Phytoplankton in Crampton Lake and Brown Lake; A Comparative Study

BIOS 569 - Practicum in Aquatic Ecology

Denise Frantonius

913 LeMans Hall SMC

Dr. Ronald Hellenthal

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Abstract

This study is concerned with the algal productivity of two lakes of the same size and location: Crampton Lake in Vilas Co., Wisconsin, and Brown Lake in Gogebic Co., Michigan. In an effort to explain the large algal bloom which develops in Brown Lake in midsummer, the communities of phytoplankton, zooplankton, and macroinvertibrates along with the physical and chemical characteristics were studied in both lakes by a team of three students. This paper is mainly concerned with an assessment of the phytoplankton communities and the water chemistry. Phytoplankton samples were taken at three different testing periods throughout the summer of 1992. The algae was identified and samples were counted so that numbers per liter could be estimated. Several chemistry tests were run on the water during the same testing periods. Crampton Lake and Brown Lake both have some of the same algal species, however Brown Lake supports large numbers of the blue-green Aphanizomenon flos- aquae and Anabaena. The significant chemical difference is that Brown is a hard water lake, which is preferred by blue-green algae, while Crampton is a soft water lake.

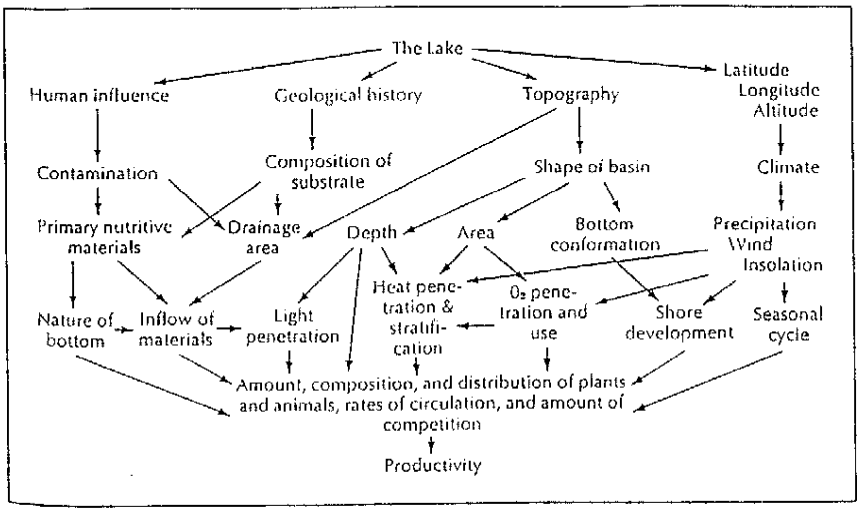

figure 1

A freshwater lake is a highly complex system. As shown by figure 1, there are many factors which interact and affect the productivity of a lake. These factors may combine in such a way that a large biomass of phytoplankton is supported. Studying these factors is important in finding ways to control algal growth in lakes and other water supplies. Crampton Lake (Vilas Co. WI) and Brown Lake (Gogebic Co. MI) present an opportunity to compare the characteristics of two lakes of comparable size and location. Brown supports a large algal bloom during the summer while the water in Crampton remains clear. A comparative study of the two lakes was conducted in order to determine stimuli of the algal growth in Brown; this paper concentrates on the phytoplankton community and the water chemistry, and is meant to be considered with two other papers on the zooplankton and benthic communities.

Prescott (1957) outlines the generalities which occur with algal blooms: 1) The lakes are enriched in nitrate and phosphate and are shallow so that decomposed matter can be circulated from the bottom. 2) Lakes which are high in CO2 (hard water) support algal blooms while soft water or acid lakes are usually spared. 3) The most adverse effects occur when one species dominates and is then followed by a succession of other dominans.

The chemistry of a body of water plays a large part in the determination of the flora of a lake. Prescott

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(1968) states,

> "Two bodies of water in close proximity may have drastically different biotic composition. Not only may the quality of the biota be different, but two such bodies of water may also vary in their productivity. The only explanation that can be offered is that the medium is different chemically."

Carbon, nitrogen, and phosphorus are the three main nutrients required for plant metabolism, along with hydrogen, oxygen, calcium, manganese, iron, and sodium. The nitrogen to phosphorus ratio should be about 10:1 Trace elements of manganese, copper, zinc, silicon and vitamins B12, thiamin, and biotin are also necessary. However, they are more likely to affect the species composition than the productivity (Darley 1982). The productivity actually depends only on the limiting factor, usually phosphorus.

Although Crampton and Brown are in close proximity and have comparable surface areas, the two lakes are really quite different. An oligotrophic lake is one which is deep, cold, has a low color index, low alkalinity, low pH, and low productivity (mostly desmids). A eutrophic lake is usually shallow, with a saucer shaped basin, warm, has a high color index, high alkalinity, high pH, and high productivity (Prescott 1968). Although both have some characteristics of a eutrophic lake, Crampton tends toward being an oligotrophic lake. It is not as deep as most oligotrophic lakes, but it is twice as deep as Brown. This greater depth causes Crampton to be more stratified. The water in the epilimnion may be circulated by wind mixing, but it is separated from the hypolimnion by a thermocline. Therefore, the nutrients from the sediments are not circulated up to the euphotic zone where it is needed by the algae. Brown, however, is shallow enough that the whole lake may be mixed all summer.

Being the largest sessile organisms in freshwater ecosystems, macrophytes have a large influence on light extinction, temperature, water flow, substrate quality, and the chemical environment. Macrophytes serve as a sink for nutrients during growth; Timms and Moss (1984)

found that phytoplankton was greatly reduced in a basin with water lilies. R. Christian Jones found that macrophytes later serve as a stimulus for algal growth because they are a source for nutrients during senescence (Jones 1990). Decaying macrophytes are a major source of dissolved total phosphorous and dissolved organic matter (Carpenter 1980). Sandy Engel (1988) researched a lake in southern Wisconsin which experienced a large mid-summer bloom similar to that of Brown Lake. Both lakes are shallow which allows a large portion of the lake bed to support macrophyte growth. The secchi depth of lake Halverson dropped from 3.5 m in the spring to 0.6 m in early July. Engel attributed this to a large crop of blue-green algae that was stimulated by the senescing curly-leaf pondweed. Engel states, "In functioning as nutrient capacitors-- to temporarily store and later release nutrients upon decay-- submerged macrophytes appeared to regulate blooms of blue-green algae.... Macrophytes dominate life in a shallow lake."

Materials and Methods

In order to account for differences in the lakes before, during, and after the bloom, three testing periods were established during the summer. Since the time of the peak of the bloom was not known, the three dates were scheduled according to when research weeks fell: June 8, June 21, and July 13. I tried to keep the physical conditions similar. However, my first collecting day was sunny and as the summer progressed, there were not as many sunny days. Consequently, the last two sample days were overcast.

Samples for both the zooplankton study and this study were taken from the deepest part of the lakes (figures 2,3). First, a secchi disk was used to find the point of light extinction. Two one liter samples were then taken at one half of the secchi depth with a Kemmerer sampler. These samples were for the purpose of identifying and counting phytoplankton. Two 500 mL samples were then taken at a one meter depth, and two more at one meter above the lake bottom, also with the Kemmerer sampler. These four samples were for evaluating

the water chemistry. The pH and dissolved oxygen should also have been taken at the test sight. However, the equipment was either faulty or already reserved on some of my test days.

Once back at the lab, the chemistry samples were immediately put in the refrigerator to inhibit any decomposition which could result in a change in the chemical makeup. The algae samples were resuspended and 25 mL were extracted and placed in a 50 mL centrifuge tube. To the samples 5 mL of a 4% formaldehyde solution were added. The samples were centrifuged on high for ten minutes, then the top 25 mL were carefully siphoned. The last 5 mL was vigorously shaken and transferred to a 4 dram vial, labelled, and placed in the refrigerator for later analysis. When analyzed, one milliliter samples were transferred to a Segdwick-Rafter counting chamber. The number of each type of alga in the one milliliter portion were counted, then multiplied by five to determine the total amount in the 5 mL centrifuged sample. This number actually represented the number of alga in the 25 mL sample, so this number was multiplied by 40 in order to determine the number of cells of filaments in a one liter sample. In this manner, the differences in the biomass of one liter samples of the two lakes could be compared. Closest attention was paid to the five most abundant species in each lake, and those that were common to both lakes on each testing date. These algae were identified using various identification manuals.

The chemical parameters were tested within twenty-four hours of taking the samples. Using the Hach water chemistry kit, spectrophotometer and titration techniques were employed to determine levels of nitrate, phosphate, ammonia, hardness, alkalinity, acidity, and true and apparent colors. Unfortunately all of the chemicals and instructions for some of the tests were not found until the second testing period. Since two samples were taken from each sight and depth, the tests could be done twice in order to insure that a value was not extraneous. If the two numbers had a high discrepancy, the test was redone. The presented data reflects the average of the two numbers.

Only qualitative observations of the macrophyte communities were made. This included identifying some

plants and observing relative abundance and senescence.

In order to further compare the biomass of the two lakes, chlorophyll a should be measured. However, the fluorometer was not functioning so the chlorophyll samples that were taken could not be evaluated.

Results

In all three testing periods, Brown had much more abundant algal growth. Tables 1,2, and 3 present the five most abundant species in each lake during each test date. Overall, the most abundant species in Crampton were Dinobryon, Asterionella formosa, Staurastrum, and Arthrodesmus. Brown supported mainly Aphanizomenon flos-aquae, Anabaena, and Fragilaria. When numerous abundant species were present, the ones that were common to each lake were counted.

The chemical data is presented in figures 4- 13.

Visual observations are as follows. The first trips to Crampton Lake and Brown Lake found two beautiful lakes. Crampton was surrounded mostly by pine trees and much of the shoreline was bordered with sphagnum. This vegetation is usually indicative of acidic conditions. Later tests proved that Crampton had a pH of 6.0 and is indeed acidic. Except for along the shoreline, the only submerged vegetation was a plant later identified as Isoetes growing for the most part on rotting logs. The shoreline did support a growth of Nuphar (yellow water lily), Nymphaea (white water lily), water irises, and Pondeteria cordata (pickerel weed). The first trip to Brown revealed a much more diverse and abundant macrophyte growth. There were many dense beds of water lilies. The channel leading to Brown Creek was covered by them, along with pickerel weed along the periphery. The channel was also choked with oxygen producing plants, Prepanocladus. Inlets and bays supported growths of Lemna (duckweed). The water was more turgid than Crampton, but it was not green. The spades of Aphanizomenon flos-aquae had begun to appear in Brown by June 7. By June 20, the water lilies and pickerel weed had begun to senesce. By June 29, the Aphanizomenon abounded. It was readily apparent with the naked eye, and gave the water a pea green color. By July 13, many of the macrophytes were dying and some of the bloom was beginning to decay, causing it to float in a noxious

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green scum atop the water.

Discussion

Although quantitative studies of the macrophytes in Brown and Crampton were not conducted, the macrophytes do contribute to the overall study. The algal growth in Brown Lake reflects the two effects of macrophytes as nutrient storage units and providers of nutrients. While there was still an abundance of blue-green algae when macrophytes were still prolific, there was considerably less algal growth in the inlet to Brown Creek. This inlet was covered with water lilies and pickerel weed. Also, I observed that the macrophytes had begun to senesce on June 20, and by June 29, Brown lake had turned completely green with the blue-green bloom.

Although measuring the nutrients present in a standing stock of water is not a very good indicator of the actual nutrient status, it does present some useful comparative information. Although the Hach system is not the most accurate method for measuring the low nutrient levels in these lakes, it is useful in studying trends. The nitrate levels of both lakes increased as the summer progressed. Brown lake, the more productive of the two, generally had higher nitrate levels. The same is true for the ammonia levels, (a more readily usable form of nitrogen). The phosphorus levels experience a dramatic increase in both lakes in the July 13 reading. This may be caused by the nutrients added to the water column by the senescing macrophytes and, for Brown Lake, the decaying Aphanizomenon. The nutrient levels are almost always higher in Brown Lake. Nonetheless, the discrepancies are not great enough to attribute the main difference between the two lakes to these nutrient levels. One area in which a large chemical difference is found is in the alkalinity. The alkalinity, hardness, and pH are all higher in Brown lake (figures 10-13). The pH is around 8.4 and the alkalinity is around 50 mg/L while the pH of Crampton is around 6.0 and the alkalinity is less than 1 mg/L. Hard-water lakes usually support more algae growth, since the algae can use HCO as a source of carbon (Darley 1982). Therefore, this is a significant difference between the two lakes. The reason

that Brown has harder water could be that it is more eutrophic than Crampton. Another cause could be a source leading into Crampton. The day before the summer program ended, a bog was discovered that feeds into Crampton through an old beaver dam. Although the outflow was not very great, the bog water might contribute to the acidity (and softness) of Crampton. The hardness of the water decreased slightly from one testing period to the next. This could be because both Anabaena and Aphanizomenon, both found in Brown, cause natural water softening (Darley 1982).

The method of counting algae is not quantitatively accurate. Concentrating 25 mL of lake water from a one liter sample into a five milliliter sample and then taking a one milliliter portion of this makes it difficult to guarantee a true representation of the phytoplankton populations. It would have been better to be able to estimate the biomass via a fluorometer.

Crampton and Brown Lakes support diverse phytoplankton populations. This variance in algae types is likely due to the chemical difference, namely hardness, of the water. The algae most common to hard-water lakes are Cyanophyta and diatoms while those most common in soft water are the chlorophyta (Prescott 1958).

The ability to support blue-green algae was the determinate of higher productivity in Brown. The numbers of the algae that the lakes had in common were more comparable (figures 14-16). There were two instances where the growth of Asterionella and Fragilaria were much greater in Brown. These diatoms prefer hard-water lakes. On July 13, Crampton supported much more Dinobryon; this algae prefers the acidic water.

I was not surprised to find Aphanizomenon flos-aquae in Brown Lake since it is one of the most common bloom species. It is a blue-green algae so it abounds in hard-water, eutrophic lakes. Also, it is more tolerant of high temperatures (Palmer 1962). Since Brown is such a shallow lake, the water temperature is higher than in Crampton. Aphanizomenon is a highly visible bloom because it occurs in bundles and has gas vesicles which provide buoyancy (Darley 1982). An Aphanizomenon bloom is often compared to the appearance of grass clippings dumped in the lake. Being that the bundles float close to the surface, they quickly deteriorate in the sunlight.

This forms a noxious scum which floats on the surface (Prescott 1968). Brown Lake is an ideal place for Aphanizomenon, not only because it is alkaline, warm, and eutrophic, but also because of a unique characteristic. Aphanizomenon originates at the bottom of the lake, then later floats to the surface. Since Brown is so shallow, light can reach the bottom of the lake early in the summer. Also, its large colony size protects it from zooplankton grazing.

Anabaena also commonly develops large blooms. It has the ability to fix nitrogen, which allows it to produce well even in periods in which nitrogen is not readily available. It is a dangerous bloom because it is the most poisonous all blue-green algae (Prescott 1968). Therefore, it is not usually grazed by zooplankton.

I found Asterionella formosa in both lakes. This is surprising since it is usually found in hard-water lakes (Prescott 1978). They usually produce a large spring population and diminish in number in the fall. The data supported this by showing a continual decrease in numbers in both Crampton and Brown throughout the summer. The growth of A. formosa may be affected by the chytrid, Rhizophidium planktonicum. This fungi may reduce the size of the maximum, thus allowing other diatoms to increase in number because of the reduced competition (Round 1965). As the number of A. formosa decreased during the summer, it was replaced by increasing numbers of Fragilaria. Makereth (1953) found that the greatest uptake of phosphate by A. formosa takes place between pH values of 6 and 7. This corresponds to the pH of Crampton and may be one indication of why A. formosa is found in Crampton while it usually prefers hard-water.

Dinobryon, Arthrodesmus, and Staurastrum are acclimated to acidic water. Dinobryon has its main growing period in the summer, as is evidenced by its increasing numbers in the subsequent testing dates (Round 1965).

Conclusions

In a descriptive study of this nature it is difficult to make any definite conclusions. Many factors play into the difference between the two lakes. Perhaps one of the most influential causes of the bloom in Brown Lake is its alkalinity. The two algae which bloomed in

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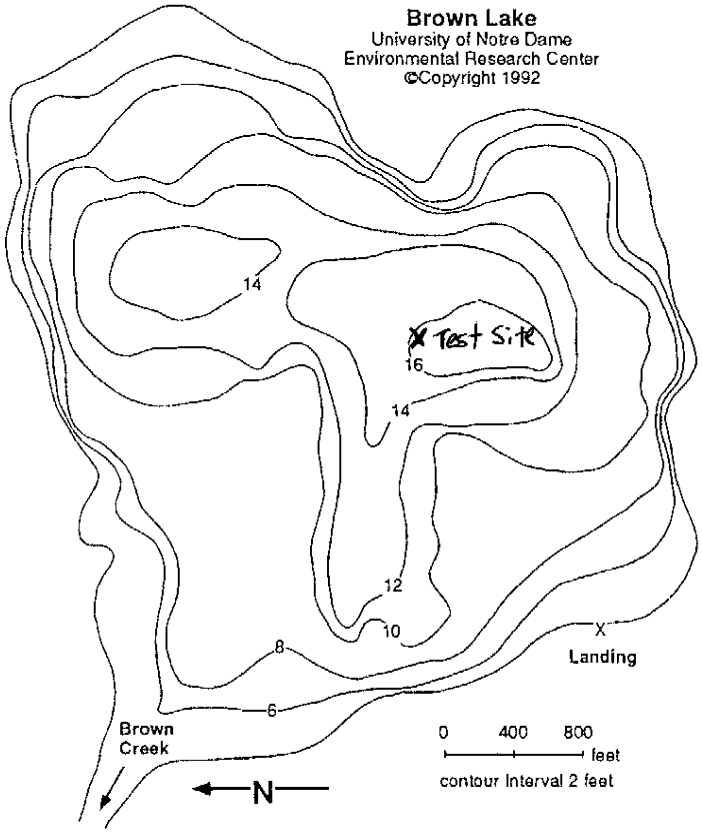
Brown were both blue-green algae which need the hard water to provide enough carbon. Also, the relative shallowness allows more nutrients to be circulated. The higher abundance of macrophytes provides many nutrients during scenescence. Brown lake is generally more eutrophic, and therefore is better suited for algae growth.

If more definite conclusions were needed, additional tests and experiments would have to be run. Small models of each lake could be set up in aquariums. The blue-green species from Brown could be introduced into the Crampton tank. Nutrient levels or alkalinity could then be manipulated to determine whether or not higher levels would cause Crampton to support blue- green algae. The chemical characteristics could be further studied by testing silica, sodium, vitamin B12, and others.

Figure 3


Brown Lake
University of Notre Dame
Environmental Research Center
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14
Test Site
16
14
12
10
8
6
X
Landing
Brown
Creek
N
0 400 800
feet
contour interval 2 feet

Figure 4

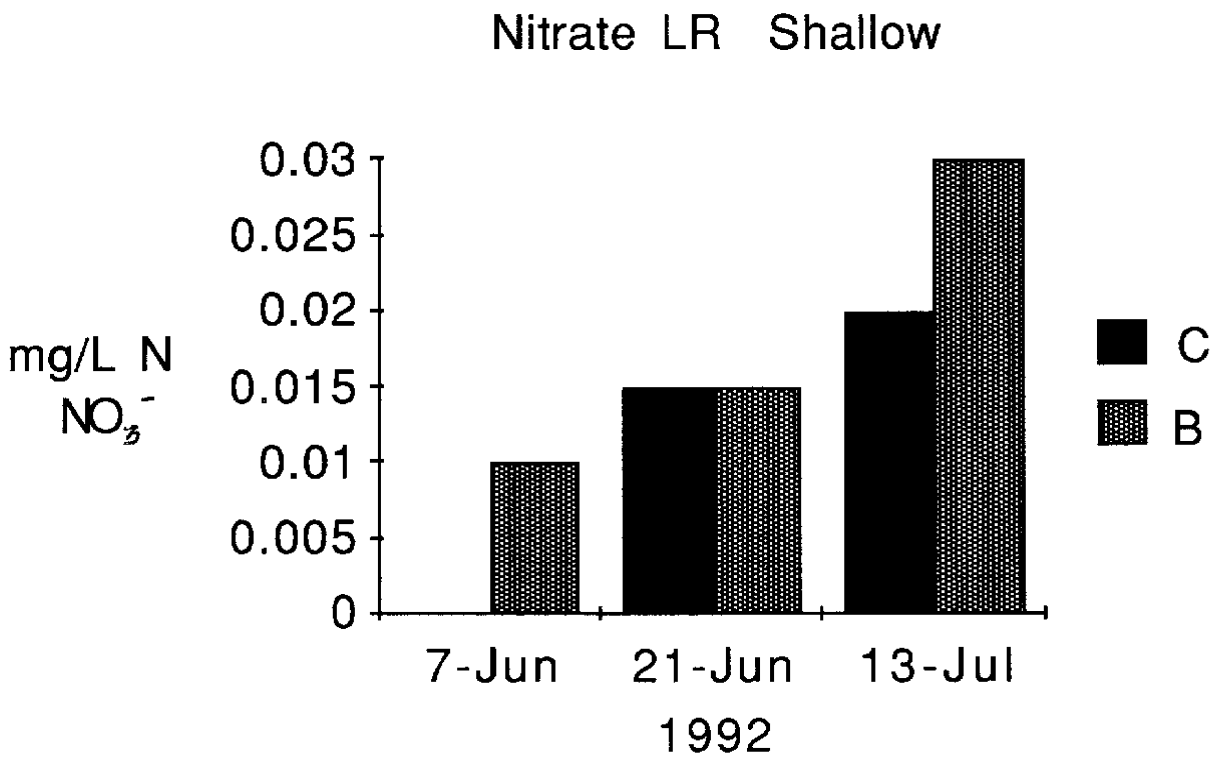
Nitrate LR Shallow
mg/L N
NO_3^-
0.03
0.025
0.02
0.015
0.01
0.005
0
7-Jun
21-Jun
13-Jul
1992
C
B

Figure 5

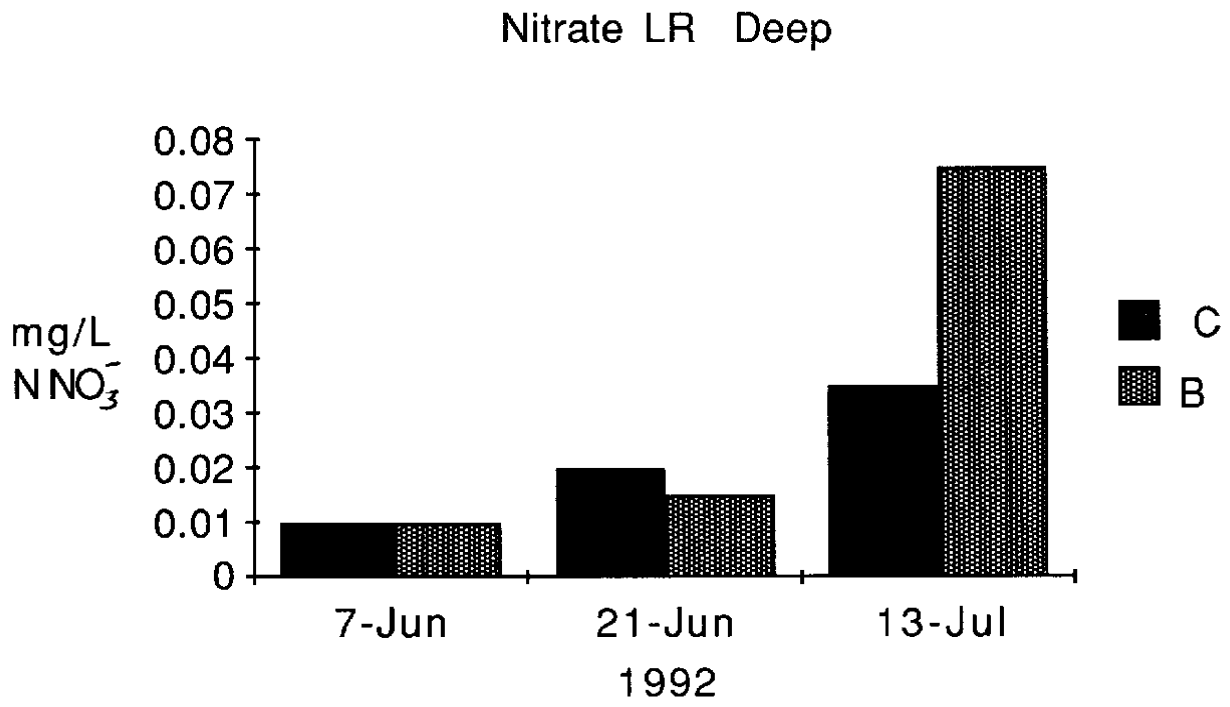
Nitrate LR Deep
mg/L
NNO_3^-
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
7-Jun
21-Jun
13-Jul
1992
C
B

Figure 8

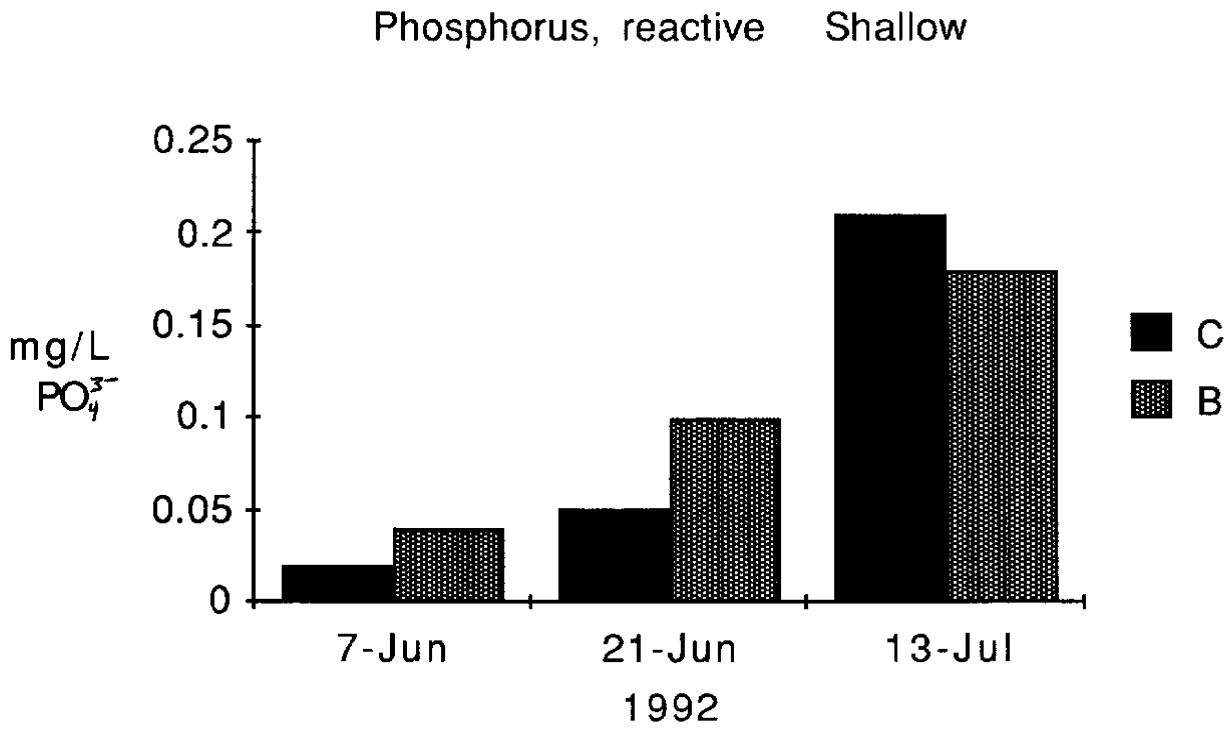
Phosphorus, reactive Shallow
mg/L
PO_4^{3-}
0.25
0.2
0.15
0.1
0.05
0
7-Jun
21-Jun
13-Jul
1992
C
B

Figure 9

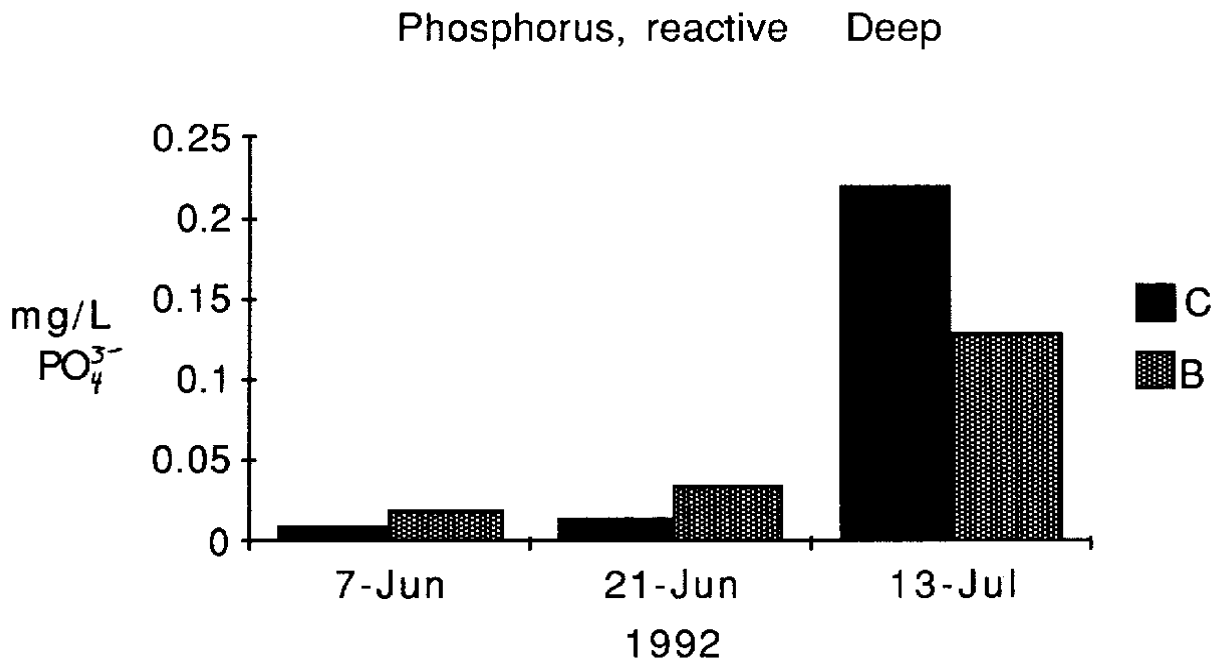
Phosphorus, reactive Deep
0.25
0.2
0.15
0.1
0.05
0
mg/L
PO_4^{3-}
7-Jun
21-Jun
13-Jul
1992
C
B

Figure 10

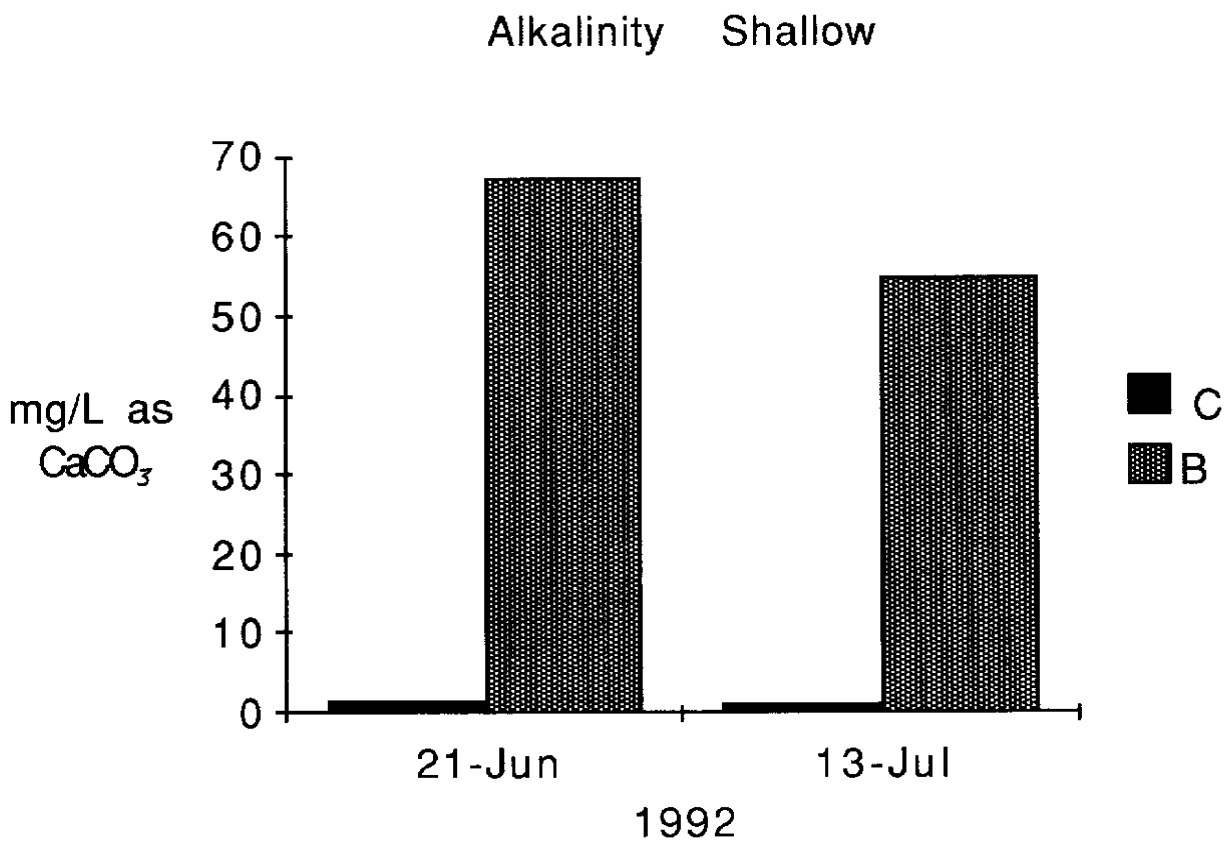
Alkalinity Shallow
70
60
50
40
30
20
10
0
mg/L as
CaCO3
21-Jun
13-Jul
1992
C
B

Figure 11

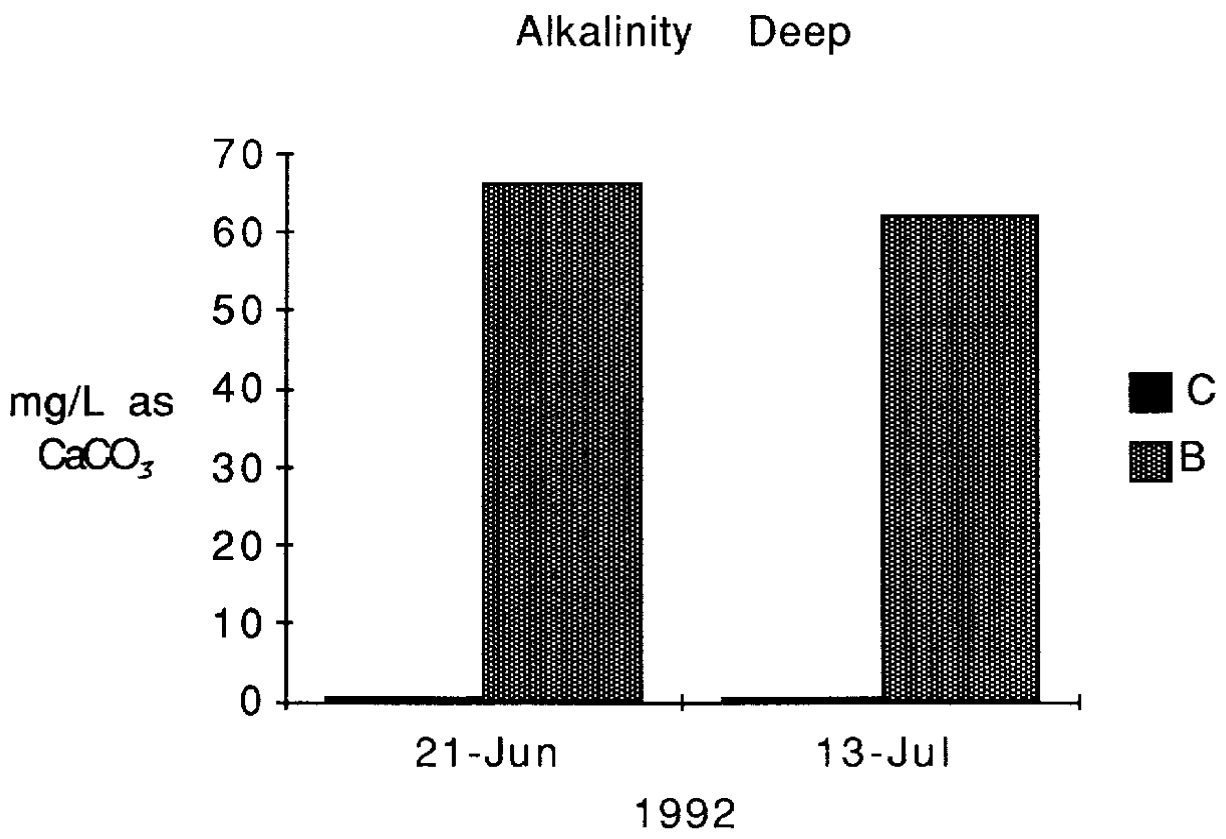
Alkalinity Deep
70
60
50
40
30
20
10
0
mg/L as $CaCO_3$
21-Jun
13-Jul
1992
C
B

Figure 12

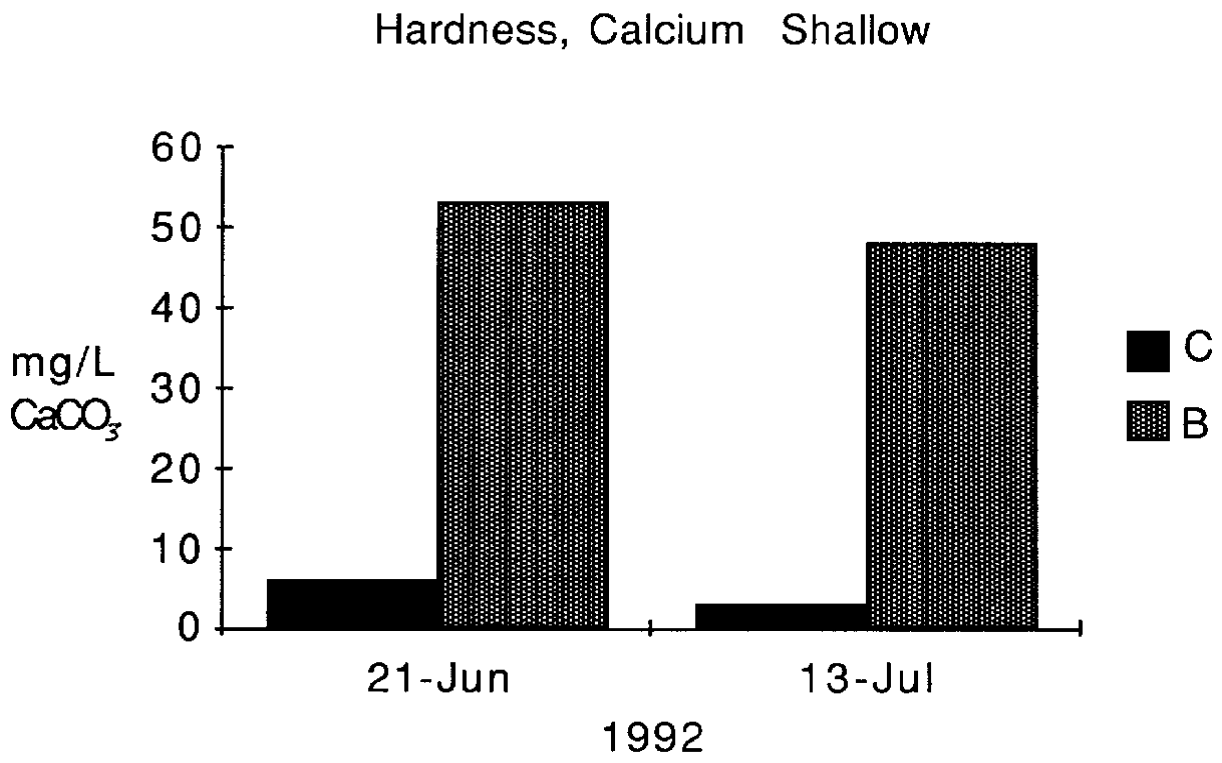
Hardness, Calcium Shallow
60
50
40
30
20
10
0
mg/L
CaCO3
21-Jun
13-Jul
1992
C
B

Figure 13

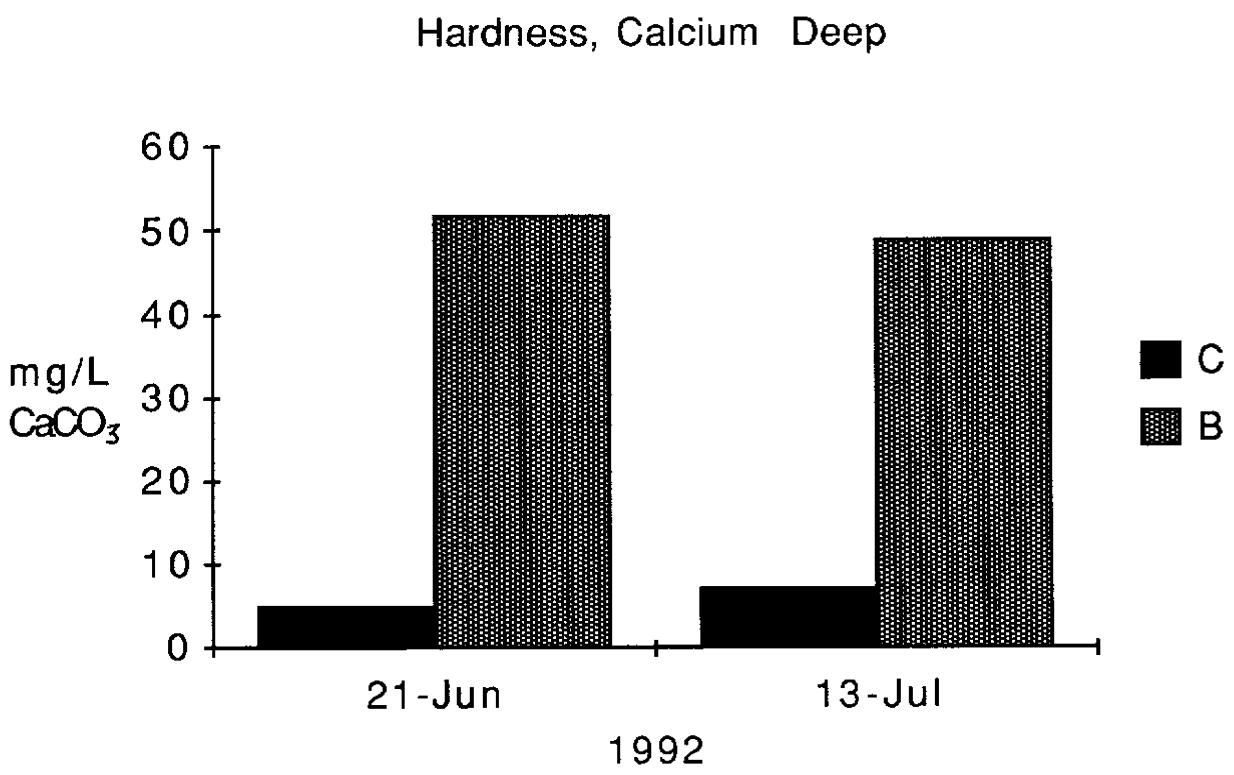
Hardness, Calcium Deep
60
50
40
30
20
10
0
mg/L
CaCO3
21-Jun
13-Jul
1992
C
B

Figure 14

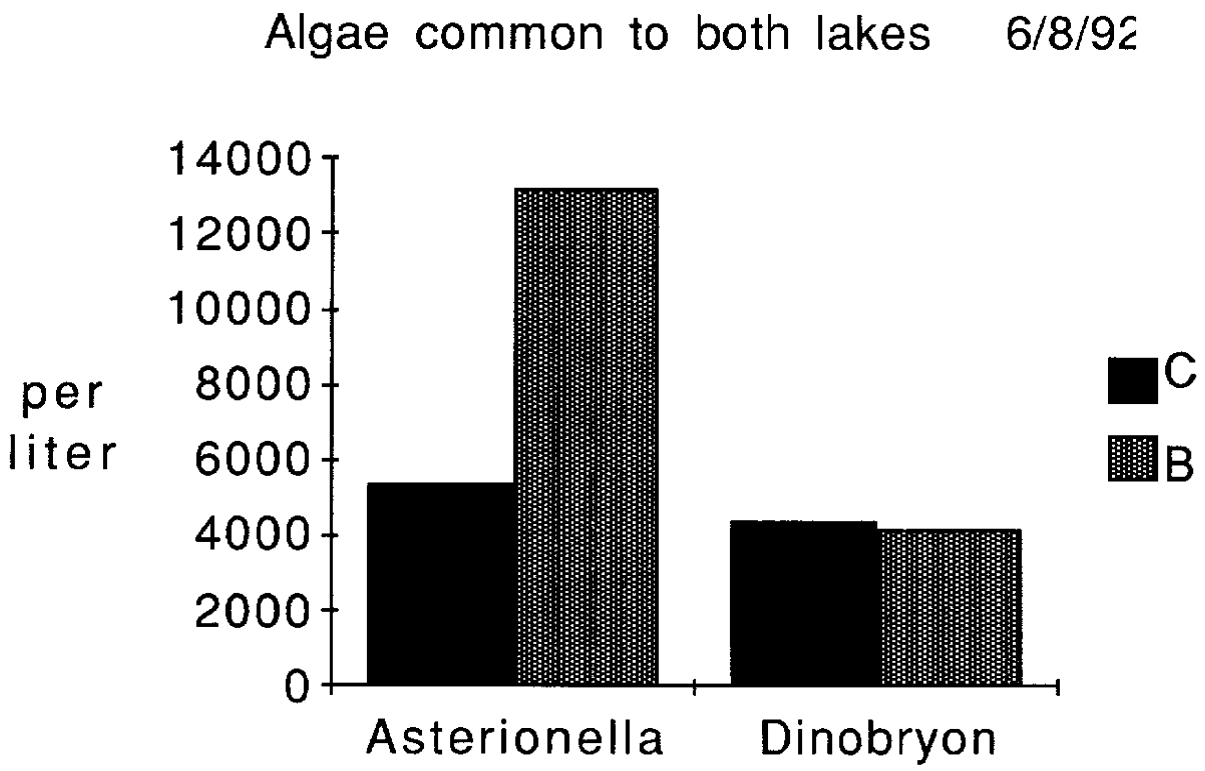
Algae common to both lakes 6/8/92
14000
12000
10000
8000
6000
4000
2000
0
per
liter
C
B
Asterionella
Dinobryon

Figure 15

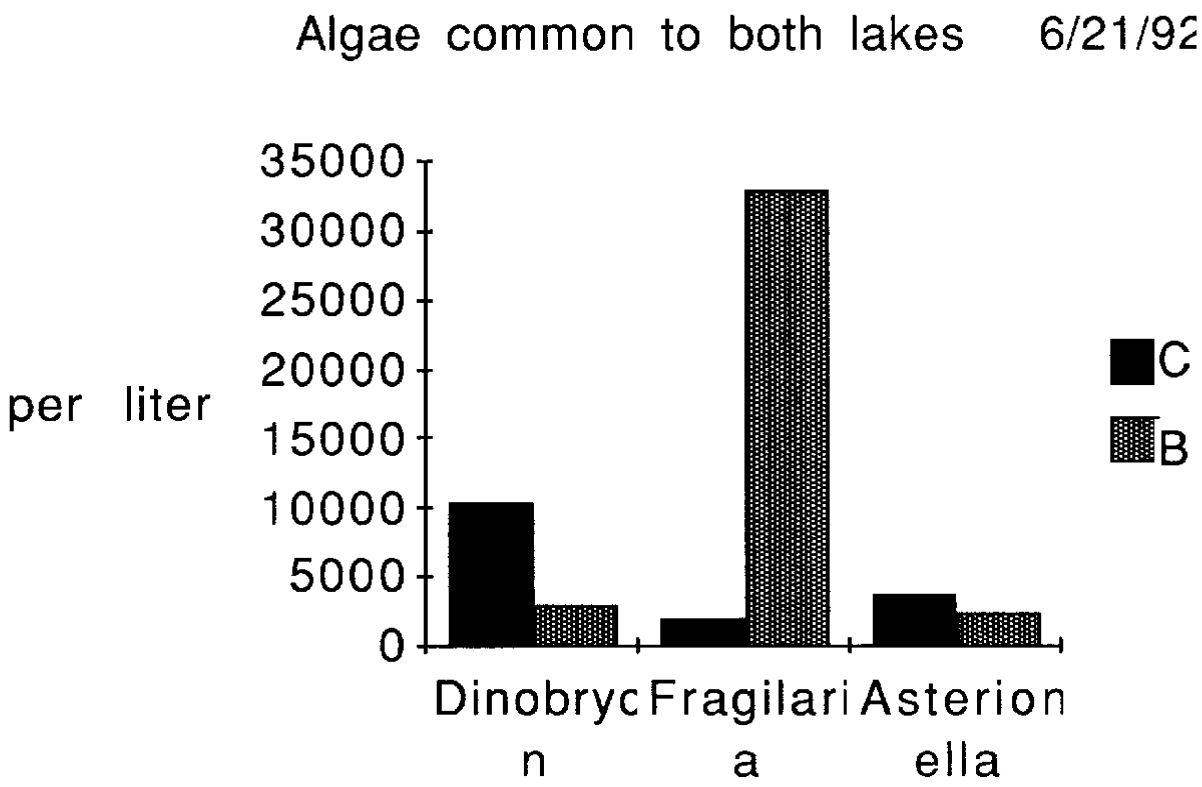
Algae common to both lakes 6/21/92
per liter
35000
30000
25000
20000
15000
10000
5000
0
C
B
Dinobryc n
Fragilari a
Asterion ella

Figure 16

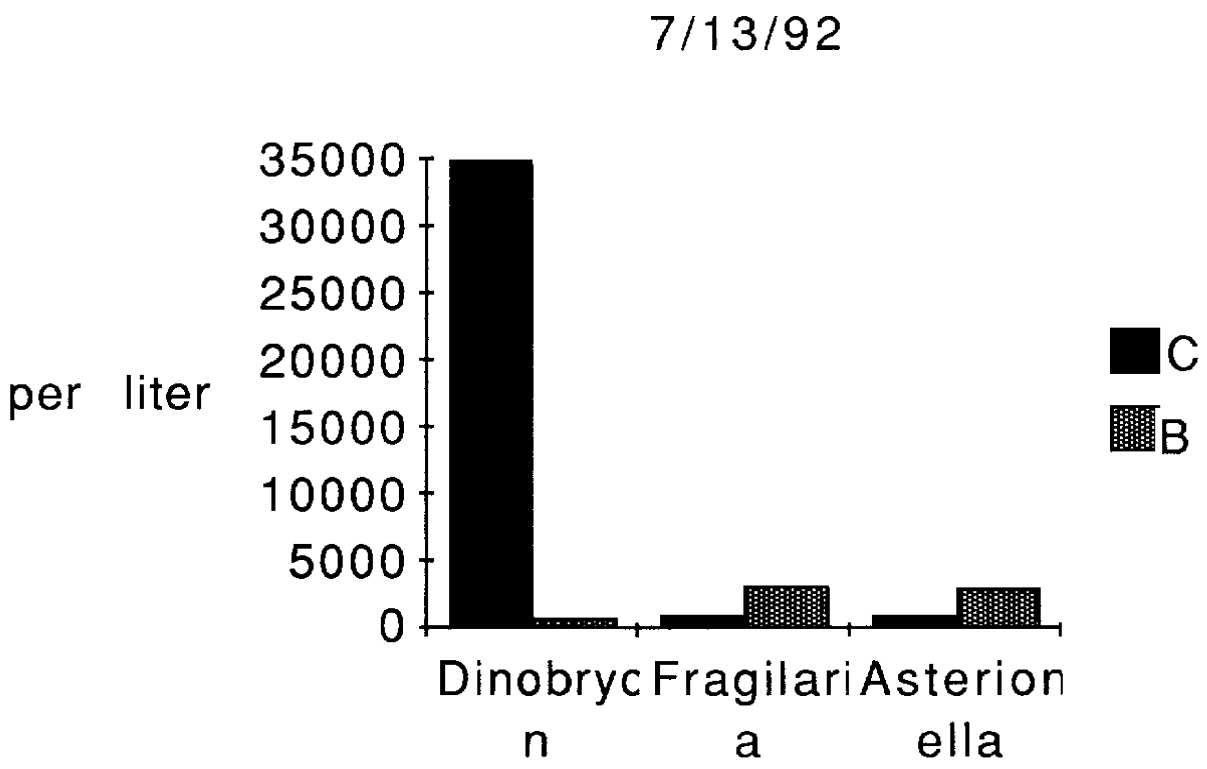
7/13/92
per liter
35000
30000
25000
20000
15000
10000
5000
0
Dinobryc n
Fragilari a
Asterion ella
C
B

Table 1

	A	B	C	D	E	F	G	H	I
1			8-Jun-92						
2									
3	secchi disk	4.25 m			secchi disk	1.5 m			
4									Brown Creek I
5	Crampton				Brown				8-Jun
6	8-Jun				8-Jun				
7		per slide	per liter			per slide	per liter		Aphanizomenor
8	Asterionella	27	5400		Aphanizomenor	343	68600		
9	formosa				flos-aquae				
10									Anabaena
11	Dinobryon	22	4400		Anabaena	320	64000		
12									
13									Dinobryon
14	Arthrodesmus	9	1800		Asterionella	66	13200		
15					formosa				
16									Asterionella
17	Staurastrum	2	400		Dinobryon	21	4200		
18									
19									Fragilaria
20					Fragilaria	15	3000		
21									
22									
23	Common algae								
24		Crampton	Brown						
25		# in 1 L	# in 1 L						
26	Asterionella	5400	13200						
27	Dinobryon	4400	4200						

Table 1

	J	K
1		
2		
3		
4	nlet	
5		
6	per slide	per liter
7	185	37000
8		
9		
10	185	37000
11		
12		
13	25	5000
14		
15		
16	8	1600
17		
18		
19	2	400
20		
21		
22		
23		
24		
25		
26		
27		

Table 2

	A	B	C	D	E	F
1	secchi disk	4.25 m			secchi disk	1.0 m
2						
3	Crampton				Brown	
4	6/21/92				6/21/92	
5		per slide	per liter			per slide
6	Dinobryon	52	10400		Anabaena	658
7						
8						
9	Asterionella	19	3800		Aphanizomenon	569
10					flos-aquae	
11						
12	Arthrodesmus	12	2400		Fragilaria	165
13						
14						
15	Fragilaria	10	2000		Dinobryon	15
16						
17						
18	Staurastrum	5	1000		Asterionella	12
19						
20						
21	Common algae	Crampton	Brown			
22	6/21/92	per liter	per liter			
23						
24	Dinobryon	10400	3000			
25	Fragilaria	2000	33000			
26	Asterionella	3800	2400			

Table 2

	G
1	
2	
3	
4	
5	per liter
6	131600
7	
8	
9	113800
10	
11	
12	33000
13	
14	
15	3000
16	
17	
18	2400
19	
20	
21	
22	
23	
24	
25	
26	

Table 3

	A	B	C	D	E
1					13-Jul-92
2					
3	secchi disk	4.25 m			secchi disk
4					
5	Crampton				Brown
6	7/13/92				7/13/92
7		per slide	per liter		
8	Dinobryon	175	35000		Anabaena
9					
10	Arthrodesmus	12	2400		Aphanizomenor
11					
12	Fragilaria	5	1000		Fragilaria
13					
14	Asterionella	5	1000		Dinobryon
15					
16	Staurastrum	5	1000		Asterionella
17					
18					
19	Common algae	Crampton	Brown		
20		per liter	per liter		
21	Dinobryon	35000	760		
22	Fragilaria	1000	3200		
23	Asterionella	1000	3000		

Table 3

	F	G
1		
2		
3	0.75 m	
4		
5		
6		
7	per slide	per liter
8	980	196000
9		
10	683	136600
11		
12	160	32000
13		
14	38	7600
15		
16	15	3000
17		
18		
19		
20		
21		
22		
23		

Acknowledgements

I would first like to thank the Bernard J. Hank family for making such a rewarding summer possible.

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Finally, my eternal thanks and praise to God for giving us this beautiful and precious earth, and the opportunity to live and learn from it. I only hope that I can aid in its longevity, and not its decay.

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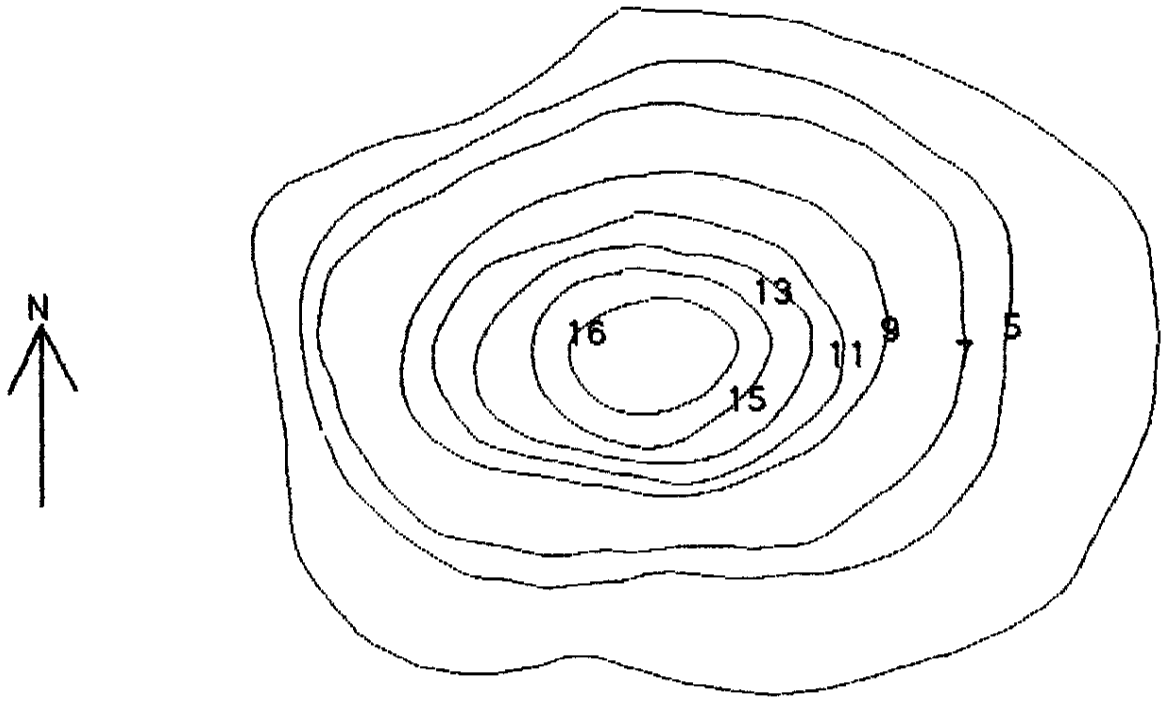
Appendix B

Softside Lake



0 .01 .02 .03 .04

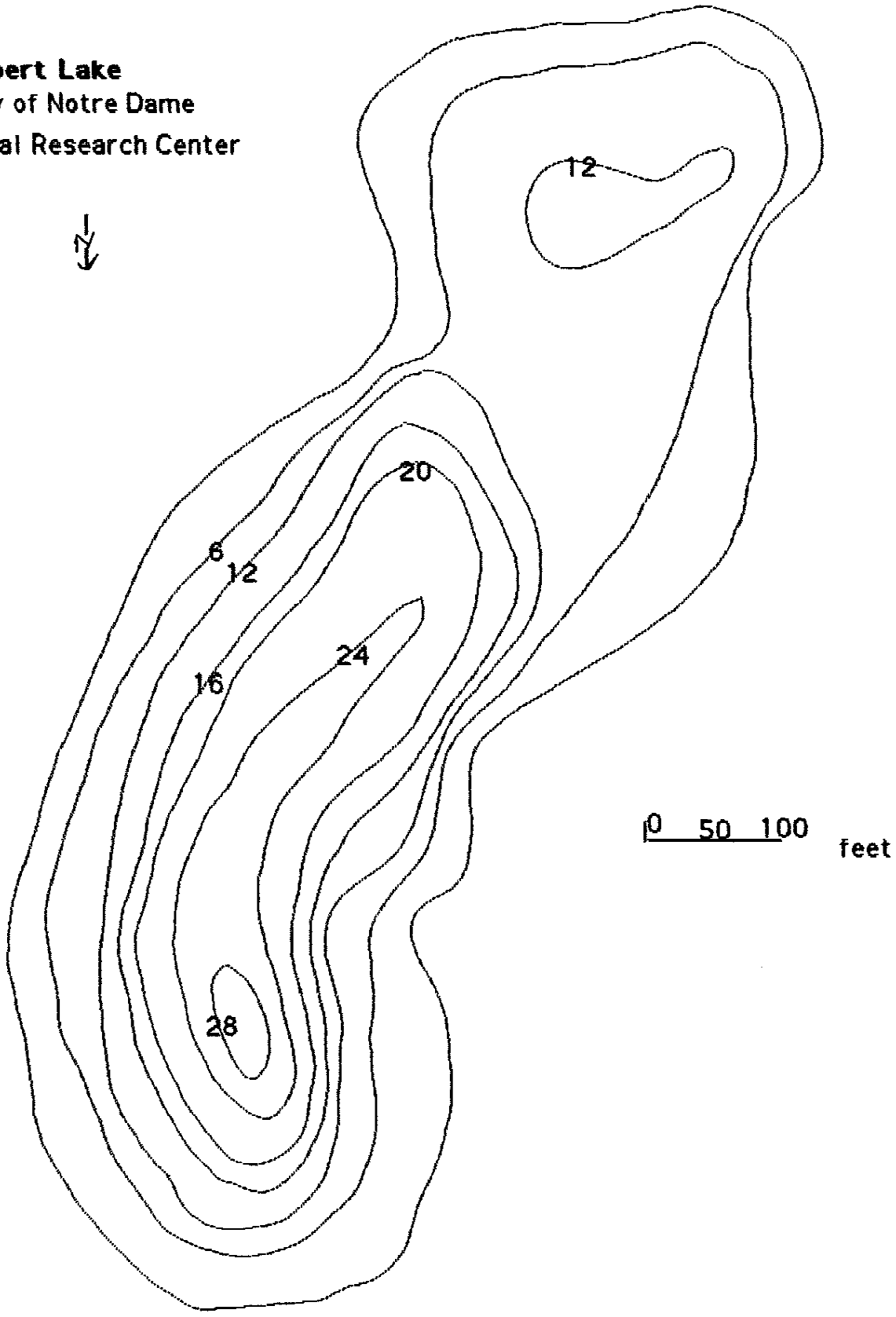
miles

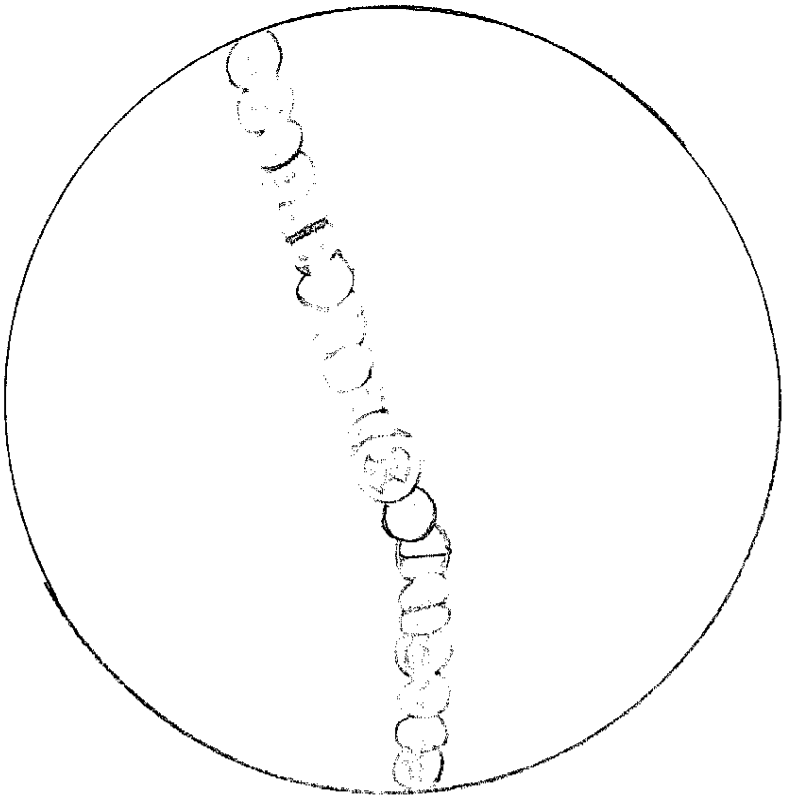
contours in feet

Gilbert Lake

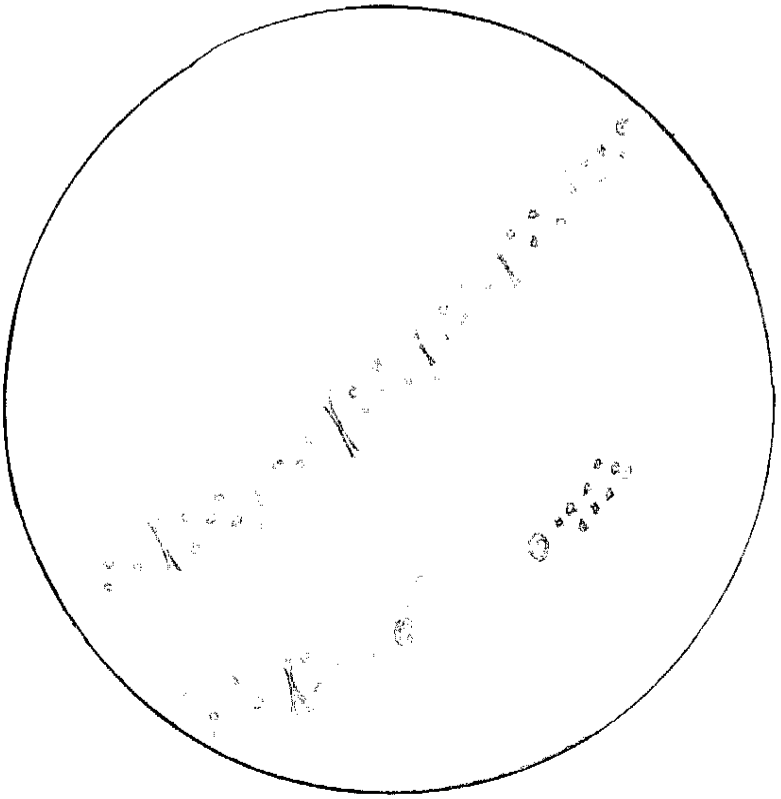
University of Notre Dame

Environmental Research Center

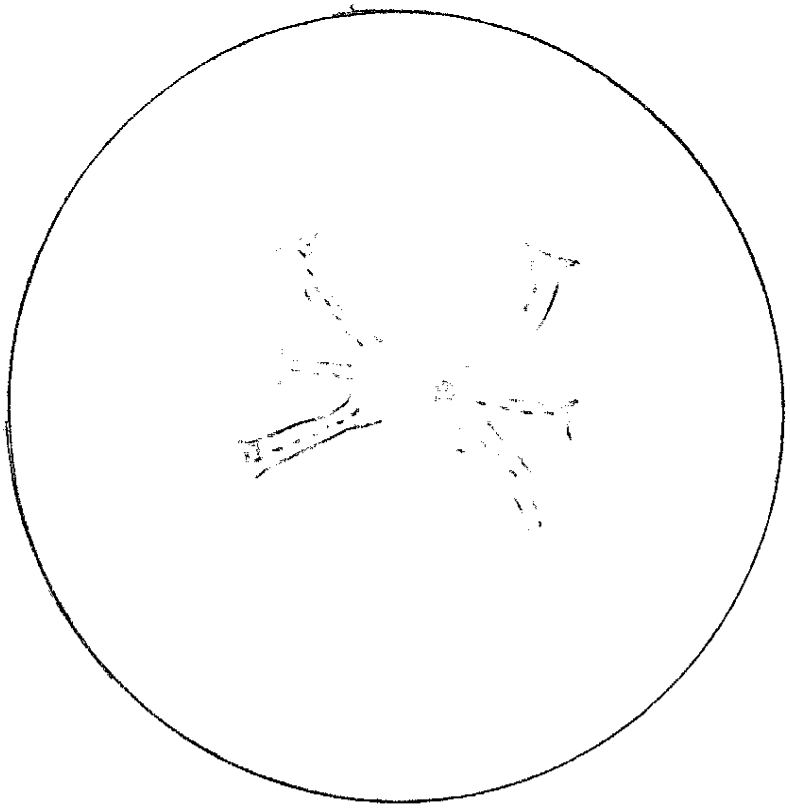




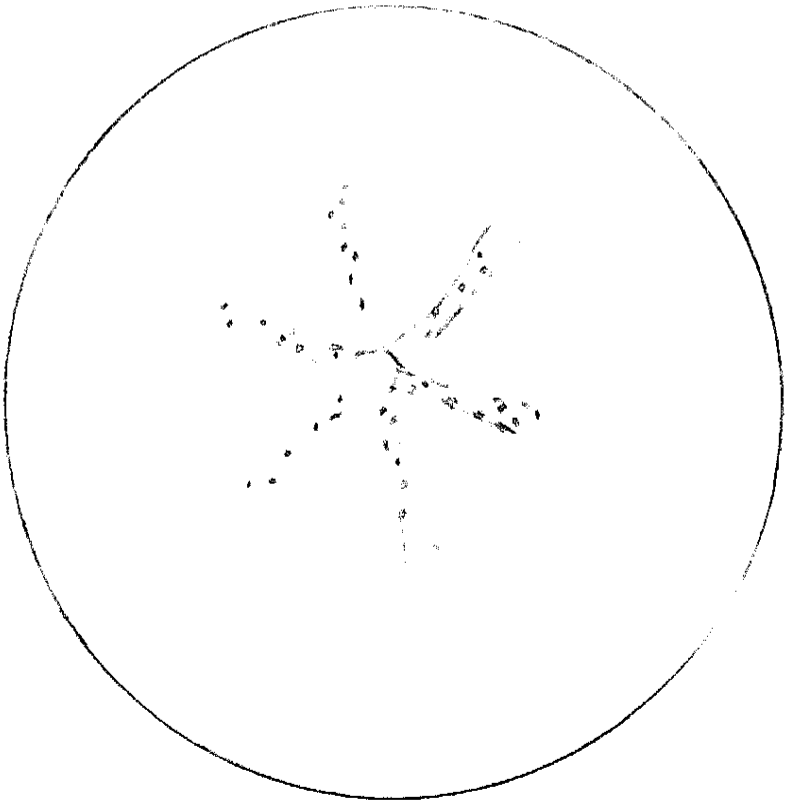
Anabaena
toxic
forms blooms
found in Brown



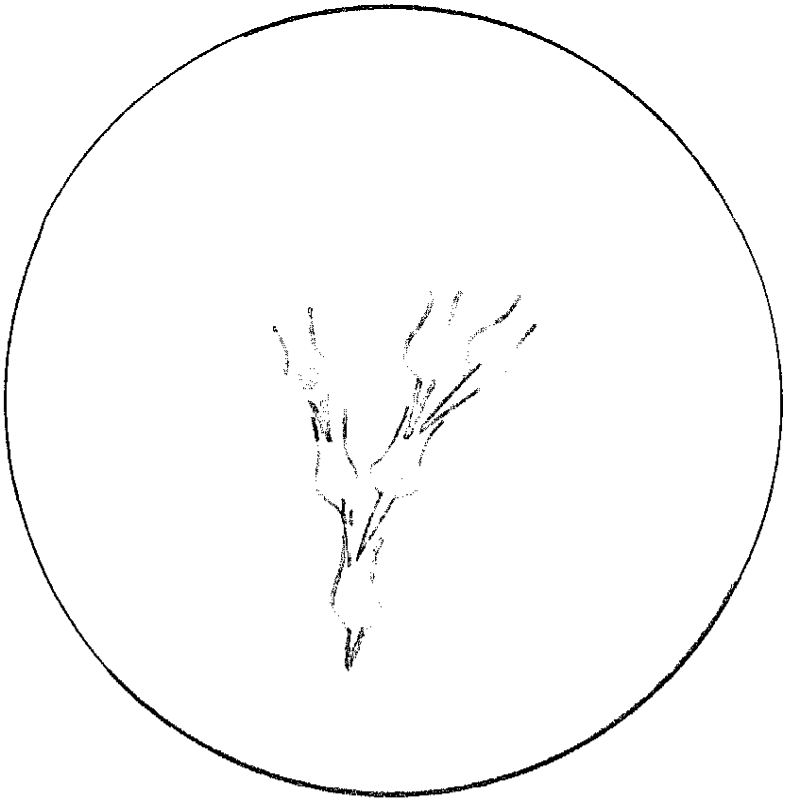
Aphanizomenon
toxic
forms blooms
found in Brown
Spade shaped colonies
colonies visible to naked eye



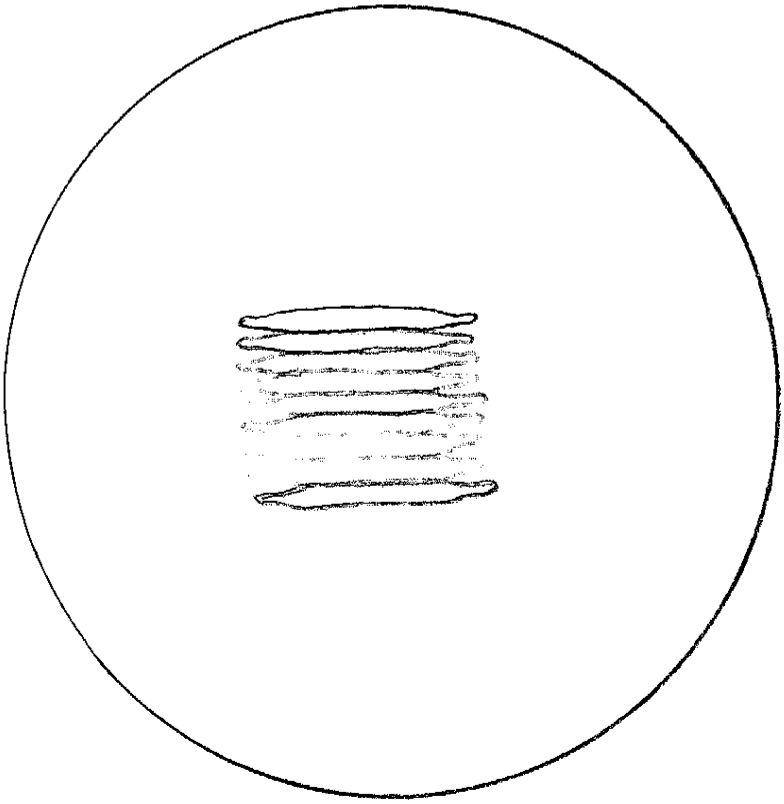
x 400
Staurastrum
prefers acidic
found in both Crampton and Brown



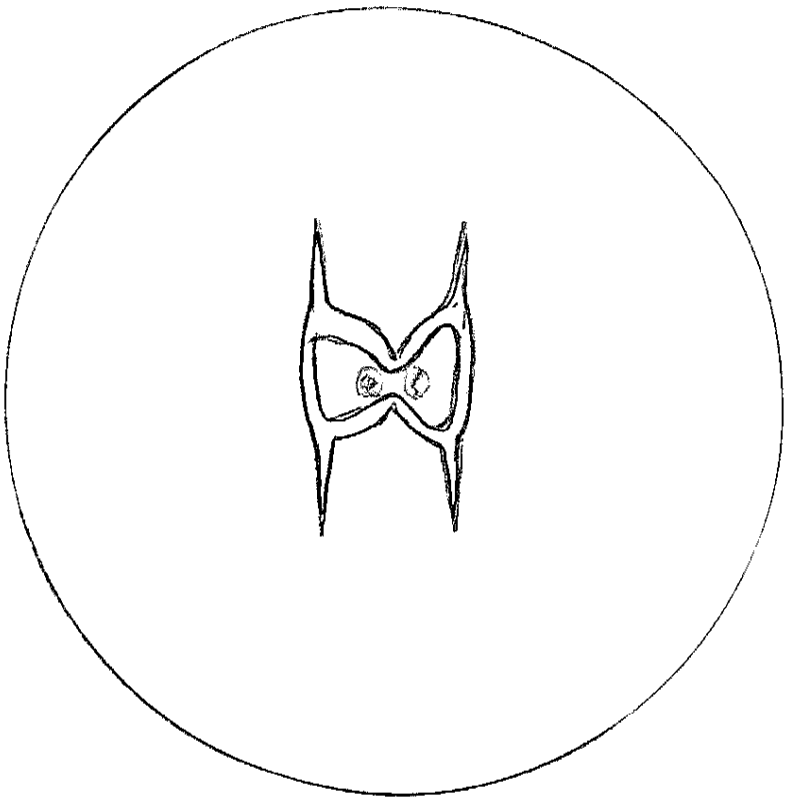
x 400
Asterionella formosa
found in both Crampton and Brown



Dinobryon
prefer acidic water
found in Crampton and Brown



Fragilaria
found in Crampton and Brown

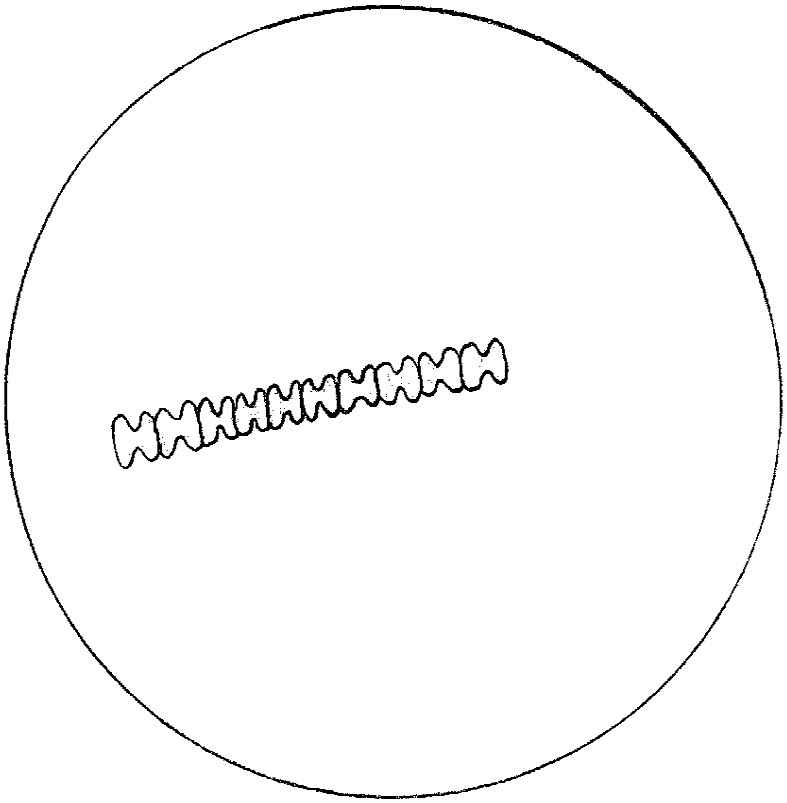


x400

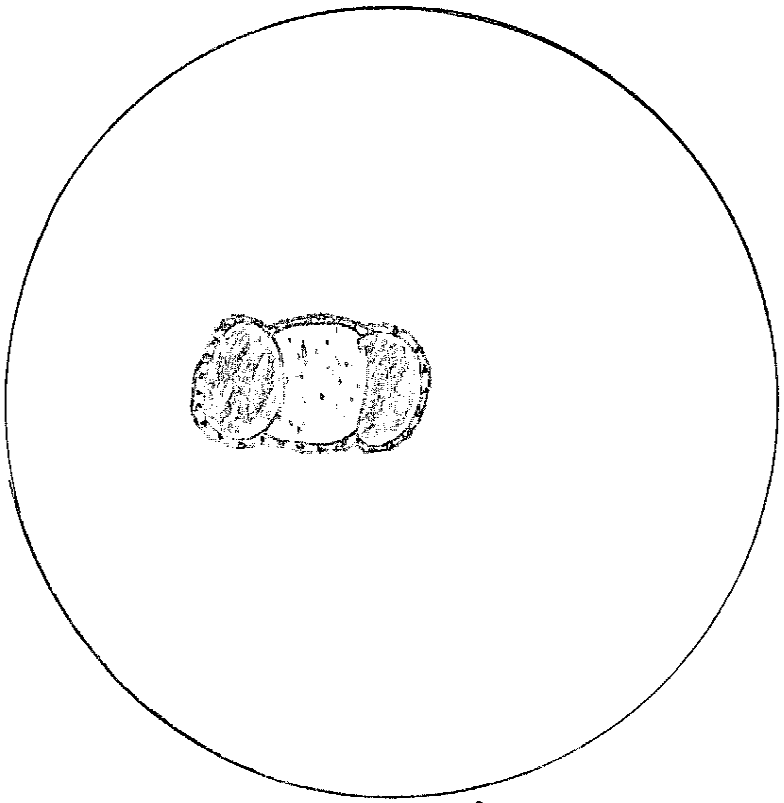
Arthrodesmus

prefers soft-water

found in Crampton Lake

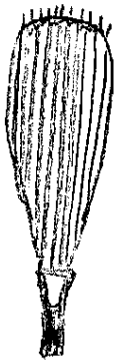


Spondulosium
found in Crampton



unidentified - Diogenes?
found in Crampton

Roach Lake - June



Spinoclosterium

Peridinium

Tabellaria