plankton 9.5
water chem 9.3
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The Water Chemistry and Plankton

of

Roach Lake and Ed's Bog

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I) Introduction

The two water systems considered in this report are Ed's Bog and Roach Lake. Befor attempting analysis with respect to water chemistry and plankton, it may be valuable to note some general physical characteristics of the lakes in question.

Roach Lake has a surface area of approximately 38.4 hectares. Much of the lake is surrounded by Birch and Aspen. The shoreline is well defined; the bottom appearing quite rocky near shore. One of the most striking characteristics of this lake was its clearness (note S.D. reading of 4.2m.). Some macrophytes were visible on the bottom and several floating mats were noted in the West end of the lake. Apparently, there is no drainage into or out of Roach, although seepage probably plays a considerable role.

The open water area of Ed's Bog, by comparison, is quite small. perhaps 1 hectare(and quite inaccessable to most mortals). A typical sphagnum mat surrounds the water, containing the expected Pitcher Plants, Sundews and Bog Rosemary. Portions of the far shore, however, appear to be more marshy than boglike due to the presence of many rush-like plants. A depth measurement of about 7 meters was noted throughout the bog. The soft, mucky, silty bottom precluded an exact measurement. In comparison to Roach the water was very turbid and posessed a brown tea coloration(S.D. reading of 1.4m.).

II) Water Chemistry--Analysis and comparison of Roach L. and Ed's Bog

The approach taken in this part of the paper will be to examine the nature and significance of each test performed on the lakes; to discuss the results as they pertain to the given lakes; and finally, to draw some general conclusions about the state of the lakes independently and in comparison to one another.

Acidity: Acidity is a measurement of the relitive capacity of water to donate H ions--i.e. to nеutralize OH. Titration to the methyl orange endpoint (4.3) indicates the amount of mineral acidity; that is, the amount of free mineral acids such as H_2SO_4 and HCl. Further titration to the phenolphthalein endpoint (8.3) determines total acidity; mineral acidity plus the acidity from weaker organic acids.

Examination of the data shows that there is no detectable mineral acidity for either lake. One might venture a guess that such acidity might come from chemical pollutants or high salt concentrations--neither of which are evident at UNDERC.

The total acidity values of Roach are relatively close at the two depths measured. This is what one would expect in a lake just finishing overturn and beginning to stratify. (see discussion on O_2-temp. profile)

Ed's Bog, on the other hand, shows a distinct difference in total acidity between the two depths(75 at 5m. vs. 40 at 1m.). Recall that most of the bog's acidity is due to uronic and humic acids--high M.W. organic acids formed from the decomposition of plant material from the surrounding forest.

Since data indicates that the bog does not turn-over it is quite possible that this material is blown into the lake, sinks, then decomposes to form the acids mentioned. This, in addition to rain water dilution of the surface water, could account for the higher acidity reading at lower levels.

Alkalinity: Alkalinity measures the tendency of the water to accecept protons. Mainly, it represents the content of Carbonates (CO_3), Hydroxides (OH) and Bicarbonates (HCO_3). Titration with acid to the phenolphthalein endpoint gives Hydroxides plus ½ of Carbonates. Further titration to the methyl orange endpoint gives total alkalinity. Obviously, this test is also a measure of buffering capacity.

Examination of the data shows that no alkalinity was detected in either body of water. This correlates fairly well with the low pH (4.5) and moderate acidity seen in Ed's Bog, but is somewhat more difficult to explain in Roach. Some alkalinily was undoubtedly present in Roach, but was not detected oweing to the sensitivity of the Hach kits. Given a pH of 5.8, most of the alkalinity would be in the form of HCO_3 -- the form most important and effective in buffering. Perhaps the increased effectiveness of this form helps counteract the low concentration, and allows a limited amount of buffering to take place.

Hardness: Hardness is a measure of the concentration of Ca and Mg ions in the water sample. Of the two ionic forms, Ca is more important as an indicator of lake productivity,(for example, Lind refers to lakes with less than 10 mg/L Ca as generally oligotrophic). Low Ca levels usually imply low self productivity in a lake or bog since Ca is necessary for decomposing bacteria to function. Note that both bodies of water examined have low Ca levels. As expected, Ed's Bog is quite unproductive. Roach Lake, is also relitively unproductive when compared to similar lakes on the property. Furthermore, the low Ca levels in Roach explain the soft bone perch.

Normally, Mg levels are much lower than Ca levels. This trend was not found in Roach where Mg and Ca levels are similar. Since Mg comes mainly from the leaching of igneous and carbonate rocks, perhaps the many rocks lining the lake bottom are a source. Because Mg is necessary for the formation of chlorophyll, extremely low levels can also adversely affect lake production.

Specific Conductance: Specific conductance is a measure of the sample's ability to conduct an electric current. Although the value is dependent upon both the amount and type of electrolyte present, according to Lind, at low ionic concentrations the relationship between conductance and the concentration of ions in solution is almost linear.

Since conductance, alkalinity and hardness all depend apon the amount of particular ions in solution one would expect a correlation between these values. Indeed, this is the case. The low alkalinity and hardness values are reflected in the low conductivity values for both Roach and Ed's Bog.

pH: The pH of Roach is 5.8 and constant throughout depth. This consistancy would be expected in a recently overturned lake which is just beginning to stratify. In August, 1975, the pH was measured as 5.0. This deviation is probably explained by the severe drought of that period. Dilution with water from heavy snowfalls and spring rains of this year would serve to raise the pH toward normal.

One notes that the pH of Ed's Bog is quite low (4.5) and therefor stressful or prohibitive to most aquatic life. The decrease in pH (5.05 to 4.5) as well as the increase in relative color since 1975 indicate that the bog forming process is continuing. One expects that the marshy area mentioned earlier will be replaced by bog mat in the not too distant future.

Color: the relative color test measures the ability of the solution to absorb a given wavelength of light. The more absorbtion, the greater the color reading.

As one would expect from the secchi disk reading and the extreme clearness of the water, Roach gives a very low color reading.

Ed's Bog, however, exhibits a very high reading for both apparent (sample) and true (centrifuged supernatent) color. this is mainly due to the tea color produced as the humic acids form complexes with the Fe ions. The depth difference in readings probably reflects surface dilution as well as a higher acid concentration at greater depths.

Nitrates and Phosphates: Total phosphate concentration includes the directly usable orthophosphates plus meta- and organic phosphates. Apparently, the ratio of PO_4 to NO_3 is more important from the viewpoint of productivity, than either of the two values taken independently. In fresh water systems

PO_4 is usually the limiting factor, with NO_3 being in excess. The main sources of PO_4 are organic decomposition and leaching from rocks. NO_3 is normally provided to the aquatic system via aerobic decomposition of organic matter and bacterial oxidation of organic nitrogen.

In the case of Roach Lake, both the PO_4 and NO_3 levels are quite low. Again, this fits into the picture of Roach as an oligotropic, clear, somewhat sterile enviroment. The lack of the nutrients indicates that very little internal decomposition is going on in the lake. Also, the amount of external organic material supplied to the lake from the surrounding forest area is minimal when compared to the total volume of the lake.

This is not the case in Ed's Bog where much organic material is supplied from the surrounding forest. The decomposition of this material probably accounts for the somewhat higher PO_4 and NO_3 values. However, due to the other considerations already noted (pH, acidity, hardness, etc.), these nutrients can hardly form the basis of a well developed food chain.

H_2S: The presence of H_2S indicates an anaerobic enviroment. Its presence in Ed's Bog, in significant amounts, at this point in spring, indicates that the system is not turning over. Thebog is permenently stratified.

H_2S was not detected at Roach. Any H_2S which might be formed during periodic stratifications would likely be removed during the spring and fall overturnes.

Temperature--O_2 profiles: The temperature profile for Roach Lake indicates that a thermocline has developed in the 2-4 meter region. Note, however, that the total decrease in temperature from the surface to 6 meters is only 8°C. The relatively limited depth of the system partially explains this. Another possible factor is that the lake is just recently completing spring overturn and stratification is only beginning. Further evidence for this hypothesis comes from the O_2 profile. Notice that the dissolved O_2 concentrations vary from 8.5 ppm. at surface to a low of only 7.0 ppm. at 4m. Thus the O_2 content throughout the water column is quite high; definitely not the result one would expect if stratification had taken place long ago or the lake was not turning over. At depths below 4m. there is a distinct increase in O_2 values. Since H_2S readings were negative, one might speculate that the increase is due to photosynthetic activity of bottom dwelling macrophytes (the clear water would easily such activity at 6-7m.).

In conclusion, Roach Lake presents a picture of a relatively oligotropic enviroment as evidenced by the low alkalinity, low Ca and Mg levels, and low conductivity. Its internal productivity is limited due to low Ca, Mg, NO_3 and PO_4 concentrations and evidenced by the low color and high Secchi disk readings. The lake is healthy, in that seasonal overturn does occur. A limited food chain has developed and supports a macrophyte and fish population.

Examination of the temperature-O_2 profile of Ed's Bog gives one a quite different impression. The thermocline lies directly below the surface, and water temperature drops 14.2°C in 3 meters. Dissolved O_2, which is quite low to begin with (3.7 ppm.) drops to .7 ppm. by 2m. Below 2m., the aquatic enviroment is most likely anaerobic, with the O_2 probe actually measuring H_2S concentrations. Recall that the H_2S test was distinctly positive at 5m. Note that there is a slight increase in O_2 between surface and 1m. The 1m. reading may represent an area of phytoplankton photosynthetic activity-- the phytoplankton residing below the surface to prevent photo oxidation.

Ed's Bog, then, presents a typical example of bog distrophy. Internal productivity is exceedingly low due to the low pH, low buffering capacity, insufficient Ca and Mg and evidenced by the low specific conductance. External organic material accounts for the PO_4 and NO_3 values, as well as the acidity and color readings. Finally, the decrease in pH and increase in specific color since 1975 may indicate that the bog forming process is continuing.

III) Plankton

The forgoing discussion on water chemistry described what types of conditions are present in the two aquatic systems studied. This section will attempt to correlate these conditions with the amount and type of planktonic organisms present and to compare and contrast the two bodies of water.

All of the phytoplankton found in Ed's Bog and Roach Lake fall into one of five catagories: Blue-green algae, Chrysophytes, Dinoflagellates, Green algae and Desmids(here considered seperately).

Blue-green Algea: It has been noted that Roach Lake is primarily oligotropic. Among the characteristics mentioned were low concentrations of organic material, in general, and low concentrations of PO_4 and NO_3. Both of these factors favor Cyanophytes so it is not surprising that they are the most prevalent organisms, with respect to genera as well as total numbers(1910 out of 2290 phytoplankton, for 83%). 4 genera of cyanophytes were found, 2 of which(Anabaena and Choorococcus) were common to the AM and PM samples. Oscillatoria appears only in the AM and Polycystis only in the PM sample. Roach is extremely clear with low color and dissolved solids. Therefor, the absence of Polycystis may be due to downward migration to avoid photoinhibition. Likewise, while a Choorococcus bloom is very probably taking place (1500 in PM sample), part of the difference between the AM and PM counts may be due to downward migration during the day, followed by a return to a lesser depth as the sun sets.

In comparing the Ed's Bog water chemistry data to Roach, one sees an increase in NO_3 and PO_4 concentrations, a sharp increase in color and decreased Secchi disk readings. Together these indicate a higher concentration of dissolved organic material(albeit allotrophic in origion), as well as higher NO_3 and PO_4. Thus one would expect Blue-greens to be less dominant with respect to types and numbers than in Roach. This is the case. Only 2 genera, Polycystis and Choorococcus, are found. Both are common to AM and PM samples. They comprise only 54% of the total sample. A lessening of the Cyanophyte competitive advantage has apparently taken place.

The increase in Choorococcus (200 AM vs. 300 PM) lends support to the earlier hypothesis of photo induced migration. The change is not nearly as dramatic as seen in Roach, perhaps because the greater amount of particulate matter in Ed's Bog (S.D. 1.4) would decrease the photo inhibition effect. Another possibility is that these organisms cannot migrate below the very shallow thermocline.

Chrysophytes--Diatoms and Dinobryon: Diatoms are ubiquitous in most fresh water enviroments. However, they were not abundent in Roach, comprising only 14% of the non Blue-green algea population and 2.3% of the total. Asterionella was the primary genus (1 Navicula was present), and occured with similar frequency in AM andPM samples.

In Ed's Bog, although Diatoms comprised 29% of the total count, only one genus, Asterionella, was present. Furthermore, it was present only in the PM count-- all 400 of 'em. In a water area the size of Ed' Bog it seems unlikely that the entire bloom would have been passed over in the AM sample. However, this is a remote possibility. Most likely, the bloom occured during the afternoon, its effect perhaps augmented by organisms returning to the surface following a photo induced downward migration during the day.

Recall that Diatoms are particularly sensitive to low PO_4 levels. Thus, one would expect to see reduced levels of Diatoms in Roach, as compared to Ed's Bog. Again, this is the case.

Dinobryon was found in Roach Lake much more frequently in the is rather puzzling (especially since nothing I found in the literature indicated that they should be inhibited by soft water or low Ca conditions--in general, it appeared the opposite was true, eg. starch storers prefer low Ca). Again, some unknown competitive factor, perhaps a toxin or lack of an essential trace element, is probably at fault.

One final note regarding phytoplankton; The O_2 curve for Ed's Bog shows a slight increase in O_2 concentration at approximately 1m. This is probably due to phytoplankton photosynthesising slightly below the surface to avoid photo inhibition.

The zooplankton feed on the phytoplankton and thus comprise the next level on the food chain. They, in turn serve as a food source to small fish and other aquatic predators.

All of the zooplankton sampled fell into 4 catagories: Rotifers, Cladocerans, Copepods and the crustacian larva, Nauplius. In addition, the larger midge larva, Chaoborus, was found in Ed's Bog.

In general, Rotifers are cosmopolitan in distribution. The majority of fresh water forms inhabit the substratum, but a number of planktonic forms are found.

In Roach Lake, Rotifers comprised 17% of the total zooplankton population. 2 genera, <u>Keratella</u> and <u>Studinella</u>, were present, with <u>Keratella</u> far more prevalent. No indication of migration is seen in the data.

In Ed's Bog, only <u>Keratella</u> was found. However, it comprised

50% of the sampled zooplankton. The number collected doubled in the PM sample, perhaps due to an upward food seeking migration tied to the presence of the Asterionella bloom.

Cladocerans: According to Barnes, cladocerans are the only branchiopod inhabiting large ponds and lakes. 3 genera of Cladocerans were found in Roach. The difference in AM vs. PM counts (7AM vs. 12 PM) is probably not significant, due to the small number surveyed.

Ed's Bog yeilds 4 species (3 genera), only one of which (Bosmina longirostris) was detected in Roach. They comprise a sizable 38% of the total zooplankton sampled. The difference in the AM vs. PM yeilds (6AM vs. 16PM) is primarily due to the presence of Bosmina longirostris in the PM sample only. Perhaps this indicates migration, but a larger sample would be necessary to tell for certain--especially since no such migration was indicated in Roach, despite the Asterionella bloom.

Copepods: Roach Lake obviously presents a favorable environment for Copepods, since 3 genera account for 54% of the sampled zooplankton. Abundent food supply is probably not the cause, since most of zooplankton feed on the same sort of phytoplankton material. Also, Reed asserts that food supply is seldom a limiting factor in zooplankton communities. Again, something has occured in the system to give the Copepods a competitive advantage, but the exact cause is uncertain.

Conversely, Ed's Bog yeilds only 1 genus (Diaptomus) in very small amounts (3 organisms; 5%). Apparently, whatever conditions favor the Copepods in Roach are not present in Ed's Bog.

Crustacian Larvae (Nauplius): Like the Copepods, the Nauplius larvae are much more prevalent in Roach than in Ed's Bog. The Roach PM sample contains substantially more than the AM sample(AM 5 vs. PM 14). Again this result may be caused by a food seeking migration; induced by the high PM yeilds of Choorococcus and other phytoplankton.

In Ed's Bog, the number of Crustacean larvae sampled are identical in AM and PM-- thus, no indication of migration. However, the total number sampled (4) is too small to present any definate conclusions.

Overall, then, one sees an increase in phytoplankton counts in the PM samples of both Roach and Ed's Bog. The overall change is much greater in Roach(due to the appearence of the Choorococcus bloom in the PM sample), but appears significant in both cases. The cause is probably photo induced migration, as mentioned earlier.

Ed's Bog shows a corresponding totao zooplankton increase in the PM sample--perhaps a feeding response to the movement of the phytoplankton. However, no such migration took place in Roach; the total AM and PM zooplankton counts are nearly identical.

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Water Chemistry Data

Roach Lake

TEST*	1m.	5m.
Acidity		
Methyl orange	0	0
Phenolphth.	70	60
Alkalinity	0	0
Color (apparent)	20 units	30 units
Hardness		
total	10	10
Ca	5	5
Mg	5	5
NO_3	.3	.1
PO_4	.14	.14
pH	5.8 units	5.8 units
Specific Conductance	14 mmhos	18 mmhos
H_2S	0	0
Secchi Disk	4.2 meters	

* units in mg/L unless otherwise stated

DEPTH	Conc. O_2 (ppm)	Temp. °C
s	8.5	20.5
1m	8.3	20.5
2m	8.0	20.5
3m	7.2	17.5
4m	7.0	14.5
5m	9.0	13.0
6m	10.0	12.5

Water Chemistry Data

Ed's Bog

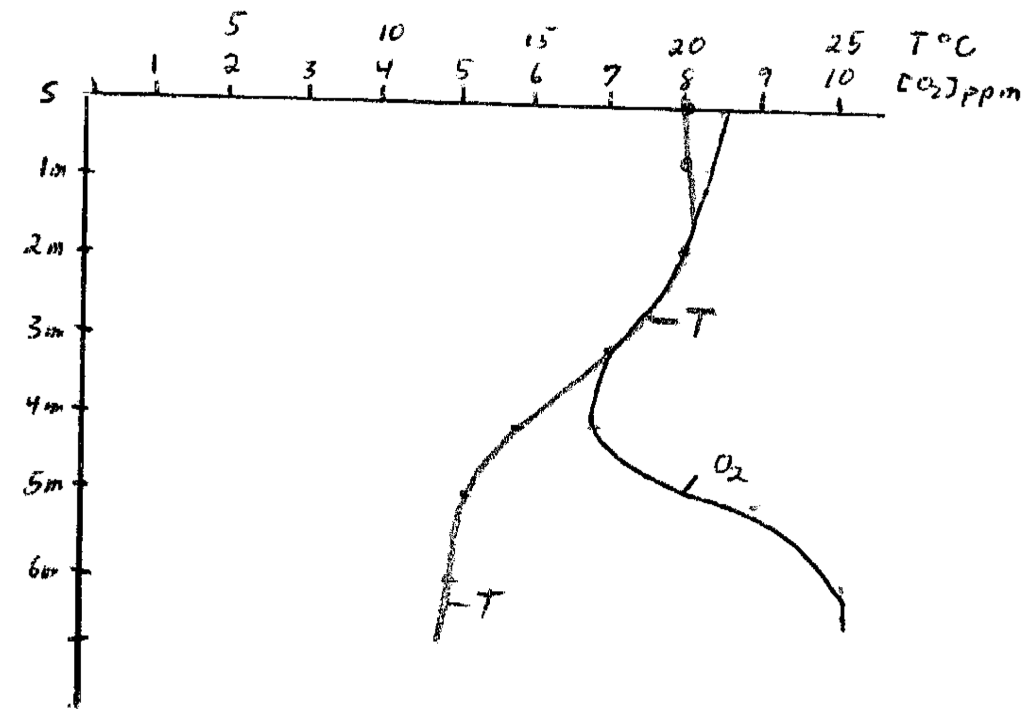
TEST*	1m	5m
Acidity		
Methyl orange	0	0
Phenolph'th.	40	75
Alkalinity	0	0
Color		
Apparent	180 units	280 units
True	170 "	250 "
Hardness		
total	5	5
Ca	5	5
Mg	0	0
NO_3	.6	.6
PO_4	.64	.68
pH	4.6 units	4.5 units
Specific Conductance	14 mmhos	22 mmhos
H_2S	0	2
Secchi Disk	1.4 meters	

* units in mg/L unless otherwise stated

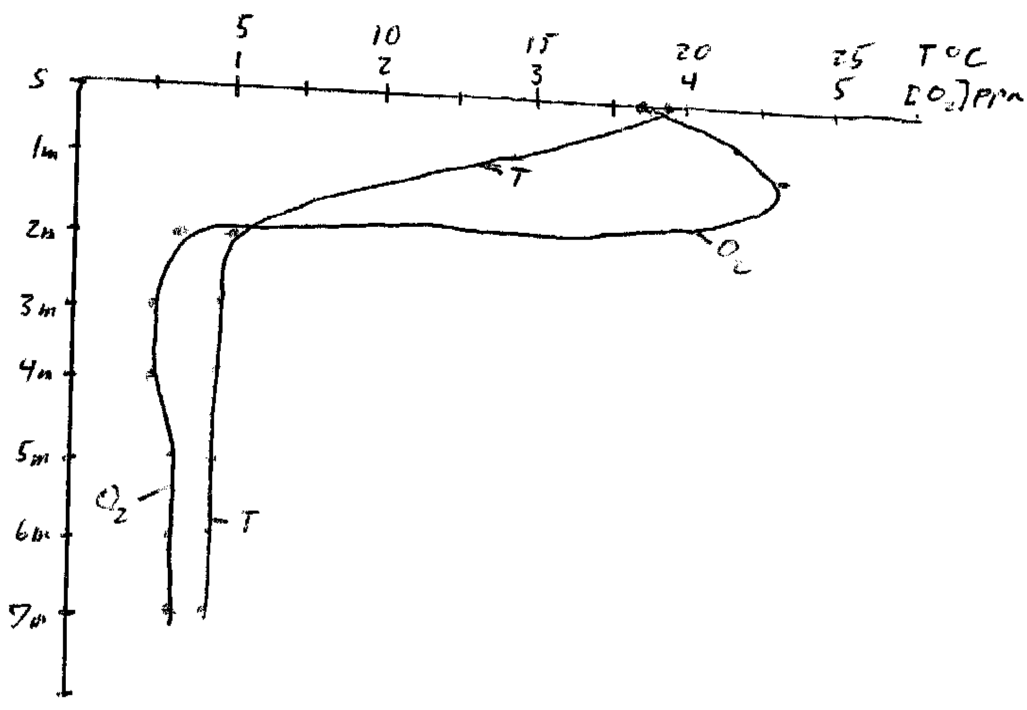
DEPTH	Conc. O_2 (ppm)	Temp. °C
s	3.7	19
1m	4.7	14
2m	.7	5.5
3m	.5	4.8
4m	.5	4.4
5m	.65	4.3
6m	.65	4.3
7m	.7	4.3

O_2 - Temp Profiles

Roach Lake



Ed's Bog



Roach Lake

Phytoplankton

Type	#/field		#/ml		%(AM+PM)
	AM	PM	AM	PM	
Blue-green					83
Anabaena	60	40	1200	800	
Choorococcus	200	1500	4000	30,000	
Oscillatoria acticulata	60	0	1200	0	
Polycystis	0	50	0	1000	
Chrysophytes					
Asterionella	30	22	600	440	2.3
Navicula	0	1	0	20	
Dinobryon bavaricum	140	60	2800	1200	8.7
Dinoflagellates					4.4
Peridinium	100	0	2000	0	
Desmids					1.1
Staurastrum	20	5	400	100	
Other Green Algae					.1
Pediastrum tetras	2	0	40	0	
TOTALS	612	1678	12,240	35,560	99.6

Zooplankton

Type	#/field AM	#/field PM	#/ml AM	#/ml PM	%(AM+PM)
Rotifers					17
Keratella cochlearis	10	10	200	200	
Testudinella	2	0	40	0	
Cladocerans					15
Bosmina longirostris	4	2	80	40	
Holopedium	3	4	60	80	
Polyphomus	0	6	0	120	
Copepods					54
copepodites	13	5	260	100	
Diaptomus	15	13	300	260	
Orthocyclops	3	5	60	100	
Senecella	9	7	180	140	
Nauplius	5	14	100	280	14
TOTALS	64	66	1280	1320	100

Ed's Bog

Phytoplankton

Type	#/feild AM	#/feild PM	#/ml AM	#/ml PM	%(AM+PM)
Blue-green					54
Choorococcus	200	300	4000	6000	
Polycystis	200	50	4000	1000	
Chrysophytes					29
Asterionella	0	400	0	8000	
Dinoflagellates					2
Peridinium	0	28	0	560	
Desmids					10
Gonatozygon	50	0	1000	0	
Netrium	1	1	20	20	
Onychonema	60	0	1200	0	
Staurastrum	1	0	20	0	
Other Green Algae					4
Ulothrix	40	0	800	0	
Spirogyra	15	0	300	0	
TOTALS	567	779	11340	15,580	99

Zooplankton

Type	#/feild AM	#/feild PM	#/ml AM	#/ml PM	%(AM+PM)
Rotifers					50
Keratella	10	20	200	400	
Cladocerans					38
Bosmina longirostris	0	8	0	160	
Daphnia longispina	4	4	80	80	
Daphnia pulex	1	4	20	80	
Leptodora kindtii	2	0	40	0	
Copepods					5
Diaptomus	3	0	60	0	
Nauplius	2	2	40	40	7
TOTALS	22	38	440	760	100

NOTE: Chaoborus; 64 AM, 44 PM