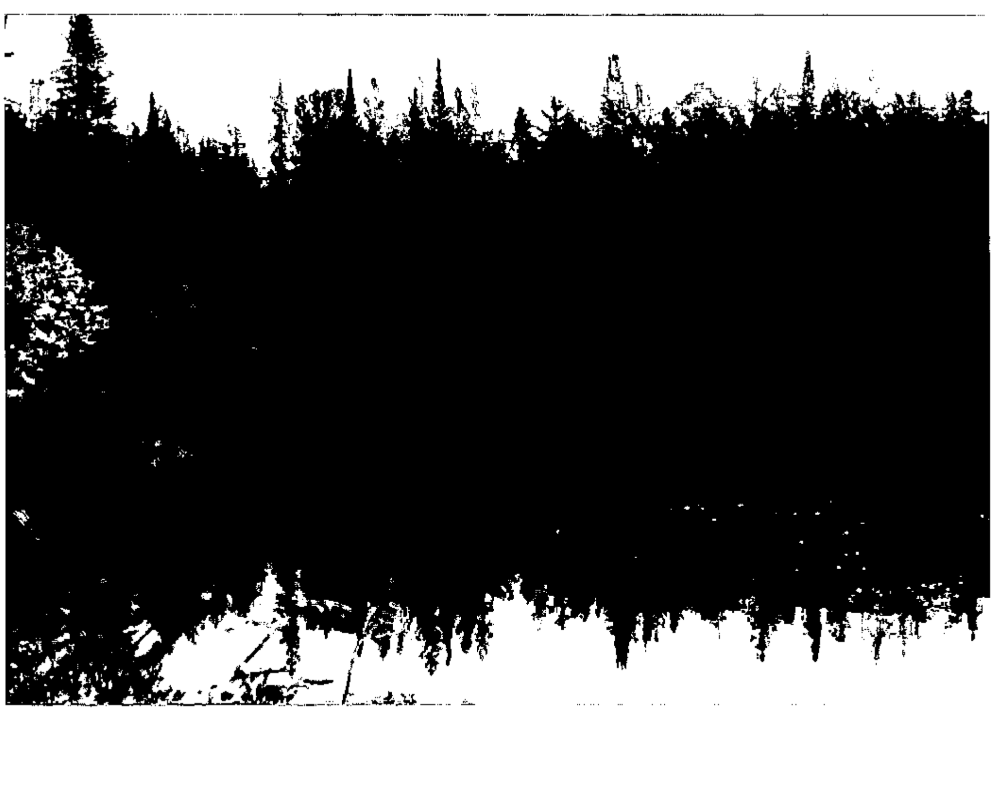
		Epilimnion	Hypolimnion
Nutrients:			
Phosphorus		a) .48 mg/l b) .38 c) .20	a) .01 mg/l b) .48 c) .53
Nitrate		.5 mg/l	.2 mg/l
Sulfate		5 mg/l	o mg/l
Iron		.14 mg/l	.55 mg/l
Sulfide			negative
Conductance		14 umhos	15.8 umhos
pH		6.5	6.5
Hardness:			
Calcium		5 mg/l	6 mg/l
Magnesium		4	9
Total		9	15
Phenopthalien	acidity	15 mg/l	20 mg/l
	alkalinity	10 mg/l	10 mg/l
Secchi disc	2.35 meters		

Oxygen-Temperature Profile

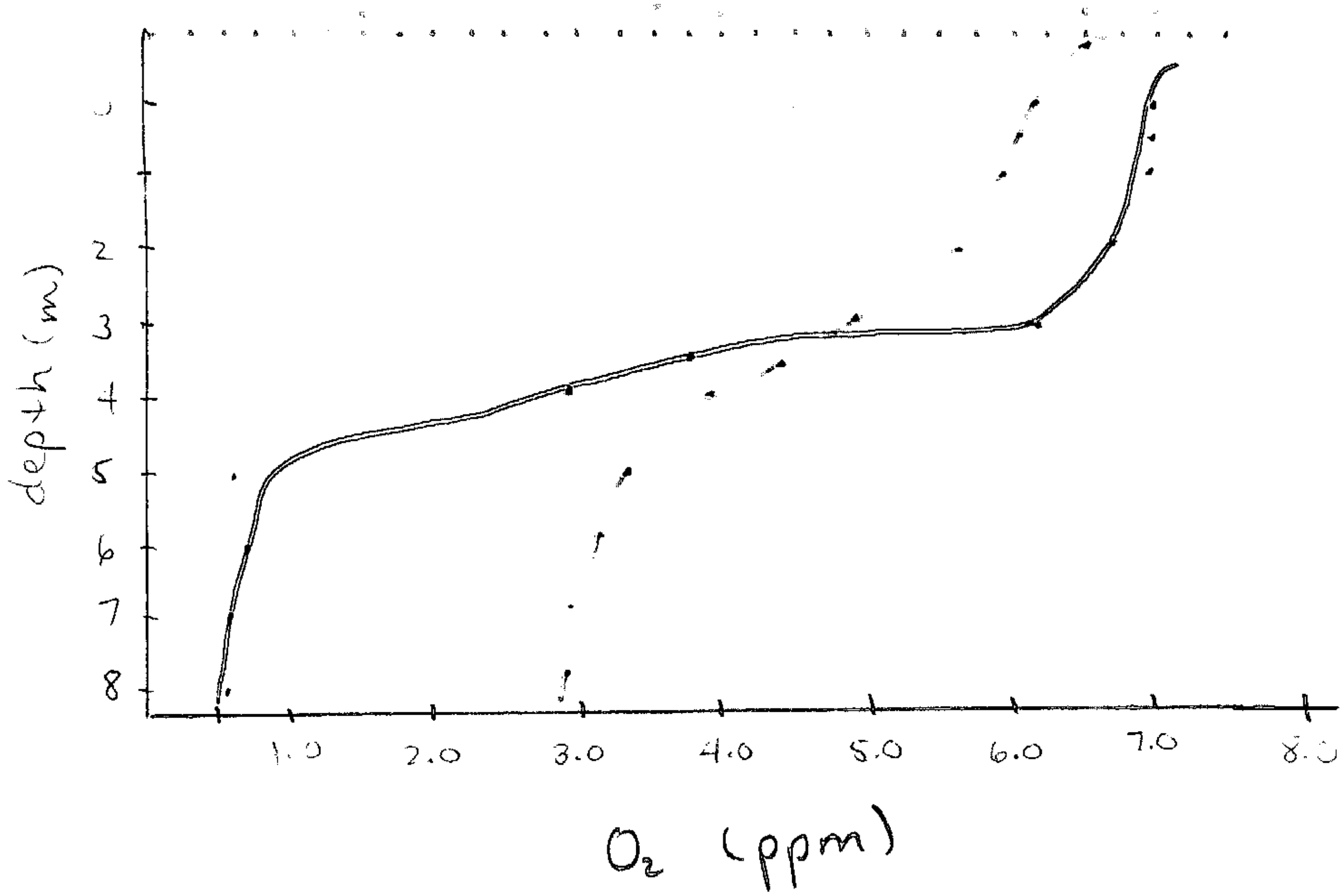
depth (m)	O_2(ppm)	Temperature (*C)
air	8.2	26
surface	6.8	24.5
.5	6.8	24
1	6.8	23.5
2	6.5	22.5
3	6.0	19.5
3.5	3.7	17
4	2.8	15
5	.6	13
6	.6	12
7	.8	11
8	.6	11

Hummingbird Lake





RASPBERRY LAKE



III. Plankton Data

Note: counts taken from 1ml of water

Hummingbird Lake

Phytoplankton:

- Anabaena 50
- Anacystis 30
- Asterionella 5
- Dinobryon bavaricum 465
- D. sertularia 90
- Melosira 5
- Mougeotia 10
- Navicula 5
- Oedogonium 20
- Peridinium 10
- Staurastrum 5
- Synura 15
- Ulothrix 5
- Uroglena 15

Zooplankton:

- Diaptomus 10
- Holopedium 15
- Keratella 1415
- Nauplius larvae 10
- Polyartha 105
- Trichocera 100

Raspberry Lake

Phytoplankton:

- Anacystis 10
- Arthrodesmus 55
- Asterionella 125
- Bambusina 15
- Dinobryon bavaricum 35
- D. sertularia 220
- Staurastrum 285
- Synura 530

Zooplankton:

- Asplanchna 5
- Bosmina 15
- Daphnia 5
- Diaptomus 80
- Eubosmina 60
- Halopedium 35
- Kertella 340
- Nauplius larvae 70
- Trichocera 5

IV. Discussion

The first lake discussed is Hummingbird and its water chemistry analysis is the basis for the discussion. The Oxygen-temperature profile shows two distinct layers. The epilimnion is located between the surface and a depth of approximately 1.5 meters. The hypolimnion, the lower layer lies below the epilimnion and extends to the bottom, a depth of approximately 4 to 5 meters.

The epilimnion is separated from the hypolimnion by the thermocline, a temperature gradient created by the different densities of the two layers. The warmer water floats above the cooler layer creating a stratification which is not easily disturbed. The water within each layer rarely mixes with the other layer if the temperature difference between layers is great.

The data for Hummingbird shows a definite thermocline that starts at 1.5 meters. The average temperature for the epilimnion is 22 degrees Celsius, and for the hypolimnion it is 6.75 degrees Celsius. Another good indication of the thermocline location is the oxygen profile. Oxygen is present in the epilimnion up to 1 meter with a drastic drop after that point.

The nutrients sampled were phosphate, sulfate, and nitrate. Both of these values for the epilimnion are lower than those of the hypolimnion. This indicates that productivity is occurring more in the top layer than in the bottom layer. This will be discussed more fully in the plankton section.

The Iron data also showed a higher concentration in the hypolimnion. Iron is soluble in acidic conditions and it precipitates out in alkaline and oxidized conditions.[1] This is in accordance with the anoxic condition of the hypolimnion.

Sulfate, a common ion, was found only in the hypolimnion. There was no test done for Hydrogen sulfide, but the rotton egg odor was present in the hypolimnion. This indicates that sulfate is reduced to H_2S which gives off the odor which occurs in anaerobic conditions.[2] The high sulfate level in the hypolimnion is probably due to the fact that the tests we performed were done sometime after the water was collected, therefore, it was oxidized by O_2 when brought to the surface. Hydrogen sulfide comes from decomposition of organic matter and is found in anaerobic conditions of hypolimnion if it is acidic.[3]

The epilimnion showed a reading of zero for sulfate which is sometimes considered a nutrient. This low reading could be attributed to the fact that productivity in this layer depleted the supply. Also H_2S is present usually when iron is precipitated out because it reacts with H_2S to form FeS. Iron is present so it could be responsible for low concentrations of sulfate. Less H_2S is present to be oxidized to sulfate. The FeS precipitates out so it lowers the concentration of soluble Fe in the epolimnion.[4]

The pH of the epilimnion is 5.3, an acidic reading, which is the result of several factors. *Sphagnum* moss, quite abundant around the lake, releases humic acid adding additional H+ ions to the water. *Sphagnum* and other mosses can act as cation exchangers due to their uronic acids. Carboxyl-associated H+ ions are released and exchanged for cations which are important for nutrition and which come from rain water or ground water.[5]

This reaction is supported by the low hardness of the water. The calcium and magnesium ions are exchanged for the H+ ion. The pH of the hypolimnion is slighter higher than that of the epilmnion. This could be due to the fact that more uronic acid is released from young Sphagnum moss than from dead ones which are present in the bottom of the lake.[6] Also, the hardness of the hypolimnion is slightly higher than in the epilimnion. This could be evidence that fewer cations are needed to react with the uronic acid because less of it is released.

Fewer cations also indicates lower alkalinity. Bicarbonate is the necessary buffer, but it is found in the form of $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. This lower alkalinity value means that there is little buffer to neutralize a high acidity reading, therefore, the pH is lowered.

Several things tie in together at this point. The low pH value is due mainly to the Sphagnum moss releasing humic acid and uronic acid. The uronic acid binds with the metal cations present which in turn lowers the alkalinity and hardness of the water. One section of the data does not fit in with these conclusions. The conductance for this lake is rather high.

Due to the low hardness and alkalinity values, conductance should also be low. Resistance declines with increasing ion concentration, therefore, the conductivity should be low. The only reason for higher than normal reading could be the H_2O temperature. Higher temperatures cause an increase in conductivity, however, I am not satified with this explanation.[7]

The Secchi disc reading was also quite low. 0.7 meters is the depth to which light penetrates so this indicates a or lots of scattering or absorption

shallow epilimnion. The tea color is due to the staining of the water by humic acid released by the Sphagnum moss. The depth of light penetration is the depth of photosynthesis.

Another very important aspect of the lake is its fauna and flora chemistry. ? The flora is the associated plant life. The phytoplankton present must be able to survive in acidic waters, and many of the species recorded are known to do so.

Myxophyceae, the blue green algae, are usually found in productive lakes in the summer, but when the nutrients are low.[8] Hummingbird Lake does not represent an eutrophic lake. It is acidic and the nutrient concentration is quite low. Algae ~~is~~ are present but only two species, Anabaena and Anacystis, are found in relatively low concentrations. The fact that these plankton are present may also be due to the fact it was late in the summer and although the lake is not very productive, most predatory zooplankton concentrations will be low. They use up most nutrients so productivity drops off. In the meantime, the algae can utilize what few nutrients are left because their predators are few.

The green algae present are the species usually found in Oligotrophic lakes. The desmid Staurastrum is typically found in slightly acidic lakes, low in calcium and magnesium.[9] The diatoms Navicula, Asterionella and Melosira are all characteristic of nutrient-poor lakes.[10] The flagellate algae Dinobryon, Synura, and Uroglena are typically found in nutrient-poor lakes. Uroglena and Dinobryon are both phosphate sensitive, usually requiring a lower concentration.[11] Dinobryon bavaricum was definitely the most common algae form present. This species tend to be found exclusively in Oligotrophic lakes especially in late summer and sometimes in Eutrophic lakes under conditions of temporary low nutrient concentration.[12]

The dinoflagellate, Peridinium, is a genus of several species some of which prefer a lower pH and low calcium concentration.[13] These algae were not keyed to species but the ones present probably were of the preference for low pH, nutrients and hardness.

Several different types of algae are present but the dominant species are of the genus Dinobryon. There is not an overall equal productivity rate among phytoplankton.

The other important aspect of the flora community is composed of the macrophages. Those present around the lake were conifers, especially black spruce, some grasses, leatherleaf, ferns, blueberries, Sphagnum moss and pitcher plants.

Chamaedaphne calycubta, leatherleaf, is frequently found in bogs, pond margins and the borders of lakes. Vaccinium is the genus of the blueberry with some species commonly found in coniferous forests.[14] Sarracenia purpurea, the pitcher plant, is characteristic of a bog environment. Typically, the plants present are adapted well for their environment. The pitcher plant digests insects to counteract the low nitrogen concentration in the soil.[15] The nitrogen concentration of the lake is low too.

The evergreens are well adapted to a low nutrient environment. Retention of leaves through the winter saves nutrients and enables photosynthesis to begin early in the spring.[16] Bog plants are adapted to deal with a waxy coating. Soil moisture is not pure water so the other compounds are toxic to plants so they are adapted to filtering the water. Usually the soil solution is so concentrated that water resists absorption which is why the plants are adapted against water loss. Also, cold water of the hypolimnion makes it difficult for plants to absorb water.

The fauna chemistry is equally important in characterizing a lake. The rotifers present are Keratella, Polyarthra and Trichocera. Keratella is an abundant genera containing several species, which vary greatly in their required environments. Some species do exist in acidic environments with low nutrient levels.

Polyarthra is another group with species tolerant of variable environments. The most common animal present is Trichocera. This creature is normally found in productive lakes, but can also be found during the summer in lakes with Myxophycean blooms.[17] Anacystis and Anabaena are third and fourth most common phytoplankton present.

The predominant Cladoceran is Holopedium, commonly found in soft water.[18] The Copepod was Diaptomus, another ~~genera~~ genus that consists of several species which are found in variable environments.

Hummingbird Lake is progressing to a bog. The lake lies in a depressed area so the surrounding coniferous forest blocks the wind from reaching the surface. The epilimnion is shallow with a warm water temperature. When the temperature gradient starts the oxygen drops extremely, from 6.1 ppm to .6 ppm. This is characteristic of bogs, as is the low hypolimnion temperatures of 6 to 4.5 degrees Celsius. The epilimnion does not turn over because the wind can not reach it. The calm surface with a film on the top indicates stagnation.

The water chemistry is characteristic of bog formation. A low pH is the result of fairly acidic waters with little buffer. Abundant Sphagnum increases the acidity and lowers the hardness.

Hydrogen sulfide present at the bottom indicates the decomposition is occurring in the hypolimnion. The nutrients are low but this is a result of poor drainage. Without adequate inflow and outflow nutrients are not replenished.

The tea color of the water with a visiblity of 0.7 meters is also characteristic of a bog. Little light penetrates so not much photosynthesis occurs. It only occurs near the surface where O_2 is present. A direct result form this is low productivity. Seveal varieties of phytoplankton are present but all at low concentrations. Dinobryon bavaricum is highly abundant and characteristic of Oligotrophic lakes as stated earlier. Bog water is analogous to Oligotrophic water because they are both low in mineral content, hardness, alkalinity and conductivity.[19]

The zooplankton productivity is more abundant than the phytoplankton. Fewer species are competing. The phytoplankton productivity has peaked and is declining. The peak of zooplankton productivity is peaking in late summer shortly after the phytoplankton peak, but that too will eventually drop off because the Nauplius larva count is not very high. Food will eventually run out. Few fish are present which is another indication of low productivity.

Raspberry Lake has an epilimnion layer that extends down to about 3.0 meters and the bottom depth is around 6.0 meters. The nutrients nitrogen and phosphorus are present in moderate concentrations which could be an indication of productivity of the plankton during the summer. The nutrients are probably slightly depleted at the end of summer because they are utilized by the plankton.

The iron concentration is quite low. In aerobic waters, the element is oxidized so it precipitates out. The hypolimnion has less oxygen and as a result there is alittle more iron present there.

Sulfate is present in the epilimnion, but none was recorded in the hypolimnion. No test was done for H_2S, but the rotton egg odor was not present. Only 5 mg/l of sulfate was present which is a low concentration. It is often considered a nutrient so this low concentration could be attributed to the productivity of the plankton. No H_2S was present in the hypolimnion. As explained for Hummingbird, iron is in the hypolimnion and it precipitates out as FeS. If iron is present H_2S usually is not. Sulfate is formed within the lake by chemical and bacterial transformations.[20] Hypothetically, there could be little of this activity possibly due to low acidity.

The pH of both layers is 6.5, slightly below neutral. It is determined by several factors. Sphagnum moss is present but not as the predominant macrophage. It will lower the pH due to its release humic acid and uronic acid. There is moderate alkalinity, so some of the acid is buffered. The Sphagnum also lowers the hardness of the water, acting as an ion exchanger. The alkalinity and hardness are low so the water should not be a good conductor, as is supported by the data. There are few ions in the water because nutrient and metal concentrations are low, and therefore, conductance is lowered.

The Secchi disc reading was 1.7 meters indicating that the water is not highly stained because Sphagnum is not concentrated enough. Productivity will occur at a lower depth.

The flora chemistry is quite abundant. The Blue Green algae Anabaena and Anacystis are present, both of which are associated with productive lakes usually when nitrogen and phosphorus are low.[21]

The desmids Bambusina, Staurastrum and Arthodesmus are produced in dilute acidic waters low in calcium and magnesium.[22] The diatom Asterionella is quite abundant and it can be found in various environments such as an Oligotrophic lake that is neutral to slightly alkaline but nutrient poor or in a Eutrophic lake usually alkaline and nutrient rich.[23] Synura, the most abundant phytoplankton, is found in lakes that are nutrient poor and neutral. Dinobryon is present in two species. The species D. bavaricum, although usually found in Oligotrophic waters, can occur in nutrient poor Eutrophic lakes. It is present in a much smaller concentration than D. sertularia which could be a species found in Eutrophic lakes of low nutrient concentrations. Peridinium is found in a low concentration and it also has numerous species. Most prefer low calcium concentrations, but their preference of pH varies.[24]

The macrophages consist of leatherleaf, sparce Sphagnum, conifers, maples and birch, grasses and lilies. The leatherleaf, Sphagnum and conifers are all indicators of an Eutrophic lake progressing towards a bog. It still has a near neutral pH so this shows the eutrophication is not very progressed. The maples and birch along with the lilies are indicators that the lake is still fairly productive, but they are located away from shore and are regressing.

The fauna chemistry consists of Copepods, Cladocerans, Rotifers and Nauplis larvae. The Copepod Diaptomus is fairly abundant but this genus has species that vary in their choice of environment. The rotifer *Keratella* is the most abundant zooplankton but once again, all this shows is that the lake is productive. *Keratella* are not an indication of a particular water chemistry because so many variable species exist. *Asplanchna* and *Trichocera* also exist. *Trichocera* is found mainly in productive lakes while *Asplanchna* can exist in waters of pH 5.7 to 8.1.[25]

The Cladocerans *Eubosmina* and *Bosmina* are indicators of lakes undergoing Eutrophication.[26] *Daphnia* is another ~~genera~~ genus that has variable species so it is only an indicator of productivity. *Halopedium* is usually found in soft water lakes such as Raspberry. The *Nauplius* larvae are the larvae of Copepods and are indication of productivity in the lake.

Raspberry also has small- and largemouth bass present, a definite sign of a productive lake.[27]

Overall, Raspberry Lake is an example of an Eutrophic lake slowly progressing to a bog. The water chemistry shows a well developed epilmnion layer which is where the majority of productivity occurs. Sunlight is able to reach 2.35 meters down so photosynthetic activity can occur to keep the layer oxygenated. The lake has a small surface area but the trees are set back far enough to allow the wind to reach the surface which circulates the water. This enables it to turn over with the seasonal changes. An Eutrophic lake supports high productivity which is evident here too. The plankton counts reveal a healthy population growth for both fauna and flora.

The lake itself is low in nutrients which could be a direct result of this productivity. The data was collected in late summer so productivity should be at its peak. The pH is slightly below neutral. This could be a result of the Sphagnum moss. It adds hydrogen ions to the water. The alkalinity maintains the pH by buffering the acid. The Sphagnum also softens the water by exchanging metal ions thereby increasing acidity and lowering hardness. The conductance is also relatively low due to the acidity of the water and the lack of free ions.

The surrounding flora of maples and birch mixed with conifers shows that this Eutrophic lake is slowly progressing to a dystrophic state.

Hummingbird and Raspberry Lakes can be contrasted and compared in several aspects. Both lakes are small with part of their surrounding terrain consisting of conifers, Sphagnum, and leatherleaf. Both lakes have a low nutrient and hardness level, while the pH of both is below neutral. Actually the lakes have a fair amount in common because they both are progressing to a bog state. They share some of the same plankton, especially those that survive in slightly acidic water, low in nutrients.

They can also be contrasted because Hummingbird is very close to being a bog while Raspberry is still a productive, eutrophic lake. Hummingbird is shallow probably because decomposing material is filling in the hypolimnion. The pH of each is below neutral but Hummingbird is lower. More Sphagnum is present to increase the acidity. The Alkalinity is low so there is less buffer. The humic acid stains the color of the water so both lakes differ in their depth of light penetration. This directly affects their productivity. Raspberry and Hummingbird both have several types of phytoplankton. In Hummingbird only one species really donimates the others. In Raspberry, several species are dominant not just one which indicates its greater capacity for productivity. The variable amount of phytoplankton also enables a greater selection of zooplankton to coexist. Hummingbird has half the phytoplankton variety of Raspberry. This is because the lower pH and light penetration of Hummingbird restricts the type of phytoplankton and that in turn dictates the zooplankton.

The only questionable data is the conductance for the lakes. Comparatively, Hummingbird should have a lower conductance than Raspberry because it has a lower alkalinity, compatable hardness and fewer nutrients. Hypothetically maybe the higher concentration of sulfate and iron somehow affects this. I looked in several books for a possible explanation but none commented on it sufficiently.

Both lakes are quite similar because they are near the same point in the aging process. They do, however, differ enough to show how this process goes through various stages.

FOOTNOTES

[1]Coke, Gerald A., Textbook of Limnology (St. Louis: The C.V. Mosby Co., 1979), p. 340.

[2]Ibid p.313

[3]Wetzel, Robert G., Limnology, Second Edition (New York: Saunders College Pub., 1983), p.319

[4]Ibid p.319

[5]Ibid p. 743

[6]Ibid p. 743

[7]Cole, p. 303

[8]Hutchinson, Evelyn G., A Treatise on Limnology (New York: John Wiley and Sons, Inc., 1967), p. 350,316.

[9]Ibid p. 361

[10]Wetzel p. 353

[11]Hutchinson, p. 352

[12]Ibid p. 394

[13]Ibid p. 394

[14]Larson, James A., Ecology of the Northern Lowland Bogs and Conifer Forests, (New York, Academic Press, 1982), p. 53

[15]Ibid p. 57

[16]Ibid p. 60

[17]Hutchinson, p. 526

[18]Ibid, p. 716

[19]Larson, p.28

[20]Cole, p. 301

[21]Hutchinson, p. 316

[22]Ibid p. 353

[23]Wetzel, p.353

[24]Hutchinson, p.335

[25]Hutchinson, p. 225,226

[26]Ibid p. 575

[27]Green, Richard W., A Guide to U.N.D.E.R.C., (Notre Dame, IN: Univ. of NotreDame), green appendix.

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