Bathymetry, *Chaoborus* migration and Physical Parameters of Cranberry Bog, Nansen Lake and Ziesnis Bog

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Abstract

Chaoborus are abundant throughout the water column of ponds, lakes and bogs and are the top invertebrate predators. For this reason their behavior is important to study and understand. Chaoborus often show a diel vertical migration to the surface waters during the night. This migration may be due to the direct effects of predator avoidance and food availability and/or the indirect effects of temperature and light availability.

Physical and biological parameters of three previously unsurveyed lakes located in Michigan's upper peninsula were determined and hypotheses were formed relating these parameters to Chaoborus migration. Basic information collected included hourly Chaoborus occurrence at various depths, fish taxonomy, geomorphology, dissolved oxygen, temperature, light penetration, and pH. A bathymetry mapping protocol and modified Van Dorn sampler were developed during the course of the study.

Introduction

The phantom midge, _Chaoborus_, (Diptera: Chaoboridae) may be abundant in large ponds and lakes (Pennak 1978). In bog lakes they often are the top invertebrate predators (Carl Norwood Von Ende 1975). During their third instar, _Chaoborus_ becomes a dominant predator and can significantly mediate the populations of other Zooplankton (Oldroyd 1964, Von Ende 1975). In addition, despite its nearly transparent body and voracious predatorial characteristics, _Chaoborus_ is still subject to predation by planktivorous fish and by other species of _Chaoborus_ (Von Ende 1975, Olroyd 1964).

Chaoborus characteristicly migrate vertically in the water column, down during the day and to the upper waters during the night. This diel vertical migration have been related to the efficient utilization of resources and/or the avoidance of predation (Spitze 1991). The epilimnion of eutrophic lakes usually has an abundant population of phytoplankton due to high levels of incident solar radiation. Small herbivorous zooplankton feed upon these phytoplankton and are in turn consumed by the carnivorous *Chaoborus*.

Chaoborus may be less vulnerable to predation under certain light conditions or temperatures of water at different times of the day. This may be due to the translucent nature of their body and the affect of temperature on the activity level of predators. This research project attempted to relate physical parameters, chemistry, and the presence of invertebrate and vertebrate predators to the nomadic life style of the *Chaoborus*.

Cranberry, Nansen, and Ziesnis lakes, located on the UNDERC property, had not been previously studied due to inaccessibility. There for baseline data had to be compiled, in order to relate *Chaoborus* behavior to environmental conditions. Nansen lake is in the Presque Isle drainage basin, draining north into lake Superior, where as Cranberry bog and Ziesnis bog appear to be closed basins. Ziesnis bog may drain through swamp land into Tenderbog then into Tenderfoot Creek. Since Nansen lake is in a different drainage basin it may receive different concentrations and types of nutrients. It also has an inlet, that may be a substantial source of fresh water, possible diluting the lake. It was hypothesized that due to these factors the physical parameters of Nansen lake could be significantly different that the other two lakes studied. These differences may be reflected in the *Chaoborus* occurrence.

Richard Huftalen and I combined our efforts to survey the of the basic physical characteristics of the three basins. Bathymetric maps of these and other lakes on the UNDERC property were constructed.

Materials and Methods

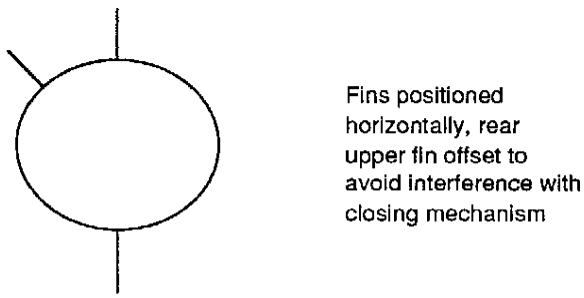
Cranberry bog and Nansen lake are located in the northwest portion of the UNDERC property. They are approximately two miles off the main road. Ziesnis bog is located one quarter of a mile from the main camp. This small bog is about 75 yard off the main road.

Initially, the study lakes were located and access routes to Nansen lake and Cranberry bog were created. Trees and brush were cut to clear the two mile road to Cranberry bog and an additional mile of trail was cleared to Nansen lake. After opening the road vehicle access to Cranberry bog was available, where as Nansen lake must still be accessed by foot. A one hundred sixty foot long board walk from the solid ground, across the *Sphagnum* mat, to the shore of Cranberry bog was constructed. This was necessary so that the mat would not be destroyed by our, and future researchers, visits to the bog.

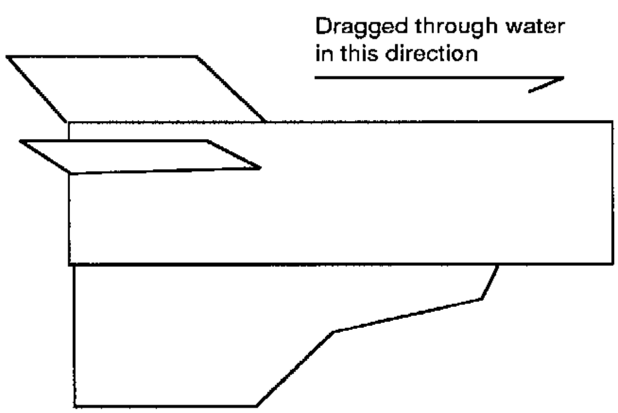
To obtain data showing the chronologic vertical migration of the *Chaoborus* we collected water samples over twenty-four hour periods. The samples were taken at one meter intervals using a Van Dorn sampler. Each sample was concentrated by filtering one liter of sample water through a dolphin bucket, with a mesh size of 64 microns. Concentrated samples were analyzed in a Segdwick-Rafter chamber under a compound microscope (Hellenthal 1990).

Water samples for chemical analysis were taken with a Van Dorn sampler (fig. 1) at the surface, .5m, and one meter from the bottom. These samples were brought back to the lab for analysis. Chemical analysis for total acidity in mg/l phenolphthalein acidity as $CaCO_3$, orthophosphate concentration in mg/l PO_4^3, nitrate concentration expressed in mg/l NO_3-N color, both true and apparent, expressed in Platinum-Cobalt units, and sulfide in mg/l H_2S were preformed as outlined by the Hach DR/2000 spectrophotometer handbook. Surface pH was taken during each sample period, in the field. Oxygen concentrations, water temperature and light intensity

FIGURE 1: Modifications to Van Dorn



Front View



Side View

were taken at one meter intervals during the same twenty-four hour sample period previously outlined and on other dates. Secchi disc readings were taken and fish were collected using minnow traps.

The bathymetric mapping protocol developed during the course of this study is outlined in Appendix 1. The maps are displayed in Appendix 2.

Results

Basic limnological analyses were conducted on the lakes. The basic physical data collected is out lined in figures 2-6. ((Insert figures 2-6)).

Total acidity was found to be 5.8 mg/l phenolphthalein acidity as $CaCo_3$ at a .5m sample, Comparable to the value of 6.0 mg/l recorded for Cranberry on the same date at the same depth. Ziesnis bog's total acidity was recorded at higher level of 28.5 mg/l $CaCO_3$ on July 1, 1991.

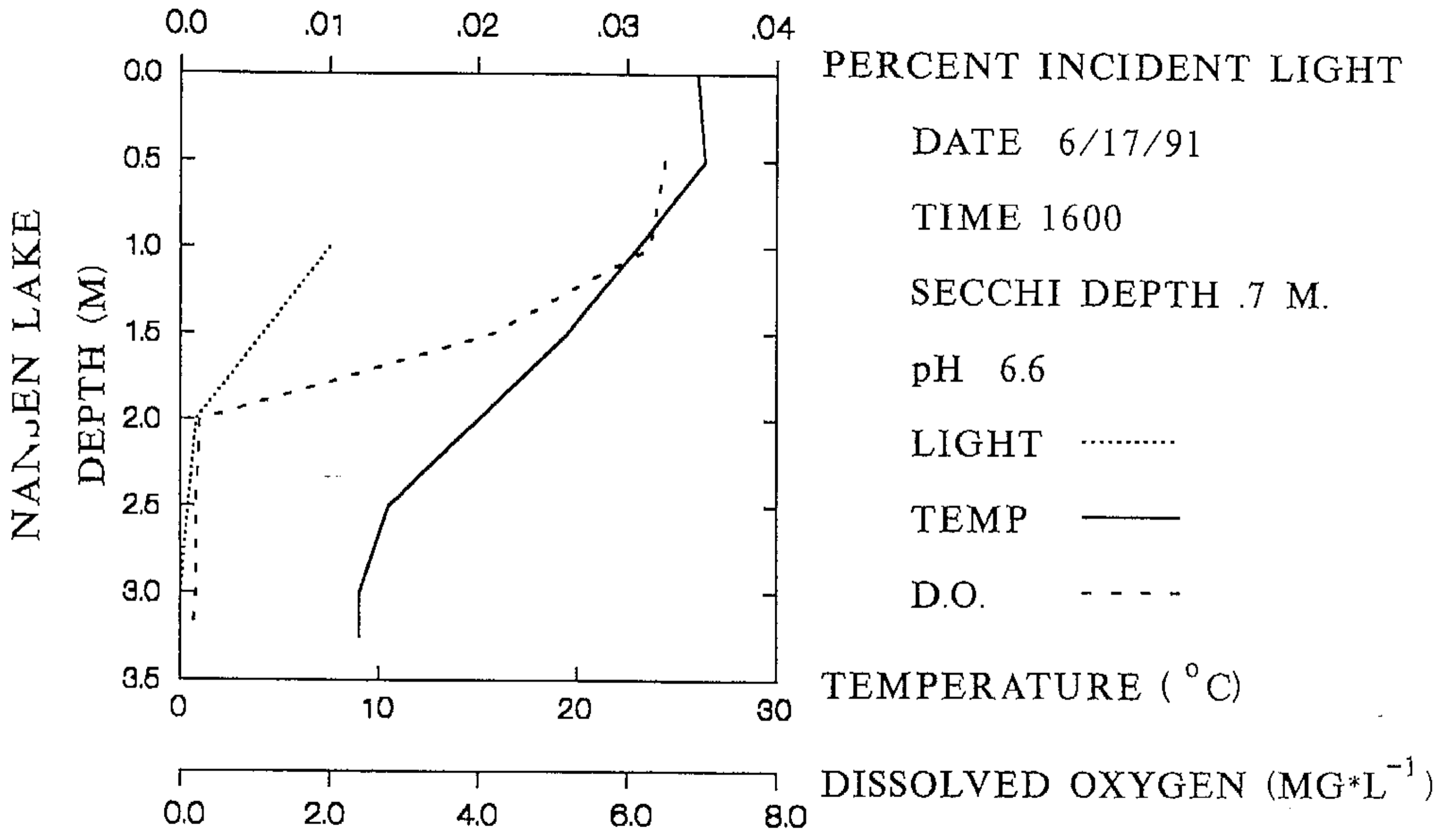
Sulfide was detectable to the nose in samples taken within 1m of the bottom in all three lakes, but sample contamination made results unattainable or suspect. Lack of oxygen in the hypolimnion of all three of the lakes suggests hydrogen sulfide is present.

Orthophosphate and nitrates were low in all three lakes. Readings ranged between 0.0 mg/l and 0.4 mg/l PO_4^{3-}, and 0.0 and 0.2 mg/l N-NO_3/l for Ziesnis Bog. In Nansen Lake the range was .03-.06 mg/l PO_4^{3-} and .02-.03 mg/l N-NO_3/l. Cranberry ranged between .01-.04 mg/l PO_4^{3-} and .01-.05 mg/l N-NO_3/l. These numbers are all low, as would be expected for undisturbed lakes in this region.

Color was measured in Platinum-Cobalt units. Nansen lake was found to be the most highly colored with a true color of 169 Pt-Co units and an apparent color of 191 Pt-Co units. Ziesnis bog had an apparent color of 141 Pt-Co units and a true color of 107 Pt-Co units. Cranberry bog was the least colored of the three lakes with readings of 119 Pt-Co units apparent color and 87 Pt-Co units true color.

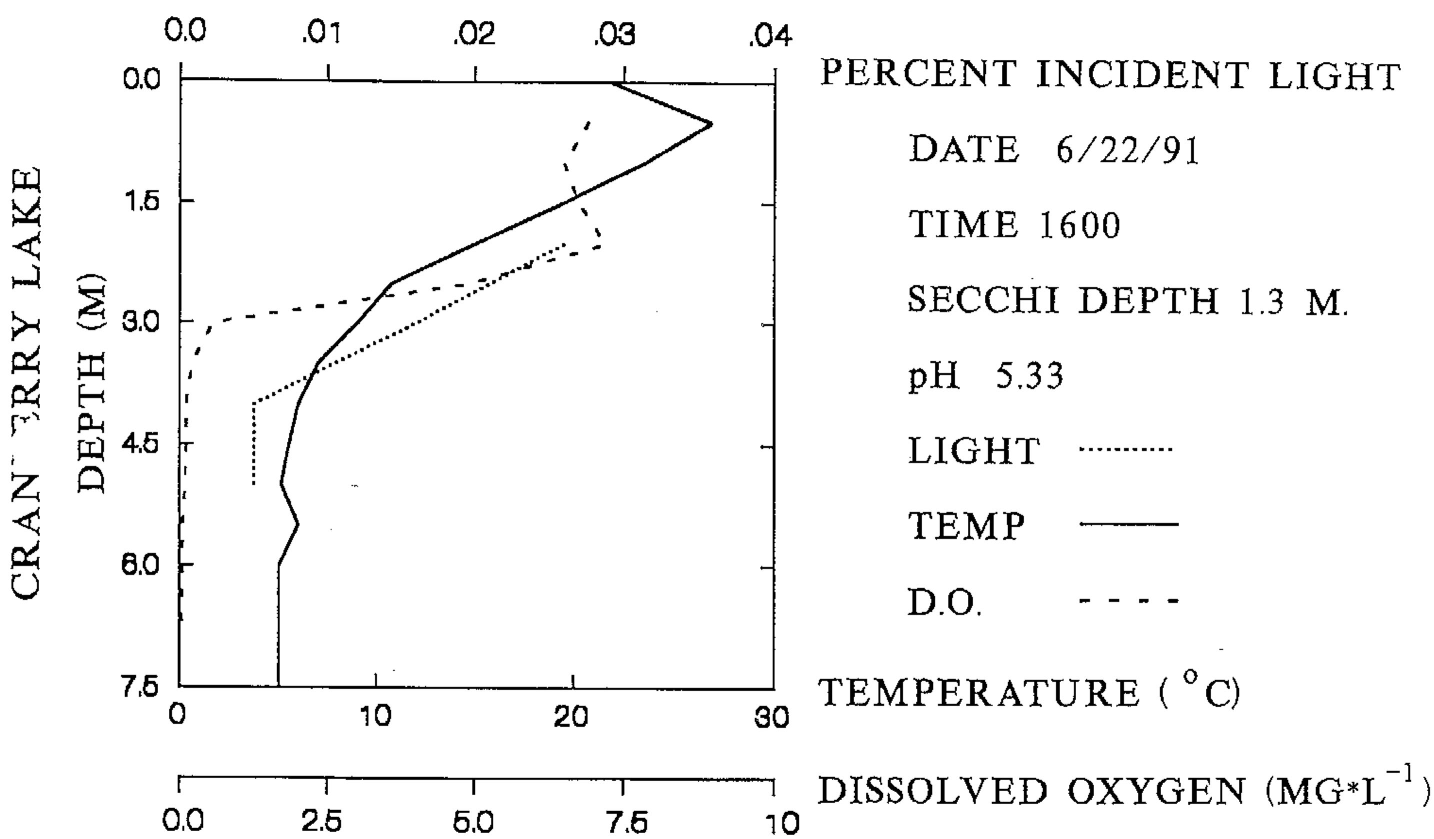
The study of *Chaoborus* was conducted with limited success due to sampling technique. The results are represented in table 1.

FIGURE 2



0.0
.01
.02
.03
.04
PERCENT INCIDENT LIGHT
DATE 6/17/91
TIME 1600
SECCHI DEPTH .7 M.
pH 6.6
LIGHT
TEMP
D.O.
NANJEN LAKE
DEPTH (M)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
10
20
30
TEMPERATURE (°C)
0.0
2.0
4.0
6.0
8.0
DISSOLVED OXYGEN (MG*L⁻¹)

FIGURE 3



0.0
.01
.02
.03
.04
PERCENT INCIDENT LIGHT
DATE 6/22/91
TIME 1600
SECCHI DEPTH 1.3 M.
pH 5.33
LIGHT
TEMP
D.O.
DEPTH (M)
0.0
1.5
3.0
4.5
6.0
7.5
0
10
20
30
TEMPERATURE (°C)
DISSOLVED OXYGEN (MG*L⁻¹)
0.0
2.5
5.0
7.5
10

FIGURE 4

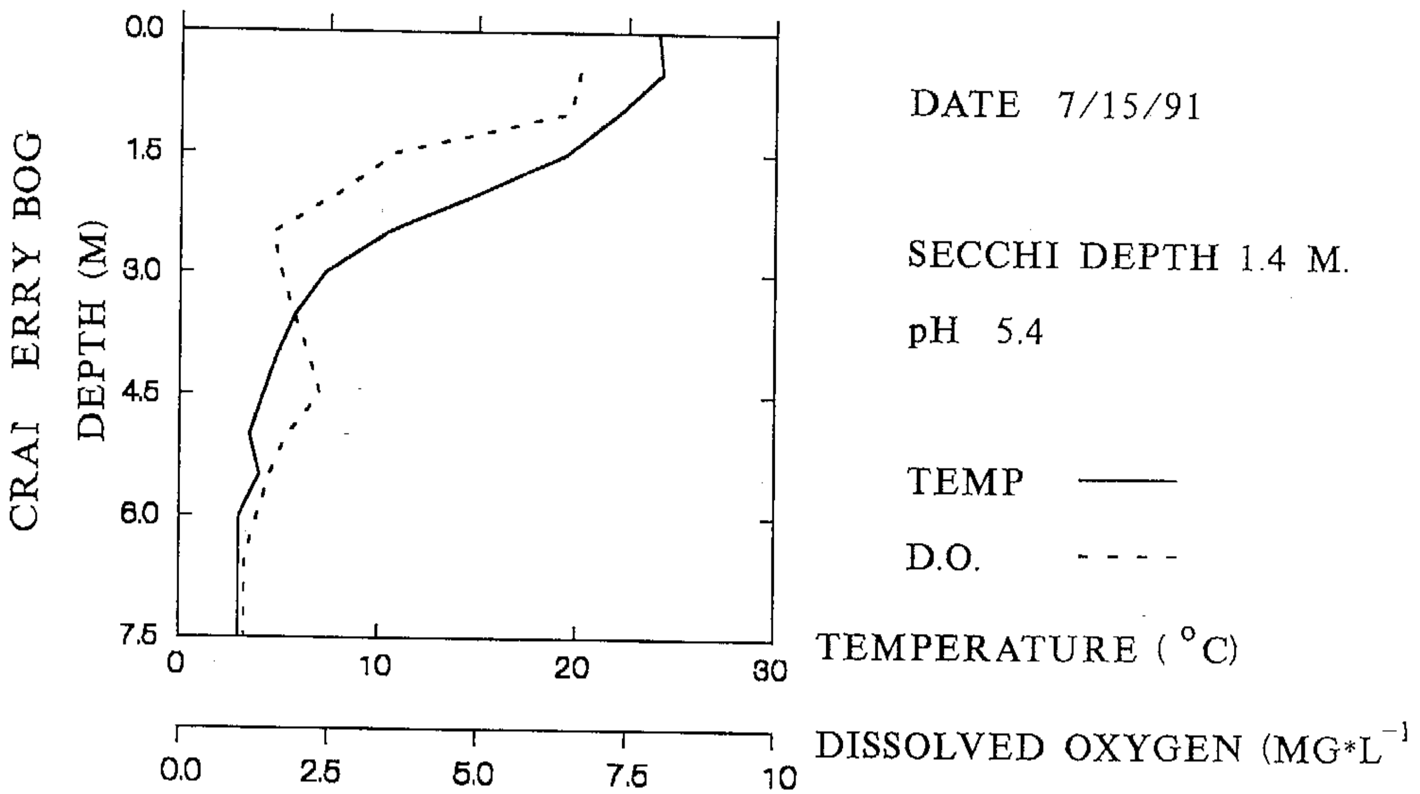

CRAI ERRY BOG
DEPTH (M)
0.0
1.5
3.0
4.5
6.0
7.5
DATE 7/15/91
SECCHI DEPTH 1.4 M.
pH 5.4
TEMP
D.O.
0
10
20
30
TEMPERATURE (°C)
0.0
2.5
5.0
7.5
10
DISSOLVED OXYGEN (MG*L⁻¹)

FIGURE 5

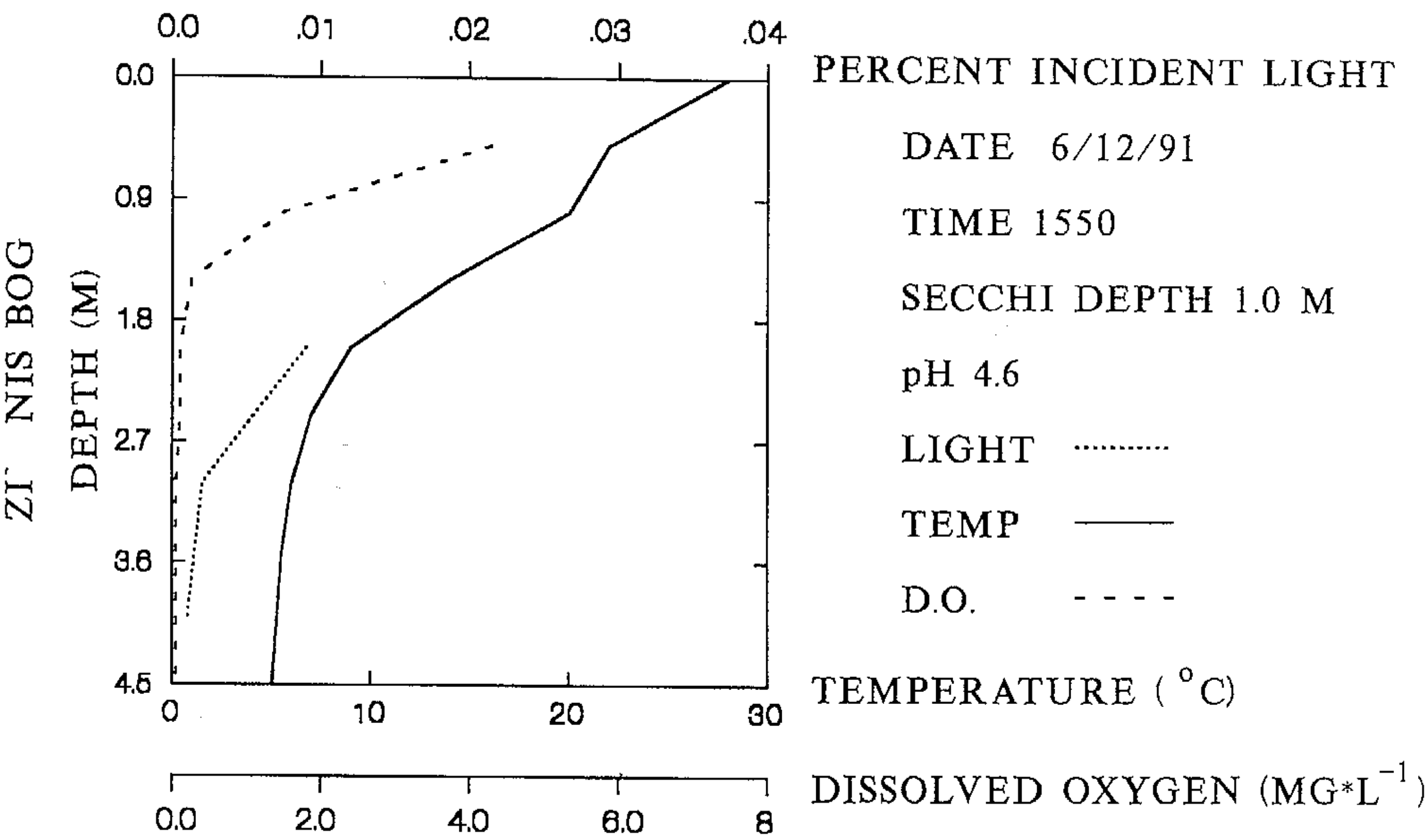
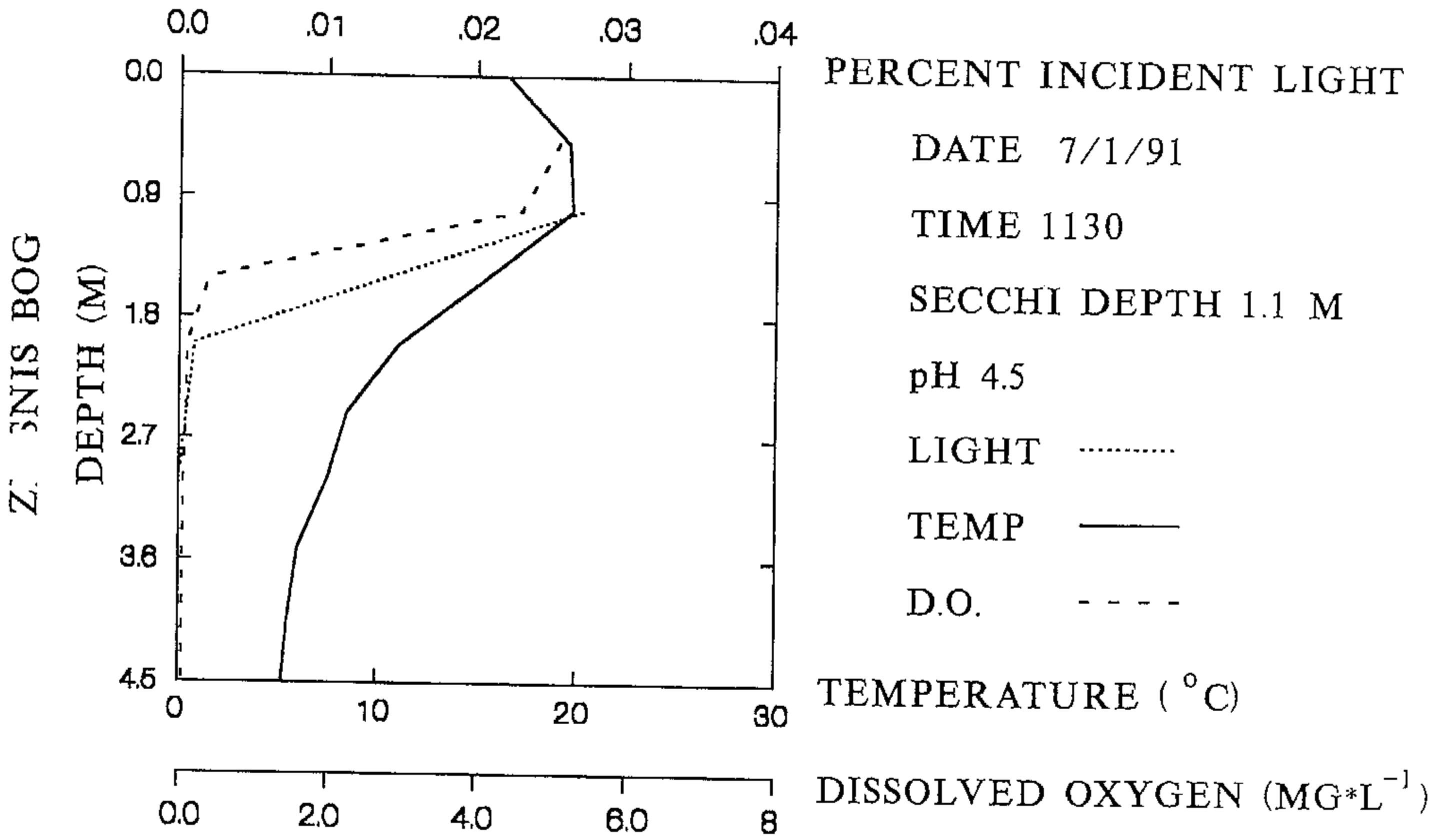

0.0
.01
.02
.03
.04
PERCENT INCIDENT LIGHT
DATE 6/12/91
TIME 1550
SECCHI DEPTH 1.0 M
pH 4.6
LIGHT
TEMP
D.O.
DEPTH (M)
0.0
0.9
1.8
2.7
3.6
4.5
0
10
20
30
TEMPERATURE (°C)
0.0
2.0
4.0
6.0
8
DISSOLVED OXYGEN (MG*L^{-1})

FIGURE 6



0.0
.01
.02
.03
.04
0.0
0.9
1.8
2.7
3.6
4.5
Z GNIS BOG
DEPTH (M)
0
10
20
30
0.0
2.0
4.0
6.0
8
PERCENT INCIDENT LIGHT
DATE 7/1/91
TIME 1130
SECCHI DEPTH 1.1 M
pH 4.5
LIGHT
TEMP
D.O.
TEMPERATURE (°C)
DISSOLVED OXYGEN (MG*L⁻¹)

Chaoborus migration, M. Lavery 1991

Table 1.

Vertical distribution of Chaoborus Species

Cranberry Bog 06/19/91

Chaoborus Species	Time	Depth
americanus	400	3.5
punctipennis	1200	2.5
	1600	4.5
	2200	0.5
	2200	1.5
trivitattus	600	6.5
	600	7.5
	800	0.5
	800	3.5
	800	3.5
	1000	7.5
	1200	2.5
	1600	7
	1800	2.5
	2000	5.5
	2400	1.5

Nansen Lake 06/17/91

Chaoborus Species	Time	Depth
punctipennis	400	1.5
	400	2.5
	400	3
	600	3
	2000	3
	2200	1.5
	2400	1.5
	2400	1.5
	2400	3

Discussion

Sampling of the Chaoborus was done on an extremely limited basis due to sampling difficulties. The Van Dorn sampler did not accurately take a sample that was homogeneous to one depth, due to the design of the sampler. The Van Dorn sampler is essentially a piece of PCP pipe with plungers, connected via surgical tubing, for caps at each end. It lies parallel to the surface of the water. When the Van Dorn is lowered through the water column, water eddies developed at the ends, giving a sample that is in effect an average of the water column. Allowing the water to equilibrate at the desired depth did not alleviate this problem.

Lower numbers of Chaoborus were obtained than expected. Chaoborus may see the Van Dorn, feel the currents created by its presence, and avoid it (Carlton personal communication). Upon realizing this problem we attempted an alternative sampling technique was needed. Rich Huftalen and I attempted to over come this problem by adding fins to the sampler (figure 1). These modifications did not increase sampling success. The fins would enable us to pull the sampler through the water, in a straight line, in order to catch the Chaoborus before they swam away. A Schindler sampler may be a more effective way to sample Chaoborus but we did not obtain one because of the cost, so sampling was discontinued.

In Nansen lake punctipennis was the only species caught in our sampler. This may mean that they out competed the other species, avoided predation better, or that our sampling method discriminated against them. Punctipennis may be able to survive better on smaller zooplankton than the larger Chaoborus, eg. americanus, trivitattus, and albatus (Von Ende 1975). Since the population of planktivorous fish is high in Nansen lake the larger zooplankton may have all been consumed leaving only the small ones. This selection by the fish may have, indirectly, selected punctipennis as the dominant species of Chaoborus in Nansen Lake. We did not catch any punctipennis during light hours, when they are presumed to be in the mud or at the water sediment interface. From this we can hypothesis that punctipennis diurnally migrates up and down in the water column.

Cranberry lake shows a different assemblage of Chaoborus (table 1) that may be explained by different strains on the system. Cranberry lake had no fish, so pressure on and selection of the food supply, zooplankton, was limited to that imposed by Chaoborus. In such situation larger Chaoborus may dominate the lake because they are capable of consuming a wider range in size of zooplankton (Von Ende 1975). The fact that trivitattus, a large Chaoborus, was found in the upper waters of the lake during the day may indicate that due to a lack of predation pressure it was able to come to the surface waters.

Nansen lake (fig. 2) shows no true oxygen peak. This causes me to believe that the phytoplankton are not grouped together in a thin laminar group, at one specific depth, but instead are spread out through the upper 1.5 meters of water. This may be because Nansen's water is quite stained, the secchi disk depth was only .7m. Substantial amounts of light penetrated almost three meters, so enough light for photosynthesis is present even at 2.5 meters. This light penetration may account for the lack of an oxygen peak at depth in the water column.

Comparison of Cranberry Bog data (figs.3 and 4) reveals similar oxygen and temperature profiles. The oxygen peak at about 1.9 meters may be explained by a phytoplankton population at this depth. The phytoplankton expel oxygen as a waste product of photosynthesis. Due to the relatively high temperatures and light availability phytoplankton congregate at this depth.

Ziesnis bog (figs.5 and 6) exhibits no substantial difference in profile between sampling dates. The bog exhibited no distinct oxygen peek. This may be because of its relatively shaded small surface area. Light penetrated almost two meters into the water column, possibly allowing for phytoplankton to be oriented in a more spread out manner. This less dense population would account for the lack of an oxygen peak at depth in the water column.

Upon analysis of Nansen Lake I have concluded that this body of water is in transition from a lake to a bog. This was concluded because the lake has a large grass/*Sphagnum* mat around it but the pH of the water is 6.8. This relatively high pH is not characteristic of true mature bogs. This discovery is very interesting for the future of research at Nansen, because of its transitional state. Future research on this lake may aid in the understanding of why a body of water becomes a bog.

Sonar data from Cranberry bog revealed interesting bathymetry. We discovered that the bog is composed of two deep basins, 25 feet, separated by a ridge that feet of the surface. This compound Kettle bog formed approximately ten thousand years ago when the Wisconsin glacier retreated from this area. When the ice sheet retreated it left huge terrestrial ice bergs buried in the ground. The ice melted and consequently left deep basins that filled in with water.

Summary

1) Different *Chaoborus* species may dominate the *Chaoborus* population depending upon the predation pressure.

2) Nansen lake may have a large population of planktiverous fish. This population may consume the larger *Chaoborus*. This selection allow the smaller *Chaoborus* to dominate the ecosystem.

3) Cranberry bog has no or few planktiverous fish. This allows the larger *Chaoborus* to dominate the ecosystem.

4) Nansen lake may be a lake in transition, from a lake to a bog habitat.

Acknowledgements

My study was conducted because I was selected to this program by Dr. R.Hellenthal and Dr. M.Berg. To them I owe a great thanks for believing that I could succeed in carrying out the goals of our designed experiment. I also extend special thanks to Mr. and Mrs. Hank for their support of the property and program. If it were not for this support I would not have been able to afford to go to UNDERC and begin my career in ecology. If it were not for the help of my partner Richard Huftalen I would not have been able to complete all the work that we planed. The assistance of the grounds crew played a huge role in the preparations for this research. Their help made the accessing of Cranberry and Nansen possible.

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Von Ende. 1975 Organization of bog lake zooplankton communities: Notre Dame, Ind.

Appendix 1: Mapping Procedure

Need: paper, pencils, clipboard, compass, sonar, trolling motor with battery

1. Orient yourself such that transects can be made N-S and E-W.
2. Reset the trip log on the sonar, this should be done after each transect.
3. Go to the Navigate screen, be sure that the trip odometer reads zero.
4. Note distance from shore and take depth reading.
5. Start the transect:

   A) one person should write the depth at each 100th mi. and make notes of land marks and how they relate to the transect.

      eg. just exited the bay (.005mi transect 2 S-N) or passing the point (.1mi. transect 2 N-S), so that relative sizes of lake features and orientations will be taken into account when drawing the map.

B) the person driving the boat should 1) locate destination before starting a transect (where the transect should end if you travel in a straight line in the chosen direction).

6. Troll at maximum speed (of the trolling motor) and keep a straight course (N-S or E-W).
7. Multiple parallel transects should be made in each direction (note the distance between the transects) and then multiple parallel transects should be made perpendicular to these.
8. Label each transect!! Be sure to note which way the transect is going. eg N to S or S to N.
9. Before leaving the lake make a rough sketch of the lakes perimeter marking note of distinctive features and be sure to draw were each transect went, this will aid in the recreation of the lake back in the lab.

Drawing the Map

Need: Graph paper, pencils, calculator, ruler or straight edge.

1. Take the longest transect and calculate how many

squares must represent a unit length (eg. 2 squares = 1/100 mi) in order for it to fit on the paper.

2. Plot the transects on the graph paper. (eg. at the first square depth = 2', put a 2 on that line) then move two more squares along that transect and record the next depth from the transect. When all the transects are plotted on the paper it will have just #'s in straight lines going across it. Where N-S and E-W transects intersect, the depths should be the same, if they are not, look to see if one is off center, it is possible that you have oriented them incorrectly, (slid them to fit together).
3. From your rough sketch, notes, and the transects that you have drawn you can now draw an accurate shoreline of the lake.
4. Look at the #'s on the page and attempt to get a feel of how the bottom of the lake must look. Group the common #'s, determine a contour interval eg. if the lake is shallow you may want to go by one foot intervals whereas if the lake is

deep you would have too many lines if you did this so choose a large contour interval, maybe 3 feet. This will give one third the # of contour lines and make it easier to read.

5. Begin to draw contour lines from the shore (shallowest) to the middle (deepest). If you chose a contour interval of 2 feet you would draw the line such that the depths of 2 feet or less were to the out side of the contour. When this line is finished you would then draw the 4 foot contour, this line would include values of 4 or less. NOTE: Contours lines NEVER cross other contours and ALWAYS are complete, enclose the space.
6. If the depth decreases within a larger depth just draw another contour. Eg. in the middle of the 8 foot contour there is a depth of 6 feet but this depth could not be included in the 6 foot contour because it is surrounded by 8 foot water.
7. The finished map should have a size scale (eg. 2 squares = 1/100 mi.), contour interval (C.I. = 2 feet), show direction (North is that way), Lakes

name.

Scanning the map

Need: Tracing paper, fine tipped black pen, Apple scanner, Apple Scan, Canvas 2.1, patience, time.

1. Trace the contours only onto tracing paper with a very fine black pen.
2. Allow the scanner to warm up for 10 minutes.
3. In Apple Scan scan the map at 75pt. resolution then adjust the threshold to be sure that all the contours are visible.
4. From the FILE menu select New then rescan the map.
5. Save the map as a "tiff" file.
6. Exit Apple Scan and open Canvas 2.1.
7. Open your file and select the magnifying tool and zoom in on the lake.
8. Select the pencil tool.
9. You must make each contour continuous, only one dot wide and it can not touch another contour. If you click on a dot with the pencil it disappears and you can dots with it. This process is very time consuming!!

-at diagonals if the corners are touching the line is continuous.

10. Once the map is finally clean with no labels **SAVE** this "bit mapped image".
11. Select the arrow tool and click on the map.
12. Go to EFFECTS and select Autotrace (Smooth Polygon), this gives a "Draw" image.
13. Immediately!! go to OBJECT and select Group. Do not click on the map!
14. Go to EDIT. Select Copy.
15. Go to layers (bottom left corner) and select Layer manager. Make a new layer called "Contours", select that layer.
16. Go to EDIT. Select Paste.
17. Make the old layer invisible.
18. Go to LAYOUT select Drawsize and make sure only one page is selected by clicking on the upper left box.
19. Click on the map and drag it onto the page. Then scale it to the page by clicking on the bottom right "tie" dot and holding down the shift key then dragging to enlarge or shrink. The shift key

moves an object in a scaled manner, if you don't hold it down the lake will be squashed or stretched.

20. When the lake is oriented and scaled as you want it:

Make a new layer, via layer manager called "Labels".

21. Label contours, direction, title, contour interval. Scale on this "Labels layer"

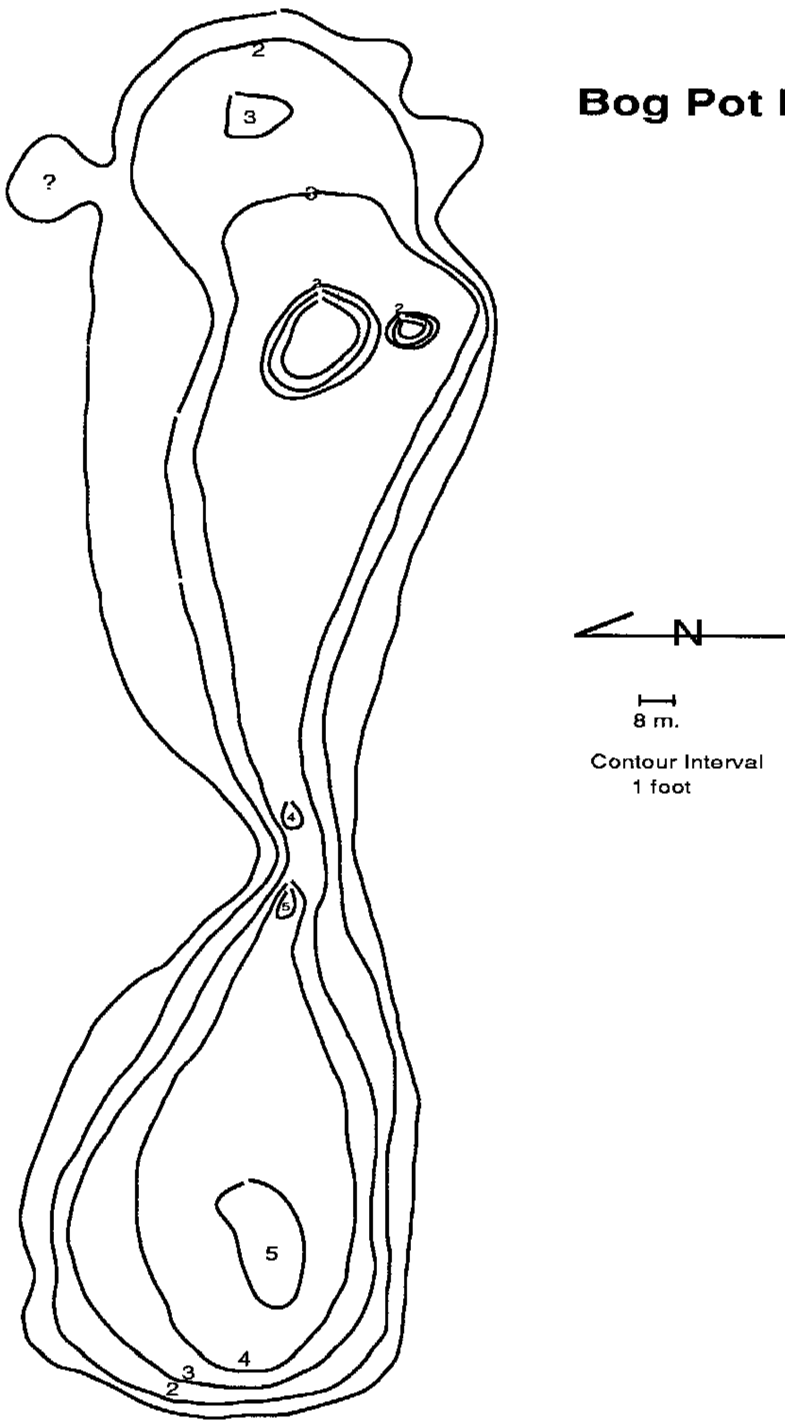
Note: you now have a layer that has contours and one that has labels.

22. Delete the first layer. Be Sure You Don't Delete your "Contour" layer or our "Labels" layer.

23. **SAVE** your finished Map on multiple disks under a name other than your cleaned Draw image, this will allow you to retrace if there is a problem.

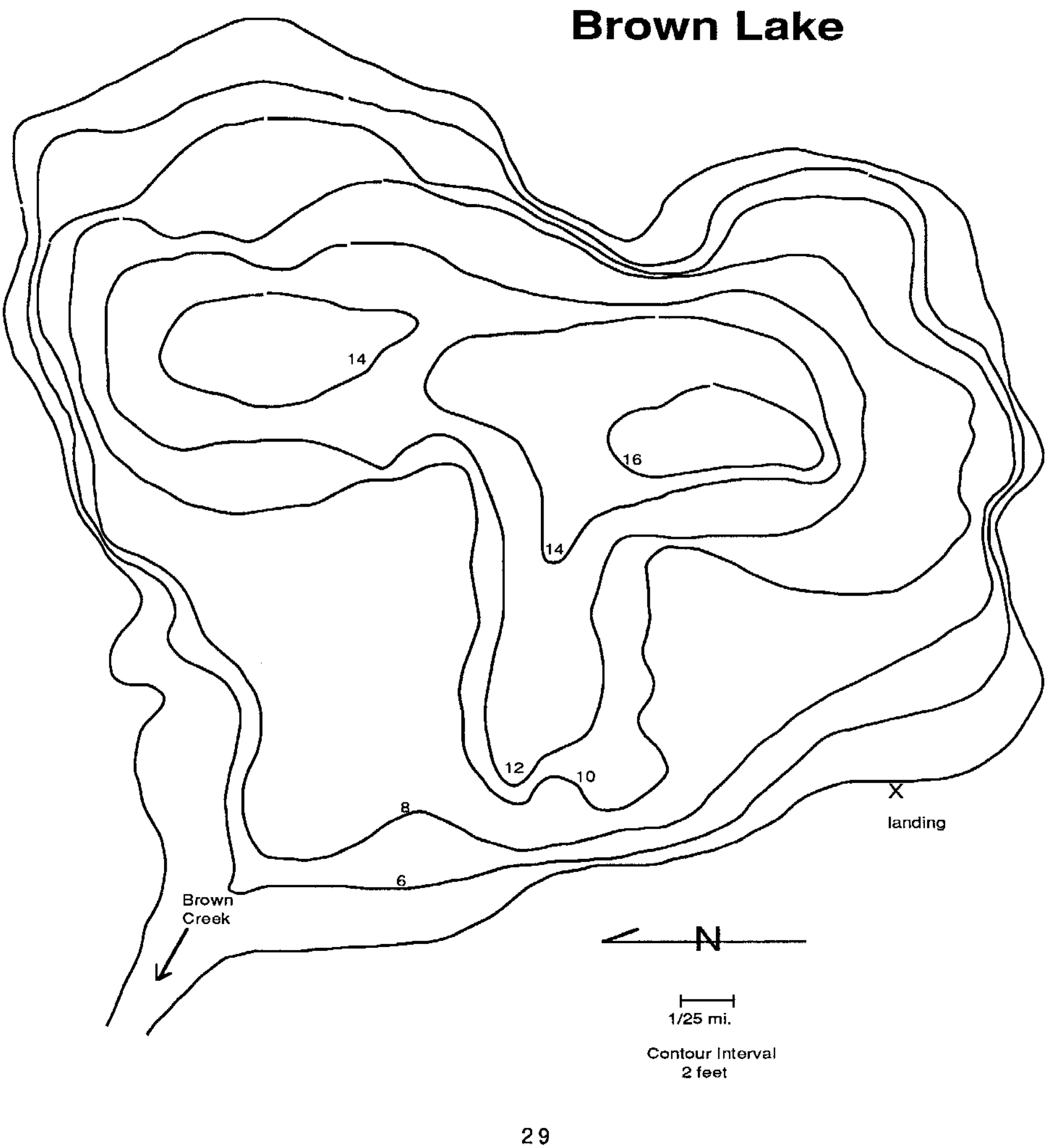
Appendix 2

Bathymetric Maps



Bog Pot Lake

Contour Interval
1 foot


Brown Lake
14
16
14
12
10
8
6
Brown
Creek
landing
N
1/25 mi.
Contour Interval
2 feet

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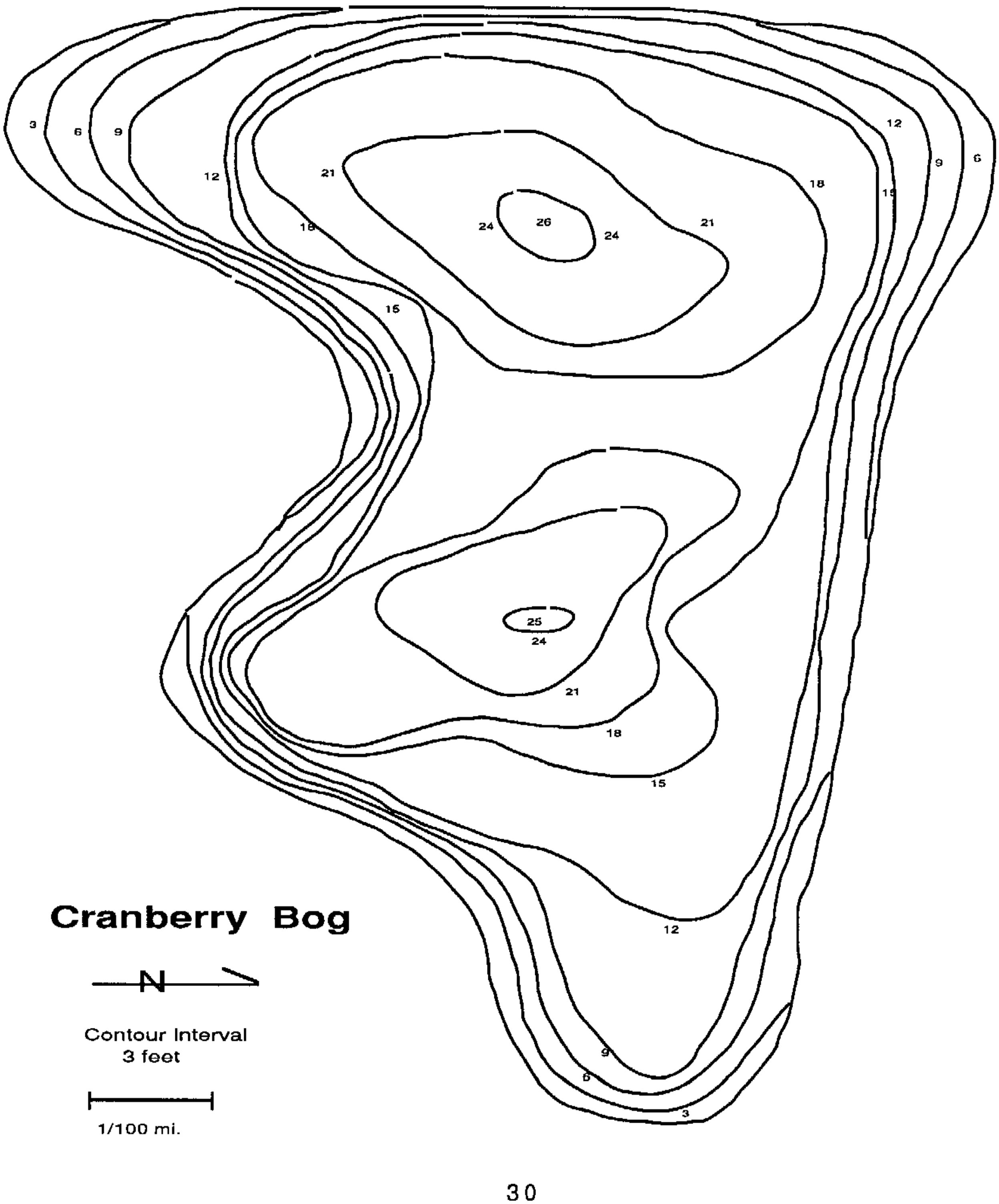
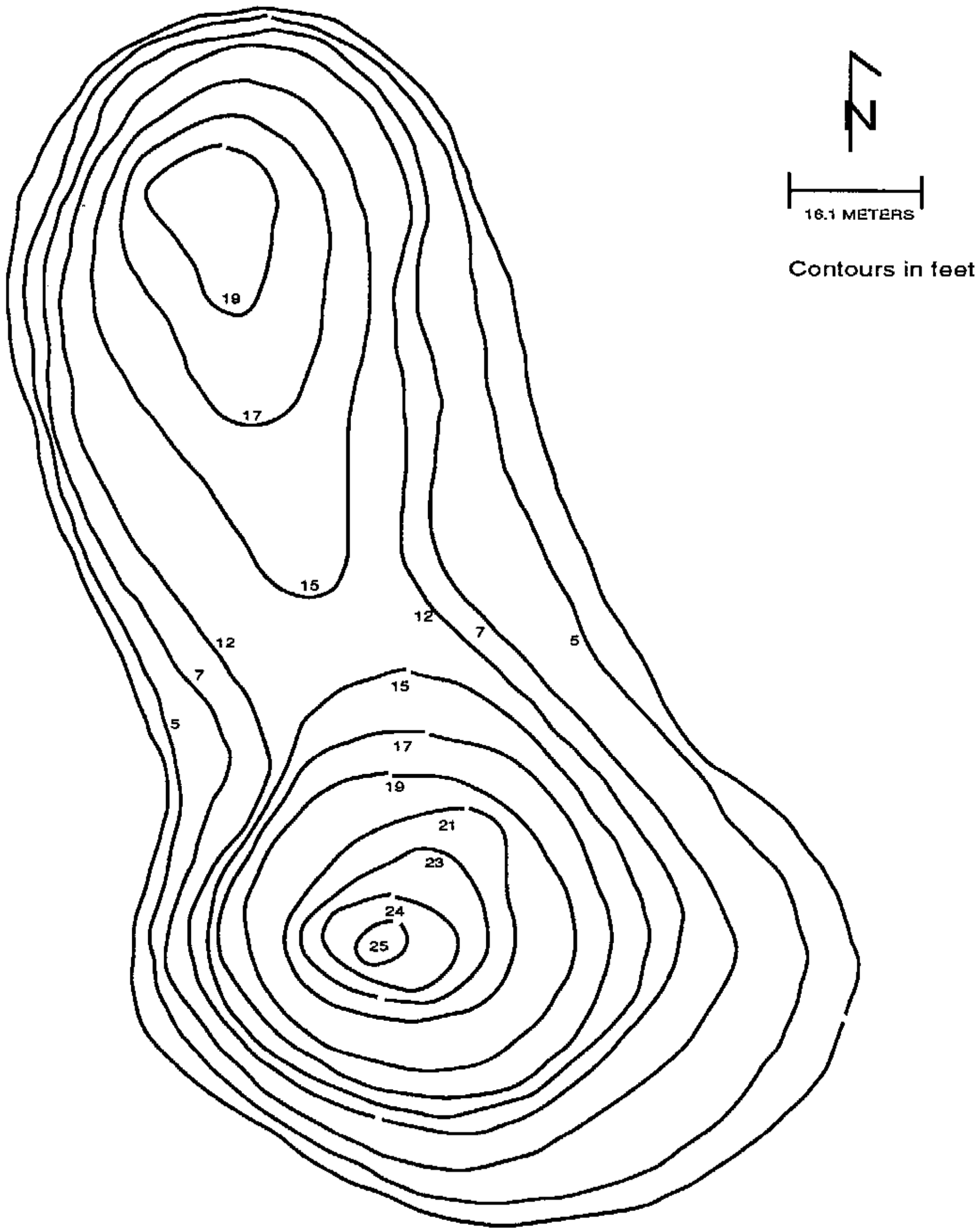
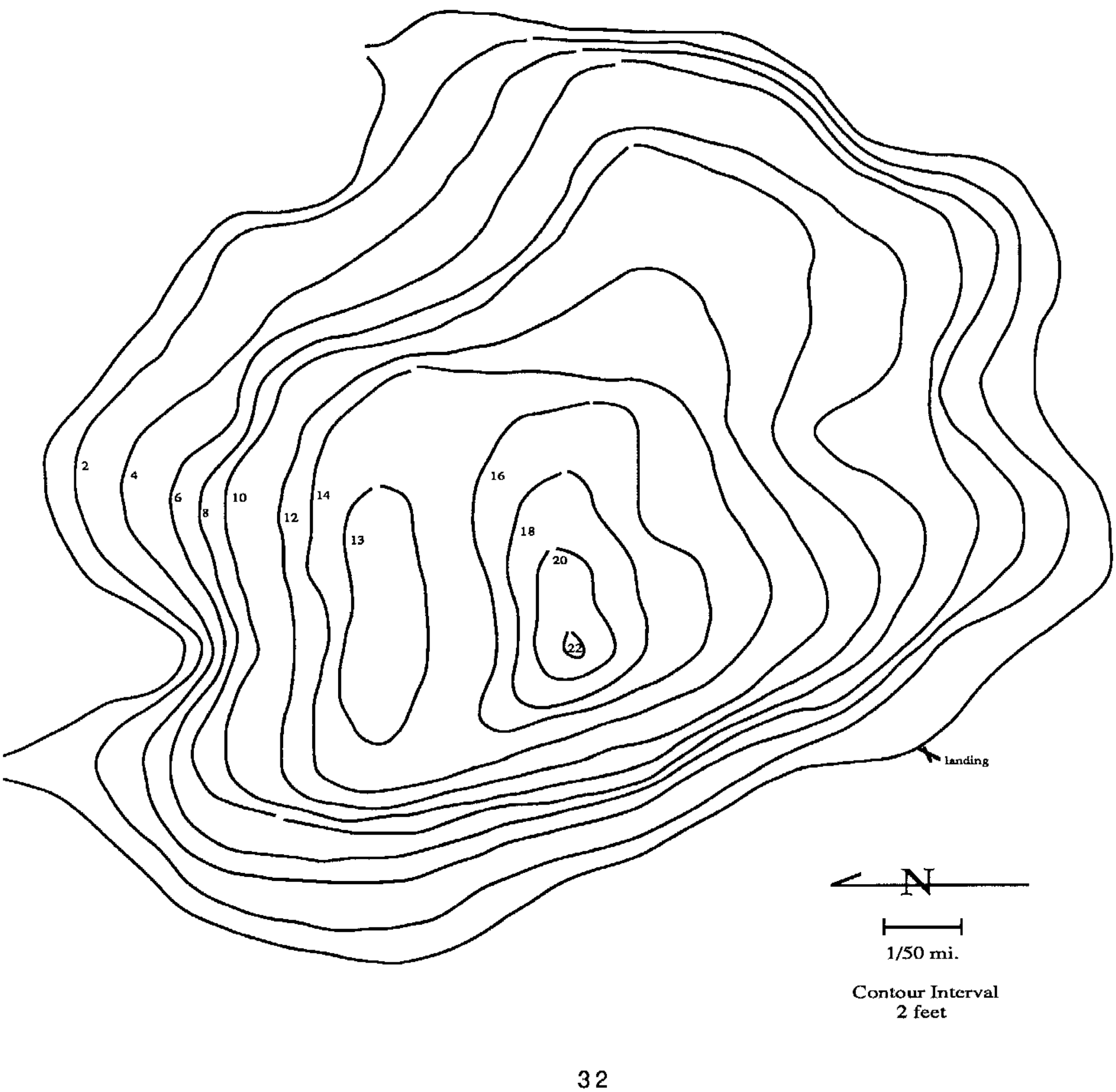


Hummingbird Bog

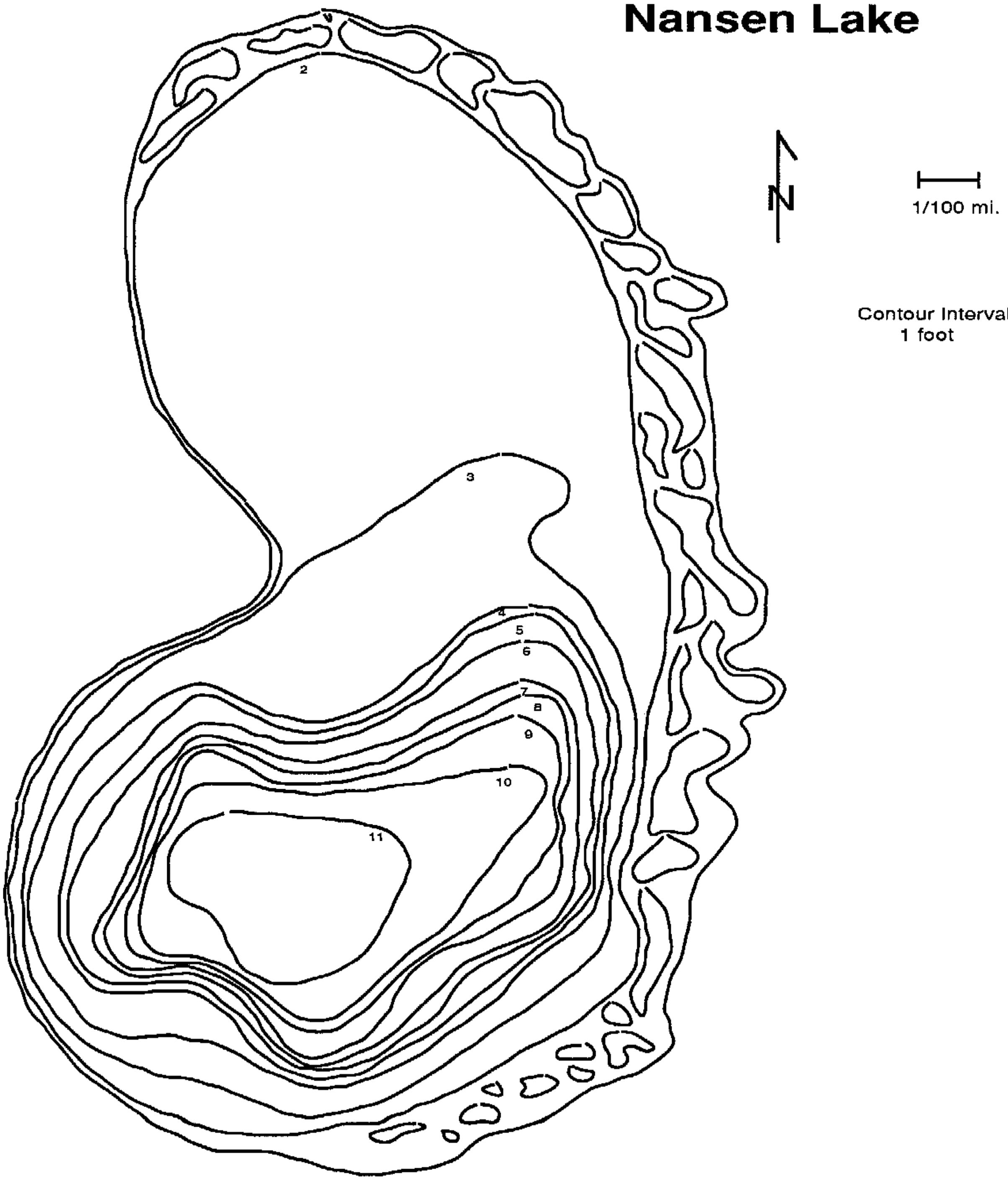


Chaoborus migration, M. Lavery 1991

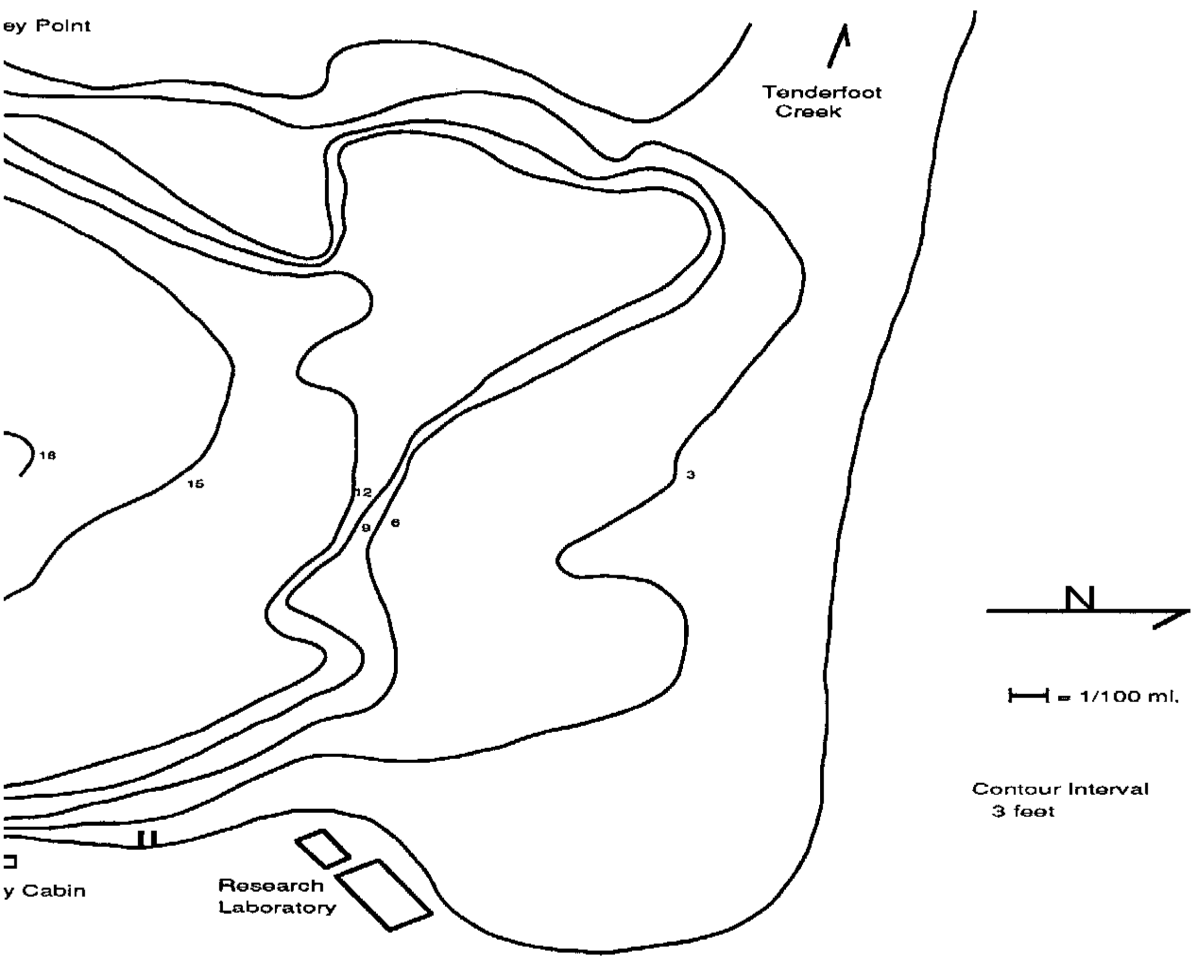
Morris Lake



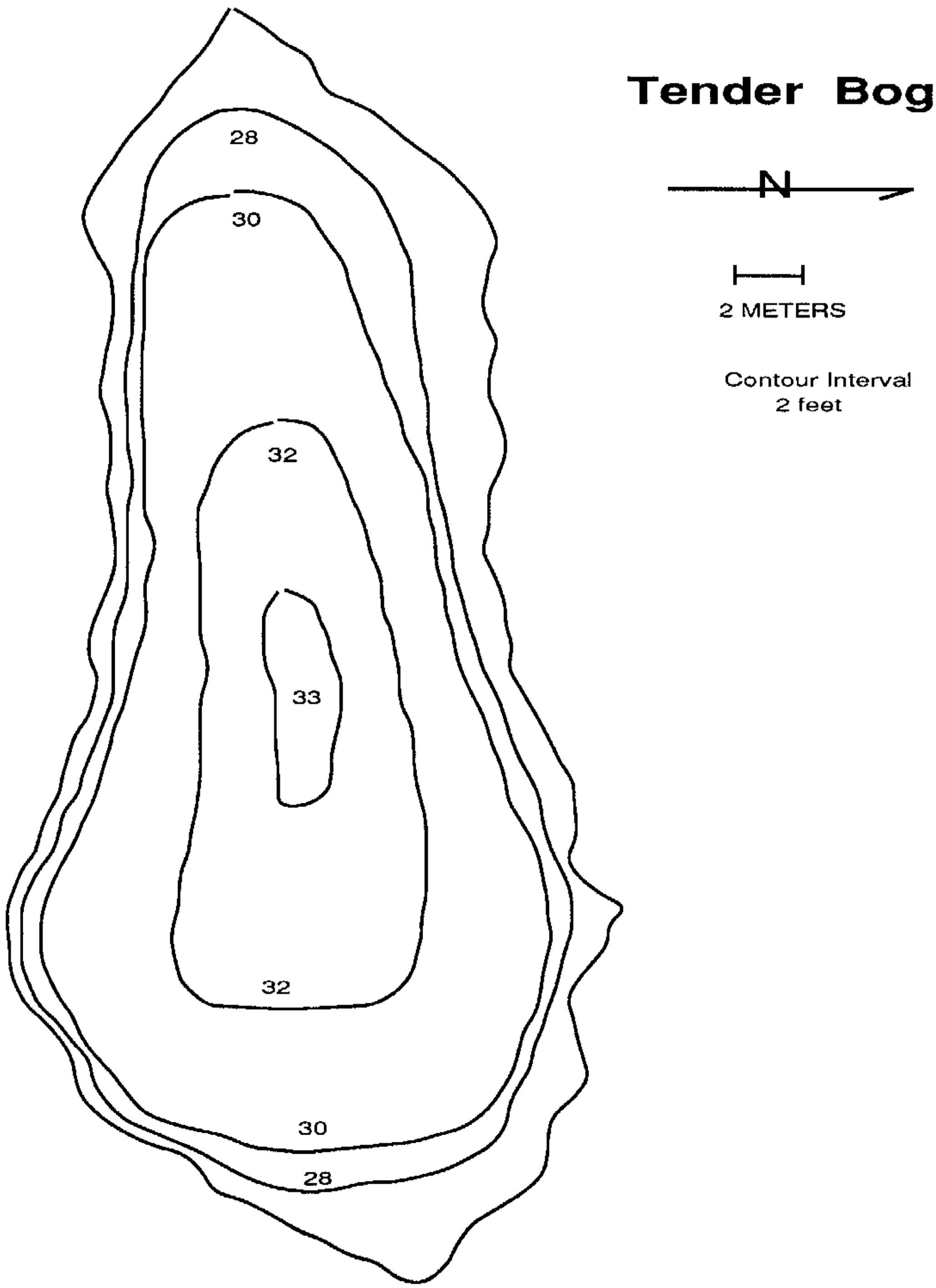
Chaoborus migration, M. Lavery 1991



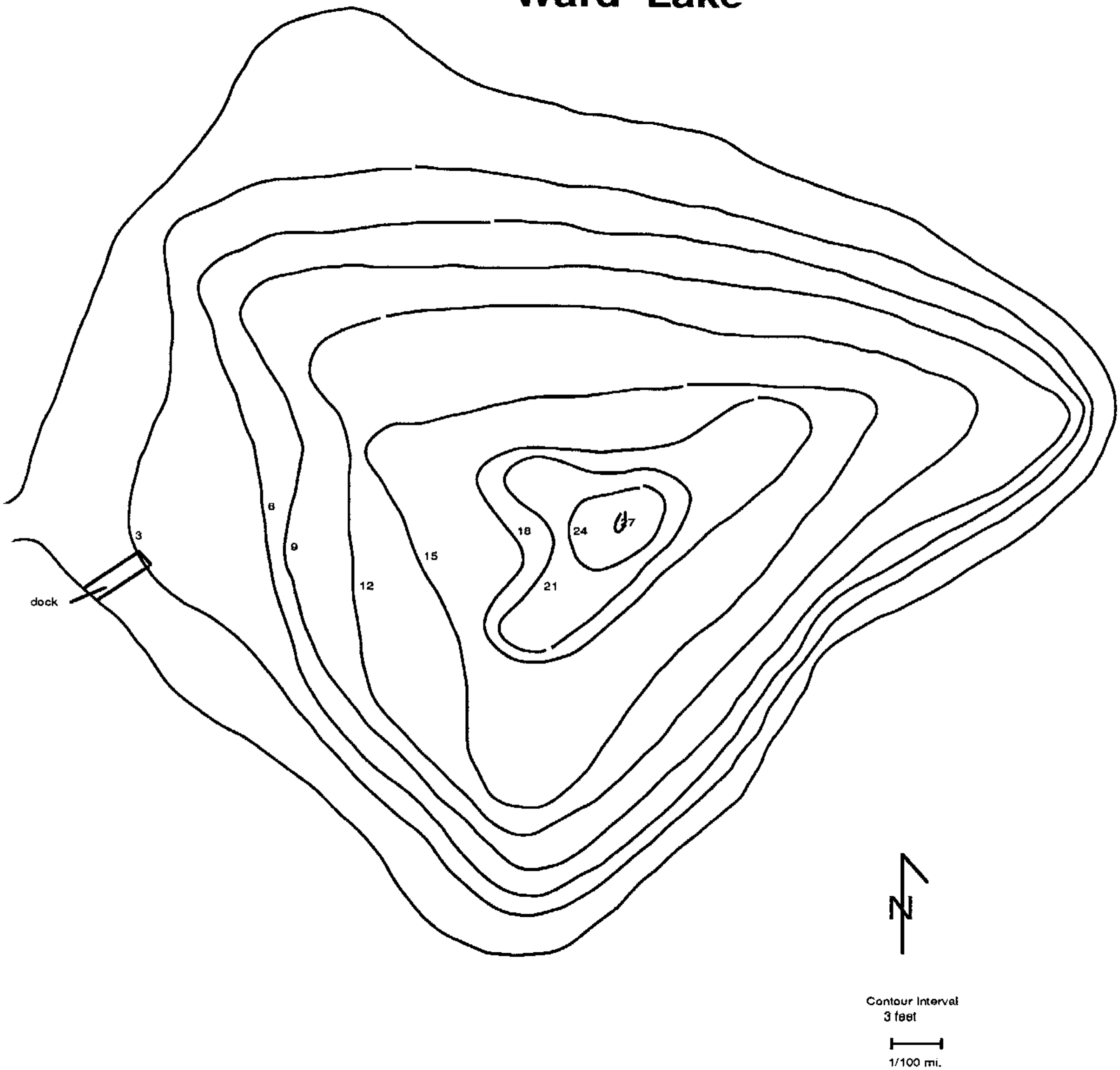
Northeast Bay,Tenderfoot Lake



Chaoborus migration, M. Lavery 1991



Ward Lake



<u>Chaoborus</u> migration, M. Lavery 1991