ED'S BOG
AND
PAUL LAKE

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Bio 569 - Aquatic Biology

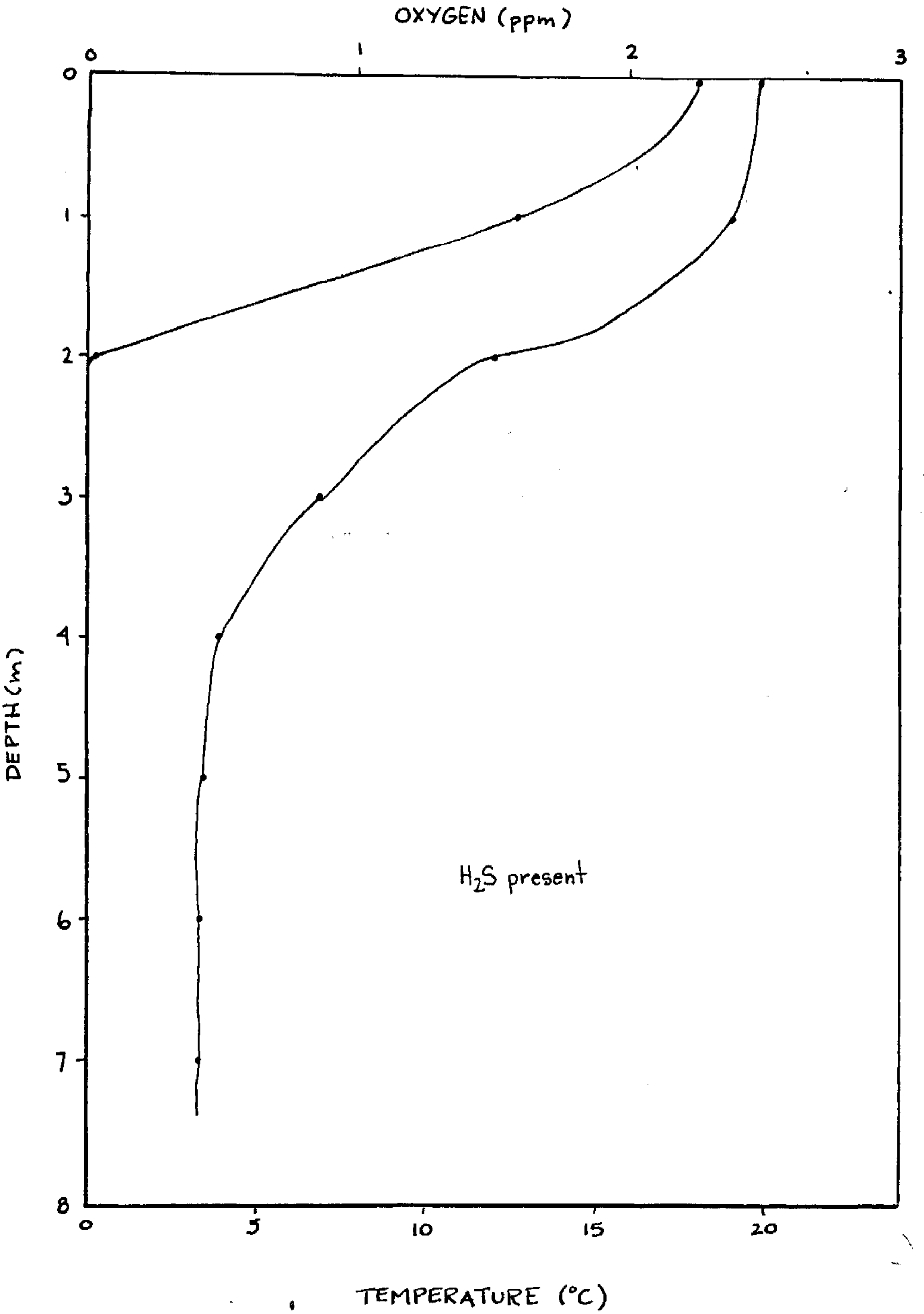
UNDERC Summer '82

The follwing is a comparative analysis of physical, chemical, and biological data collected at Ed's Bog and Paul Lake. Data ~~was~~ were collected during late July and August of 1982 at the University of Notre Dame Environmental Research Center. Temperature, oxygen, and Secchi disc readings were taken on the lakes, and water samples were taken with a Kemmerer sampler. Chemical analysis was done in lab using Hach kits. Plankton counts were done to find the number of organisms from an undetermined volume of water in a plankton tow - this shows only the relative size of the populations.

Ed's Bog - General Description

Ed's Bog is a fairly small bog. It is mostly covered by the bog mat with only approximately a 10X20 m area of open water. It is a well-protected bog, lying in a low area with a thick forest of mainly black spruce and tamarack growing right up to its edge. The mat itself supports tamarack, Ericacean shrubs, grasses, and sedges. The bog also supports a large population of wood frogs, Rana sylvatica. In early spring, the tadpoles are in the open water near the surface. Later in the summer, the frogs may be seen on the mat. Ed's Bog is apparently a seepage lake with no known inlets or outlets.

ED'S BOG


OXYGEN (ppm)
0
1
2
3
DEPTH (m)
0
1
2
3
4
5
6
7
8
H$_2$S present
0
5
10
15
20
TEMPERATURE (°C)

Ed's Bog - Water Chemistry

Data collected 7-27-82

	EPI	HYPO
Acidity- Methyl Orange	0	0
Acidity- Phen.	21 mg/l	53 mg/l
Alkalinity	3.3 mg/l	6.7 mg/l
pH	5.4	4.9
Hardness- Ca	5 mg/l	5 mg/l
Hardness- Mg	5 mg/l	0
Hardness- Tot	10 mg/l	5 mg/l
Specific Conductance	15 µMho/cm	17 µMho/cm
Secchi Disc	1.4 m	
Color- Apparent	90	140
Color- True	90	125
Iron	0.1 mg/l	0.4 mg/l
Phosphates- Ortho	0.08 mg/l	0.1 mg/l
Phosphates- Total	0.18 mg/l	0.15 mg/l
Nitrates	0.5 mg/l	0.6 mg/l
Sulfates	0	0

Ed's Bog - Plankton

Phytoplankton:

Anabaena- 4

Ankistrodesmus- 6

Desmidium- 57

Dinobryon- 25

Fragilaria- 1

Microspora- 16

Mougeotia- 126

Navicula- 1

Peridinium- 22

Staurastrum- 2

Ulothrix- 89

Zooplankton:

Bosmina- 20

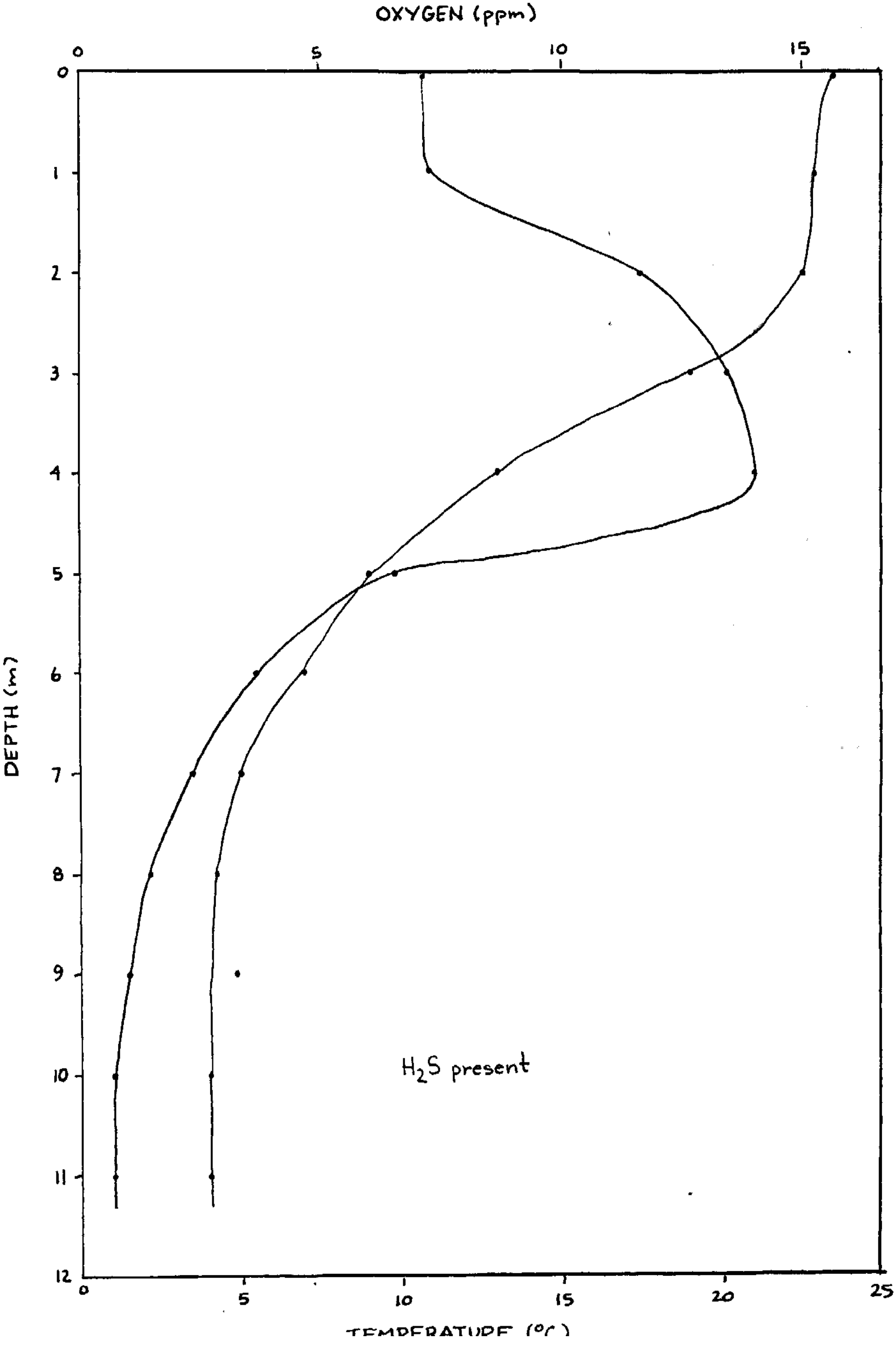
Daphnia- 18

Keratella- 239

Paul Lake - General Description

Paul is the smaller of the Peter and Paul Lakes, which were involved in a study by Stross and Hasler in the 1950's to determine the effects of lime on lake metabolism. Since Paul Lake drains into Peter Lake through a culvert between them, it was kept as a control. Therefore its water chemistry and community structure remain unaltered by the experiments. Paul Lake is lined by deciduous and coniferous trees. Its mucky bottom has a sparse macrophyte population with a few fresh water sponges. The lake supports a fairly large population of minnows. It has a surface area of 1.6 ha and a depth of approximately 11 m in the middle.

PAUL LAKE


OXYGEN (ppm)
0
5
10
15
DEPTH (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
H_2S present
0
5
10
15
20
25

Paul Lake - Water Chemistry

Data collected 7-29-82

	EPI	HYPO
Acidity- Methyl Orange	0	0
Acidity- Phen.	10 mg/l	30 mg/l
Alkalinity	10 mg/l	15 mg/l
pH	6.5	6.3
Hardness- Ca	5 mg/l	10 mg/l
Hardness- Mg	15 mg/l	30 mg/l
Hardness- Tot	20 mg/l	40 mg/l
Specific Conductance	20 µMho/cm	50 µMho/cm
Secchi Disc	3.85 m	
Color	4	58
Iron	0.1 mg/l	>2mg/l
Phosphates- Ortho	0.8 mg/l	1.1 mg/l
Phosphates- Total	0.9 mg/l	1.3 mg/l
Nitrates	0.15 mg/l	4.5 mg/l
Sulfates	29 mg/l	26 mg/l

Paul Lake - Plankton

Phytoplankton:

Anabaena- 58

Dinobryon- 108

Micrasterias- 1

Microcystis- 10

Navicula- 1

Staurastrum- 5

Tabellaria- 11

Zooplankton:

Asplanchna- 14

Conochilus- 77

Keratella- 16

Nauplius- 3

Discussion

The temperature profiles of Ed's Bog and Paul Lake show a definite thermal stratification. In the spring, heat from the sun melts the ice which has covered the lake for the winter, and the lake becomes isothermal at 4°C. During this time, wind blowing over the surface mixes the water resulting in an even distribution of oxygen, nutrients, and so on. This is the spring turnover. In the summer, as the sun continues to warm the surface, the density differences increase and it therfore requires more energy to mix the water. Thus the lake gradually becomes stratified. The water of the epilimnion no longer mixes with the water of the hypolimnion below the thermocline. In the fall, the surface cools and there is a turnover again once the lake is isothermal. In the winter, there is an inverse stratification since the maximum density of water is at 4°C. The bog has a small exposed surface area relative to its volume, so it receives less heat from the sun and less energy from the wind. It therefore has a shallow thermocline and probably doesn't turn over.

The amount of oxygen present in the water depends on: 1) contact between the water and the atmosphere, 2) water circulation, and 3) the amount of oxygen produced and consumed within the system. Oxygen from the atmosphere diffuses into the water at the surface and is circulated throughout the epilimnion. Because of the stratification, however, it does not circulate down to the hypolimnion. Phytoplankton, which must live near the surface in order to get sunlight, also produce oxygen in the epilimnion. When organisms die, they fall to the hypolimnion, and their decomposition uses up oxygen. Respiration uses oxygen in both the epilimnion and the hypolimnion. The epilimnion, thus, has two sources of oxygen to replace that which is used up for respiration. The hypolimnion, however, produces no oxygen, and, since it is isolated by the stratification, any oxygen that was there is soon used for respiration and decomposition. In Ed's Bog, there is a sharp drop off in the oxygen content, with no oxygen occuring below 2 m. This is because there is no turnover and because the phytoplankton must stay right near the surface since the dark color of the water doesn't allow much light penetration. In Paul Lake, there is an oxygen bulge at about 4 m. This could be due to a population of phytoplankton living at a certain depth/density. Both Ed's and Paul had H_2S near the bottom, which is present only under anaerobic conditions.

Neither Ed's Bog nor Paul Lake were acidic enough for the methyl orange test, which will only show acidities below a pH of 4.5. However, the phenolphthalein test showed that Ed's Bog was clearly much more acidic than Paul Lake. This is because uronic acids on the Sphagnum exchange H^+ for Ca^{++} and Mg^{++} making the water more acidic. Ed's was less alkaline than Paul - probably also due to the uronic acids. Bogs also usually have lower pH's as is the case here.

Ed's Bog had much softer water than Paul Lake. This is because the Ca^{++} and Mg^{++} ions present in the water are taken up by the uronic acids on the Sphagnum. (Ca^{++} is often the limiting factor for bacterial decomposition in bogs.) Due to the lack of ions, the bog also has a much lower specific conductance than the lake.

Paul Lake had fairly clear water, as can be seen by the deep secchi disc reading and the low color measurements. Ed's Bog, on the other hand, is much darker, with a shallow secchi disc reading and a lot of color. Since the apparent color and the true color were the same for the epilimnion and very close for the hypolimnion, the color is not due to phytoplankton. Bogs frequently get a tea color from humic acid produced by the decomposition of plants. The secchi distance is approximately equal to 1/3 of the depth where 1% of the incident light reaches. This is usually the lowest depth phytoplankton can possibly grow at. Since this distance reaches nearly to the bottom in both Ed's and Paul, there are probably other reasons for the lack of phytoplankton in the hypolimnion.

When dissolved oxygen is present in the water, iron exists only in the ferric state which is insoluble. The iron is precipitated as ferric hydroxide or other ferric compounds and falls to the bottom. Once the oxygen is used up for decomposition or otherwise and anaerobic conditions prevail, the iron is reduced to its ferrous state which is water soluble. This explains the lack of iron in the epilimnions of both Ed's Bog and Paul Lake as well as the abundance of iron in the hypolimnion of Paul. As for the hypolimnion in Ed's Bog, either there is very little iron in the bog to begin with, or the iron that is there is tied up colloidally with the humic acids in humates.

One of the nutrients, usually phosphate, will probably be the limiting factor in the growth of the phytoplankton. The population can only grow at the rate allowed by the scarcest nutrient, even if the others are in abundance. Since phytoplankton are primary producers for the lake, the nutrient balance affects the entire lake community. The nutrients are evenly distributed after turnover. However, after stratification occurs, organisms in the epilimnion take up nutrients, die, and fall to the hypolimnion, thereby depleting the epilimnion of nutrients. This explains the general trend of the data to have more nutrients in the hypolimnion than in the epilimnion. Nutrients are often sealed in the sediment by the precipitation of ferric compounds, and are trapped there until anaerobic conditions develop. In Ed's Bog, it appears that sulfate may be the limiting nutrient.

Analyzing one plankton tow doesn't give a very complete idea of the plankton populations of the lakes. First of all, many plankton migrate vertically in the water column to avoid predation, and so at different times of the day one might find an entirely different composition of organisms in the same area. Secondly, zooplankton are not always distributed randomly, but often times tend to cluster together. A population count from a random tow could very easily be thrown off by the effect of this clustering. Thirdly, the type of plankton collected would depend very much on the depth at which the tow was done(which wasn't very precise at all.) For example, while Staurastrum are distributed throughout, Navicula are hypo-neustic and live just below the surface. Conochilus and Daphnia stay mainly in the upper and middle layers and Asterionella are usually deeper down.

Plankton populations fluctuate a great deal anyway. Nutrients that were abundant in the spring may become depleted later in the summer. The organisms may modify the chemical composition of the water. For example, Diatoms may use up the silicon. As the season advances, environmental conditions change. The temperature rises, which may lead to blooms or a retreat to cooler depths. The radiation varies in duration and intensity. An increase in the number of primary producers leads to an increase in the number of consumers, which in turn.

will lead to a decrease in the number of primary producers. Reproduction rates vary. For example, A single female cladoceran is capable of producing 13,000,000,000 descendants in 60 days if they all live and reproduce. However, they are almost all eaten by small fish and other predators, so the population is merely maintained. A slight imbalance in the factors though, could lead to either vast swarms or a sudden disappeara~nce. Due to all these factors, a lot of data must be collected over an extended period of time before generalizations can be made about plankton populations in a given lake.

The bulk of the phytoplankton is nanoplankton which are too small for the net. Daphnia, Bosmina, Diaptomidae, nauplii, and most rotifers and ciliates are directly dependent on nanoplankton for their nourishment. These are "automatic feeders", capturing their food randomly. In contrast, the "seizers" are predacious on other small animals and sometimes plants. Examples of these are Asplanchna, Chaoboris, and Cyclops.

The plankton collected exhibit several different flotation mechanisms. Conochilus has a gelatinous sheath that is approximately equal in density to water. Asplanchna has a large accumulation of water inside the body for equal bouyancy. Diatoms have very thin shells. Chaoboris have a voluntary swim bladder. Asterionella has an increased specific surfacearea. Staurastrum has an increased orthogonal projection area.

Many of the phytoplankton are especially well-adapted to specific conditions. Desmids do well in soft water (-Staurastrum in Ed's Bog.). Bluegreens (such as Anabaena and Microcystis) do well in nutrient-poor water. Green algae may become extremely abundant, especially in small lakes and ponds where water is relatively undisturbed by wind (Mougeotia in Ed's Bog.)

effect of predators on zooplankton present? why are Daphnia and Bosmina in Paul? Why are they in Ed's?

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