# An Analysis and Comparison of Three Lakes in Close Proximity

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Bios 569: UNDERC
November 30, 1990

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# INTRODUCTION

When lakes are near each other, are formed at the same time in the same manner, and have had similar influences acted on them, it is expected that the lakes will be nearly the same--sharing many characteristics. This is not what is observed in three lakes on the University of Notre Dame Environmental Research Center property in Gogebic County, Michigan. The three lakes, Morris Lake, Ward Lake, and Mullahy Lake, are all in close proximity of each other and were formed at the same time by glaciation. The differences and similarities of the three lakes were studied. The aspects which were looked at were zooplankton, littoral zone invertebrates, minnows, and other larger fish. Another student considered the water chemistry of the lakes. By comparing these aspects one can look for connections and differences between the different lakes.

Morris Lake, although the largest and deepest of the three lakes, is a relatively small, shallow lake with a muddy bottom. It is a late stage mesotrophic to early stage eutrophic lake with much macrophyte growth, especially *Elodea.* It is surrounded mostly by a hedge of alder, with only a few evergreens. Morris has an area of 4.9 ha with a maximum depth of 8 meters. It has a well defined shore, has a higher pH, and is without stable stratification. Morris has a low secchi depth with high turbidity and high color.

Ward Lake is smaller and a little more shallow than Morris. The bottom of the lake is mostly mud. Along the edge there are ferns, grasses, and some *Sphagnum.* In the area there are tamaracks, cattails, a few birch trees, and many evergreens. The area of Ward is 1.1 ha with a maximum depth of 7 meters. It has a semi-solid shore, a higher pH, and is not strongly stratified. Ward has the highest secchi depth of the three with lower turbidity and lower color.

Mullahy is the smallest and by far most shallow of the three lakes. It is rather marshy with a very soft "muck" at the bottom. Mullahy drains into Ward through a narrow channel. The area of the lake is .5 ha with a maximum depth of 2 meters. It has little of a definite shore, a low pH and is not strongly stratified. Mullahy has a low secchi depth with high turbidity and high color. Surrounding Mullahy there is sphagnum and a large number of pitcher plants. These are indicators of high acidity and are characteristics of a lake turning into or already a bog.

Ward is anoxic on the bottom. Also, both Ward and Mullahy have many plants throughout and are shallow lakes. Because of the large amount of vegetation per volume of water, there is much photosynthetic activity. In the Winter this causes decomposition and all of the oxygen is used up, which leads to death of many oxygen utilizing organisms. These are signs of a winterkill lake, making it possible that Ward and Mullahy are winterkill lakes.

## MATERIALS AND METHODS

The first thing done was to take an expedition around the three lakes by rowboat. At this time an approximate sketch of each lake was done and the major physical characteristics were noted (Figures 1-3).

**Zooplankton.** In the afternoon of June 11, 1990, three zooplankton samples were collected from each lake. First, a boat was rowed out to the middle of the lake. The direction of the wind was determined and the approximate sampling areas were designated, one upwind(about 20 m southwest of the center), one in the center, and one downwind(about 20 m northeast of the center). The boat was then rowed to the designated sampling zone (Figures 1-3). An anchor was gently lowered to hold the boat while a sample was taken. The depth at that position was determined using a weight and rope marked every half meter. A few minutes were given for any loose sediment to resettle. Then a plankton net with a 63 um bucket mesh size, a 153 um net, and a diameter of 25 cm, was slowly lowered until the top of the net was 1.5 meters from the bottom. The depth the trap was lowered to was 6.5 m in Morris Lake, 5.5 m in Ward, and .5 m in Mullahy. When this proper depth was reached, the gathering net was pulled up strait, slow, and at a consistent rate. When the net emerged, the contents were poured into a labeled jar containing a small amount of Lugals solution to immediately fix, stain, and preserve the zooplankton. The bucket was carefully rinsed and the remaining contents were added to the holding jar to insure that all of the organisms were collected. The zooplankton was brought back to the lab, identified using Pennak, and counted.

**Littoral zone invertebrates.** First a boat was taken out around the littoral zone of each lake. Areas of sampling were selected with an attempt to choose sites that were representative of the whole lake. A total of six sites were chosen-- five in the littoral zone and one in the middle of each lake (Figures 1-3). A sample site was rowed to and an anchor was carefully placed down, usually between one to five feet deep. An Ekman Dredge was used to get the sample. This is a 3540 $cm^3$ (152*152*152 mm) square box, with two spring operated jaws. The apparatus was set up and slowly lowered to the bottom. Once at the bottom, a weight was thrown down the rope at the Ekman, to set off the spring trap. Once set off, the Ekman was raised up near the surface of the water and put into a sieve bucket (500 um mesh). As much sediment as possible was sieved out. The material residual material was placed into a glass jar with 70% ethanol to preserve the organisms. These were taken back to the laboratory, sorted into vials, and later identified using Hilsenhoff for insects and Pennak for other invertebrates.

**Minnows.** First, six sample areas were selected-- five near the shore and one in the middle of the lake (Figures 2-3). Six minnow traps were hooked together and white bread was placed inside, which acted as bait. Floats were attached to the traps for easy retrieval, and those near the shore were tied to vegetation. The traps were left in the water overnight. Upon retrieval, numbers were noted and unfamiliar species were brought back to the laboratory for identification using Becker, others were set back into the water. In Morris, the procedure had to be repeated due to uncooperative fish. In the second trial fresh hot dog buns were used in place of the plain, white bread as bait in the six traps. This was not effective. In the third trial, thirteen traps were used from a Friday night to Sunday morning, still with little success. Because the quick, avoiding minnows could be seen, a seine net was used as opposed to the traps. The method that finally worked was forming a giant loop with the net over the side of the boat hoping to trap the minnows, then lifting the net in a scooping motion. When the minnows were caught they were also identified using Becker.

**Larger Fish.** Larger fish were sampled using two methods: fyke net and angling. The lead line of the fyke net was tied to a sturdy tree or bush on the surrounding shore (Figures 1-3). A rower, with the net in the boat, rowed perpendicular to the shoreline until the lead line was strait and taught. Then the side arms were tossed out at forty-five degree angles, and the frames were set in the water by another person in the boat. At that time, the rower rowed as hard as possible, while the other slowly let out the frame-- keeping it strait and stretched to its limits. With the net stretched out to its fullest, the other person in the boat let the anchor attached to the end of the net go, allowing everything to fall to the bottom. The side arms were then gently stretched. If everything seemed strait enough, the net, with floats as markers, was left alone until morning. In the morning the net was lifted and the fish were quickly identified, measured, and weighed. Scales were also taken from each fish. The scales were taken from the anterior portion of each fish, near the lateral line. The scales were aged by looking at the annuli patterns under the microscope.

The other way of obtaining larger fish for analysis was by hook and line sampling. Several types of bait were used including live worms and a variety of man-made lures. The time spent angling in each lake was measured by man-hours (mhrs). The amount of time angling was 8 mhrs in Morris, 3 mhrs in Ward and 6 mhrs in Mullahy. Due to the lack of specimens observed at Ward and Mullahy lakes the total hours spent angling at the two lakes were less then the total hours at Morris. As the fish were caught, they were identified, measured, weighed, and the scale samples taken. Two Northern Pike from Morris that had not survived handling were taken back to the lab and their gut contents were analyzed.

## RESULTS

**Zooplankton.** There were eleven species of zooplankton collected and identified in the three lakes (Table 1). Morris had the largest diversity, it contained all eleven species. The sizes of zooplankton found in Morris were very different. They ranged from tiny *Keratella cochlearis* to large *Mesocyclops edax*. The number of organisms per species was well distributed, with the dominant organisms being *Diaptomus*, *Bosmina*, and *Mesocyclops*. Ward contained less diversity of species. It was dominated by the tiny *Kellicotia longispina*. Mullahy had the least amount of diversity but the largest number of zooplankton after the organisms per meter were calibrated. Mullahy was dominated by *Diaptomus* and, at the time the sample was taken, *Copepoda* nauplii.

**Ekman.** In Morris, a higher number of dragonflies (*Odonata Anisoptera*) was found (10), while in Ward and Mullahy a higher number of Mayflies (*Ephemeroptera*) was found (10) (Table 2). Morris had many clams (*Pelecypoda*) (91), while Ward and Mullahy had many snails (*Gastropoda*) (209 and 96 respectively) (Table 3).

**Minnows.** Only three species of minnows were caught in Morris: Pugnose Minnow (*Notropis emiliae*), Blacknose Shiner (*Notropis heterolepis*), and Mudminnow (*Umbra limi*). Neither the Pugnose Minnows nor the Blacknose Shiners went into the minnow traps. In Ward and Mullahy a large diversity and large number of minnows were caught, especially in Ward (Table 4). In Ward Lake, 8 species and 305 total minnows were caught. In Mullahy Lake, 6 species and 71 total fish were caught. 245 and 42 Northern Red-bellied Dace were caught in Ward and Mullahy. This was the dominant species.

**Fyke net and Hook & Line.** The first two times the fyke net was tried in Morris, zero and one fish, Northern Pike (*Esox lucius*), were found. When the net was moved to another position on the lake, 4 Northern Pike, 8 Yellow Perch (*Perca flavescens*), and 13 Pumpkinseeds (*Lepomis gibbosus*) were caught (Table 5). Through 8 man-hours of angling, 8

Northern Pike, 3 Perch, and 1 Pumpkinseed were caught (Table 6). When this data is combined, there is a good distribution of different sizes and ages. The Northerns varied from 260 cm, 90 g, 1+ in age to 52 cm, 800 g, 4+ in age. The Perch varied from 9.5 cm, 7 g, 1+ to 28 cm, 190 g, 4+. The Pumpkinseeds varied from 8 cm, 7 g to 15.5 cm, 85 g. With the fyke net in Mullahy only 3 small Pumpkinseeds and 10 Western Painted Turtles (*Chrysemys picta belli*) were caught. In Ward no larger fish were caught. Angling in Ward and Mullahy did not increase the number of fish found in either lake. Although various methods were used, no fish were caught. The gut contents of two Northern Pike from Morris were analyzed, but nothing was found inside the stomachs of the fish.

## DISCUSSION

**Zooplankton.** By taking samples at different positions of the lake (upwind, center, and downwind), position effects on zooplankton could be seen. However, according to analyzed data on Mystat, there was no recognizable pattern between different positions. Because of this, the three samples in each lake could be taken as equal repetitions.

Morris Lake had the highest diversity of the three lakes. It was the only lake where samples contained either *Keratella cochlearis* or *Mesocyclops edax*. An explanation for this high number of large zooplankton could be that they have few predators. If a minnow tried to swim too far to eat the zooplankton, it would be eaten by the Northern Pike in the lake. The zooplankton may in this way be protected by the Northern Pike. This observation corresponds with Carpenter et el. (1987). Carpenter observed that when piscivorous fish were added to Tuesday Lake (also in Gogebic Co. Michigan), there was an increase in Zooplankton biomass. Also, in another finding (Elser and Carpenter, 1988), piscivorous fish were added to a lake. This resulted in an increase in previously rare large-bodied cladocerans.

The zooplankton in Ward were much smaller than in the other two lakes. *Kellicotia longispina* is a tiny species of zooplankton which dominated the water of Ward. There were more *K. longispina* in Ward than the other lakes (P= .016, Figure 4). This species is too small to be preyed on by minnows. In Ward, there were fewer *Diaptomus* and no *Mesocyclops edax*; both are large species easily seen by predators. The large numbers of minnows found in Ward means there are many predators of larger zooplankton. Carpenter et al. (1985) wrote that planktivorous fishes, such as minnows, consume large zooplankton and promote dominance of small zooplankton. So, it is expected that there would be fewer large zooplankton and this is what is experimentally observed.

Mullahy has less diversity but high population densities. Mullahy has a high number of the large *Diaptomus* sp. A (P= .003, Figure 5), the large *Diaptomus* sp. B (P= .012, Figure 6), and a tendency for more *Copepoda* nauplii (P= .059, Figure 7). Mullahy's low diversity can be seen in the fact that it has no *Diaptomus* sp.C and no *Kellicotia longispina*, while the other two lakes have both. Because of this high number of larger zooplankton in Mullahy, one would expect its prey, phytoplankton, to be lower. This is what is observed. Christine Taafe's data of 1990 shows a lower value of chlorophyll A in Mullahy. What is observed is high numbers of zooplankton feeding on phytoplankton which lowers chlorophyll A in the lake. This matches other literature. Elser and Carpenter (1986) observed low standing stocks of algae in lakes in which the zooplankton was dominated by large grazers, such as *Diaptomus.*

**Ekman Samples.** Although few insects were collected, general trends may show that Morris is different from Ward and Mullahy. In Morris ten odonates were identified, compared to one in Ward and Mullahy together. In Ward and Mullahy ten mayflies were identified when there were zero in Morris. Similarities did exist between the three lakes in the numbers of chironomids. There probably were differences in the species of chironomids, but they were only identified to "Family."

Much more data was collected on other invertebrates such as mollusks. In Morris there was a higher number of clams compared to Ward and Mullahy but there was too much variability between samples for significant results. Mullahy and especially Ward have more snails than Morris. If more data were taken, it might be shown that Ward has more *Amnicola* sp. (P= .078, Figure 8). When looking at Gastropods in general, total differences become apparent (Figure 9). When comparing the lakes, it is observed that there is a tendency (P= .063) for a difference in the total number of Gastropods between lakes: Ward is greater than Mullahy which is greater than Morris. When comparing species, it is clear (P= .000) that certain species are more abundant overall in the three lakes. *Amnicola* is shown to be much greater than *Helisoma* which is greater than *Menetus*. When looking at the lakes and species together, one can see the lakes are significantly different (P= .024) when looking at numbers of specific species.

When looking at functional feeding groups, one can see higher filterfeeding in Morris but higher scraping in Ward and Mullahy. According to Christine Taafe's 1990 water chemistry data: Ward Lake has high alkalinity, high readings of hardness, and a high phosphorus concentration. While in Morris there is low alkalinity, hardness, and phosphorus. This explains a possible reason for there being many more gastropods and even more mollusks overall in Ward versus Morris. Finally, it was seen that there was little found in the Ekman sample taken in the middle of each lake.

**Minnows.** Since different methods of trapping minnows were necessary in Morris, it is difficult to compare numbers. In Ward there was more diversity and a greater number of minnows than Mullahy, but many of the species were collected in both lakes. It was expected and observed that the species in Ward and Mullahy would be similar because the two lakes are connected by a small channel. The organisms in Morris are very different and less diverse. It seems the minnows in Morris, such as the Blacknose Shiner and the Pugnose Minnow, were quicker and more evasive. These were not found in either of the other two lakes. These characteristics could be reasons why the traps did not capture the minnows. This may also reflect why there are fewer species in Morris. It is possible that only quicker, more evasive minnows could survive in a lake with a large number of predatory fish such as Northern Pike.

**Larger Fish.** There were no larger fish in Ward and Mullahy other than three small Pumpkinseeds caught in the fyke net in Mullahy. This makes comparing limited. One reason for this absence of large fish could be that the two lakes are winterkill lakes. Both lakes show qualities possessed by winterkill lakes, as explained in the introduction.

In Morris Lake, larger fish were collected. The Northern Pike sampled from Morris were smaller than the average growth of Northern Pike found in Northern Wisconsin according to Becker (1983) (fig 10). Morris was dominated by Northern Pike. When angling, most of the fish caught were Northern Pike. This situation is unusual. Becker states that normally, Northern Pike are present in natural environments in low densities. In a previous experiment done at UNDERC (Schlais, 1987), the population density of Northern Pike in Morris Lake was calculated to be 180 fish/ha. In past studies by Snow (1978), it is considered that a density of 148 fish/ha is high. This stunting may be due to this overpopulation of Northern Pike in the lake. There may be heavy competition for what foraging fish **are** there. The fish may need more room in order to live and grow in a healthy manner. Another possible reason for stunting could be that Northerns can not suitably grow in a small, warm, and shallow lake like Morris. The Perch in Morris on the other hand were "normal" when compared to the average.

## CONCLUSION

Three lakes: Morris, Ward, and Mullahy have had similar influences acted on them, because of their close proximity. Although this is the case, these lakes are different in many respects. Differences in zooplankton, littoral zone invertebrates, minnows, and larger fish were observed the Summer of 1990. By studying and comparing different aspects of the lakes, reasons for the lakes' individual development are possible to identify.

| ORGANISM | SAMPLE | MORRIS | WARD | MULLAHY |
|---|---|---|---|---|
| *Diaptomus* sp. A | SW | 18.6 | 23.4 | 110.0 |
| | C | 31.2 | 34.0 | 83.3 |
| | NE | 57.6 | 25.5 | 87.5 |
| | MEAN | 35.8 | 27.6 | 93.6 |
| *Diaptomus* sp. B | SW | 2.8 | 5.0 | 12.5 |
| | C | 3.8 | 6.0 | 28.3 |
| | NE | 8.8 | 2.0 | 22.5 |
| | MEAN | 5.1 | 4.3 | 21.1 |
| *Diaptomus* sp. C | SW | 4.8 | 1.3 | 0.0 |
| | C | 6.2 | 10.0 | 0.0 |
| | NE | 29.4 | 8.3 | 0.0 |
| | MEAN | 13.5 | 6.5 | 0.0 |
| *Copepoda* nauplii | SW | 8.6 | 8.8 | 32.5 |
| | C | 29.4 | 29.3 | 30.8 |
| | NE | 9.8 | 15.0 | 67.5 |
| | MEAN | 15.9 | 17.7 | 46.9 |
| *Holopedium gibberum* | SW | 0.6 | 6.0 | 17.5 |
| | C | 6.6 | 0.0 | 5.0 |
| | NE | 32.6 | 4.8 | 7.5 |
| | MEAN | 13.3 | 3.6 | 10.0 |
| *Bosminopsis dietersi* | SW | 9.8 | 3.5 | 0.0 |
| | C | 21.0 | 7.0 | 11.7 |
| | NE | 24.2 | 1.3 | 2.5 |
| | MEAN | 18.3 | 3.9 | 4.7 |
| *Bosmia Longtrosis* | SW | 7.8 | 0.5 | 10.0 |
| | C | 9.6 | 0.0 | 1.7 |
| | NE | 27.2 | 0.0 | 0.0 |
| | MEAN | 14.9 | 0.2 | 3.9 |
| *Daphnia* | SW | 0.0 | 0.5 | 0.0 |
| | C | 0.0 | 2.0 | 0.0 |
| | NE | 0.4 | 0.8 | 0.0 |
| | MEAN | 0.1 | 1.1 | 0.0 |
| *Kellicotia longispina* | SW | 6.8 | 134.3 | 0.0 |
| | C | 6.8 | 82.0 | 0.0 |
| | NE | 4.6 | 38.8 | 0.0 |
| | MEAN | 8.3 | 85.0 | 0.0 |
| *Keratella cochlearis* | SW | 4.6 | 0.0 | 0.0 |
| | C | 8.2 | 0.0 | 0.0 |
| | NE | 12.2 | 0.0 | 0.0 |
| | MEAN | 8.3 | 0.0 | 0.0 |
| *Mesocyclops edax* | SW | 8.0 | 0.0 | 0.0 |
| | C | 9.2 | 0.0 | 0.0 |
| | NE | 32.2 | 0.0 | 0.0 |
| | MEAN | 16.5 | 0.0 | 0.0 |

Table 1: Numbers of zooplankton per sample with mean.

| ORGANISM | SAMPLE | MORRIS | WARD | MULLAHY |
|---|---|---|---|---|
| *Odonata Corduliidae Somatochlora* | 1 | 2 | 0 | 0 |
| | 3 | 2 | 0 | 0 |
| | 4 | 1 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| *Odonata Libellulidae Ladona* | 1 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 1 | 0 | 0 |
| | 4 | 1 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| *Odonata Libellulidae Sempetrum* | 1 | 1 | 1 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| *Odonata Coenagrionidae Enallagma* | 1 | 1 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| *Diptera Chironomidae* | 1 | 37 | 8 | 1 |
| | 2 | 11 | 10 | 8 |
| | 3 | 20 | 2 | 24 |
| | 4 | 0 | 19 | 55 |
| | 5 | 26 | 43 | 7 |
| *Ephemeroptera Caenidae Caenis* | 1 | 0 | 1 | 0 |
| | 2 | 0 | 0 | 1 |
| | 3 | 0 | 0 | 4 |
| | 4 | 0 | 0 | 3 |
| | 5 | 0 | 0 | 0 |
| *Ephemeroptera Baetidae Baetis* | 1 | 0 | 1 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| *Trichoptera Leptoceridae Oecetis* | 1 | 0 | 1 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| *Odonata Cordulidae Epitheca* | 1 | 0 | 0 | 3 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |

Table 2: Number of insects per sample in each lake.

| ORGANISM | SAMPLE | MORRIS | WARD | MULLAHY |
|---|---|---|---|---|
| *Pelecypoda Sphaeriidae Pisidium* | 1 | 0 | 4 | 0 |
| | 2 | 55 | 6 | 2 |
| | 3 | 0 | 11 | 10 |
| | 4 | 12 | 5 | 2 |
| | 5 | 22 | 4 | 0 |
| | MEAN | 17.8 | 6.0 | 2.8 |
| *Gastropoda Hydrobiidae Amnicola* | 1 | 6 | 12 | 2 |
| | 2 | 6 | 42 | 14 |
| | 3 | 0 | 92 | 37 |
| | 4 | 2 | 44 | 14 |
| | 5 | 15 | 5 | 2 |
| | MEAN | 5.8 | 39.0 | 13.8 |
| *Gastropoda Planorbidae Helisoma* | 1 | 0 | 0 | 0 |
| | 2 | 4 | 7 | 1 |
| | 3 | 0 | 0 | 5 |
| | 4 | 0 | 2 | 2 |
| | 5 | 3 | 5 | 1 |
| | MEAN | 1.4 | 2.8 | 1.8 |
| *Gastropoda Planorbidae Menetus* | 1 | 6 | 0 | 7 |
| | 2 | 0 | 0 | 5 |
| | 3 | 0 | 0 | 6 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| | MEAN | 1.2 | 0.0 | 3.6 |
| *Amphipoda Talitridae Hyalella azteca* | 1 | 2 | 1 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 |
| | MEAN | 0.4 | 0.2 | 0.0 |

Table 3: Number of non-insect invertebrates per sample, per lake, with mean value.

| **FISH** | **MORRIS(25 traps)** | **WARD(6)** | **MULLAHY(6)** |
|---|---|---|---|
| *Umbridae Umbra limi* | 25 | 2 | 4 |
| *Cyprinidae Chromus eos* | 0 | 245 | 42 |
| *Cyprinidae Notropis cornutus* | 0 | 12 | 0 |
| *Cyprinidae Pimephales promelas* | 0 | 3 | 1 |
| *Cyprinidae Rhinichthys atratulus* | 0 | 0 | 12 |
| *Gasterosteidae Culaea inconstans* | 0 | 20 | 6 |
| *Percidae Etheostoma exile* | 0 | 9 | 6 |
| *Percidae Etheostoma nigrum* | 0 | 13 | 0 |
| *Percidae Perca flevescens* | 0 | 1 | 0 |

Table 4: Number of minnows per lake.

| FISH | MORRIS: | TL(cm) | WT(g) | AGE | WARD: | MULLAHY: | TL(cm) |
|---|---|---|---|---|---|---|---|
| *Lepomis gibbosus* | 13: | 15.5 | 85 | - | 0 | 4: | 13 |
| | | 15.5 | 84 | - | | | 9 |
| | | 15.0 | 70 | - | | | 8 |
| | | 10.0 | 21 | - | | | 7 |
| | | 10.0 | 17 | - | | | |
| | | 9.0 | 14 | - | | | |
| | | 9.0 | 11 | - | | | |
| | | 8.5 | 11 | - | | | |
| | | 8.0 | 10 | - | | | |
| | | 8.0 | 9 | - | | | |
| | | 8.0 | 8 | - | | | |
| | | 8.0 | 7 | - | | | |
| *Esox lucius* | 4: | 26.0 | 90 | 1+ | 0 | 0 | - |
| | | 28.0 | 110 | 1+ | | | |
| | | 35.0 | 250 | 3+ | | | |
| | | 41.0 | 360 | 3+ | | | |
| *Perca flavescens* | 8: | 9.5 | 7 | 1+ | 0 | 0 | - |
| | | 11.0 | 14 | 1+ | | | |
| | | 12.0 | 19 | 1+ | | | |
| | | 18.5 | 80 | 2+ | | | |
| | | 20.0 | 90 | 2+ | | | |
| | | 24.0 | 175 | 3+ | | | |
| | | 24.5 | 170 | 3+ | | | |
| | | 24.5 | 175 | 3+ | | | |

Table 5: Number, size and age of fish caught in fyke net.

| FISH | MORRIS #(8mhrs): | TL(cm) | WT(g) | AGE |
|---|---|---|---|---|
| *Lipomis gibbosus* | 1: | 10 | - | - |
| *Esox lucius* | 8: | 52 | 800 | 4+ |
| | | 48 | 400 | 3+ |
| | | 45 | 410 | 3+ |
| | | 44 | 400 | 3+ |
| | | 44 | 400 | 3+ |
| | | 43 | 410 | 3+ |
| | | 38 | 250 | 2+ |
| | | 32 | 150 | 2+ |
| *Perca flavescens* | 3: | 28 | 190 | 4+ |
| | | 27 | 200 | 3+ |
| | | 23 | 150 | 3+ |

Table 6: Number, size and age of fish caught angling.

Figure 1.

MORRIS LAKE

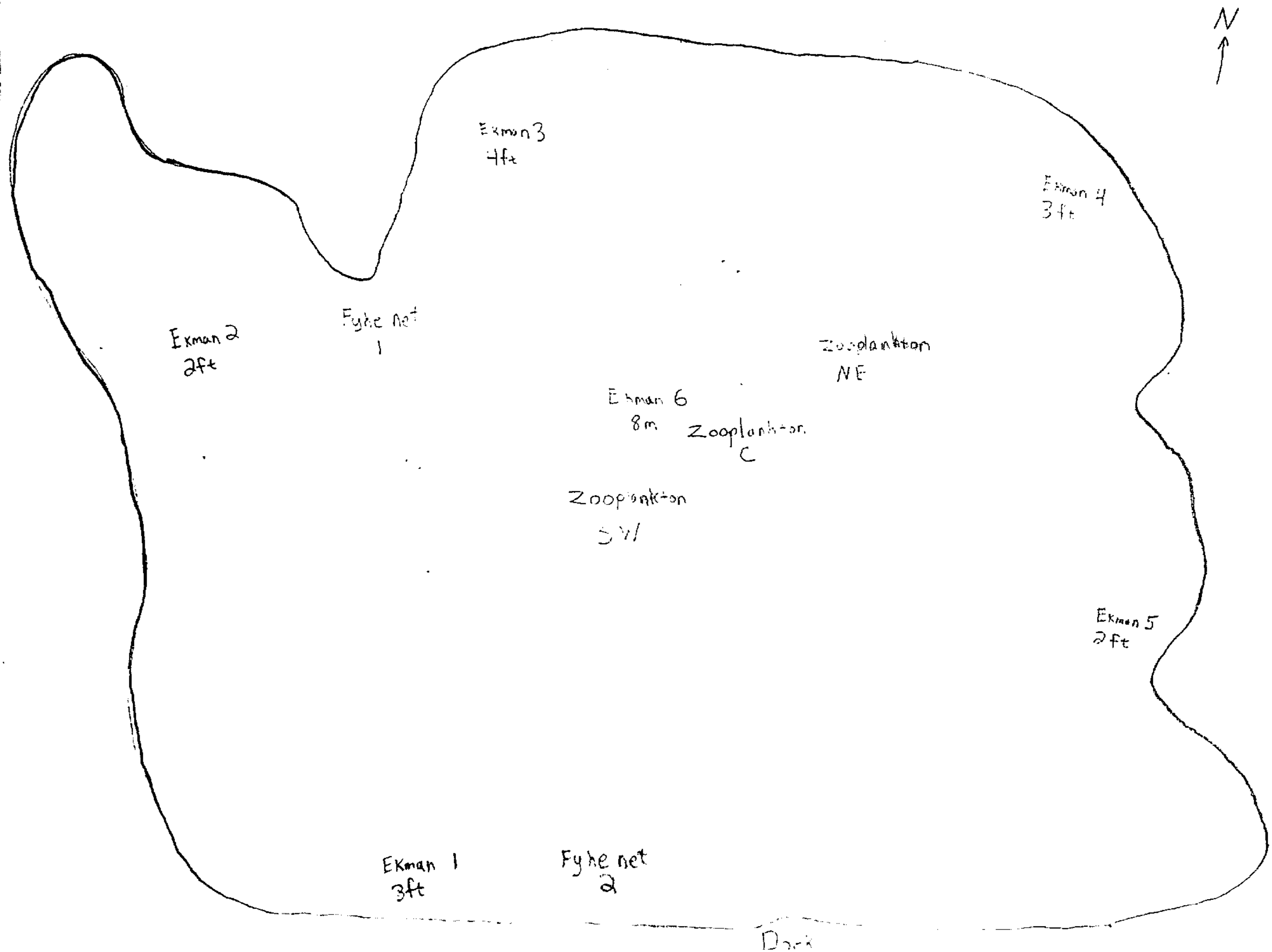


Figure 2.

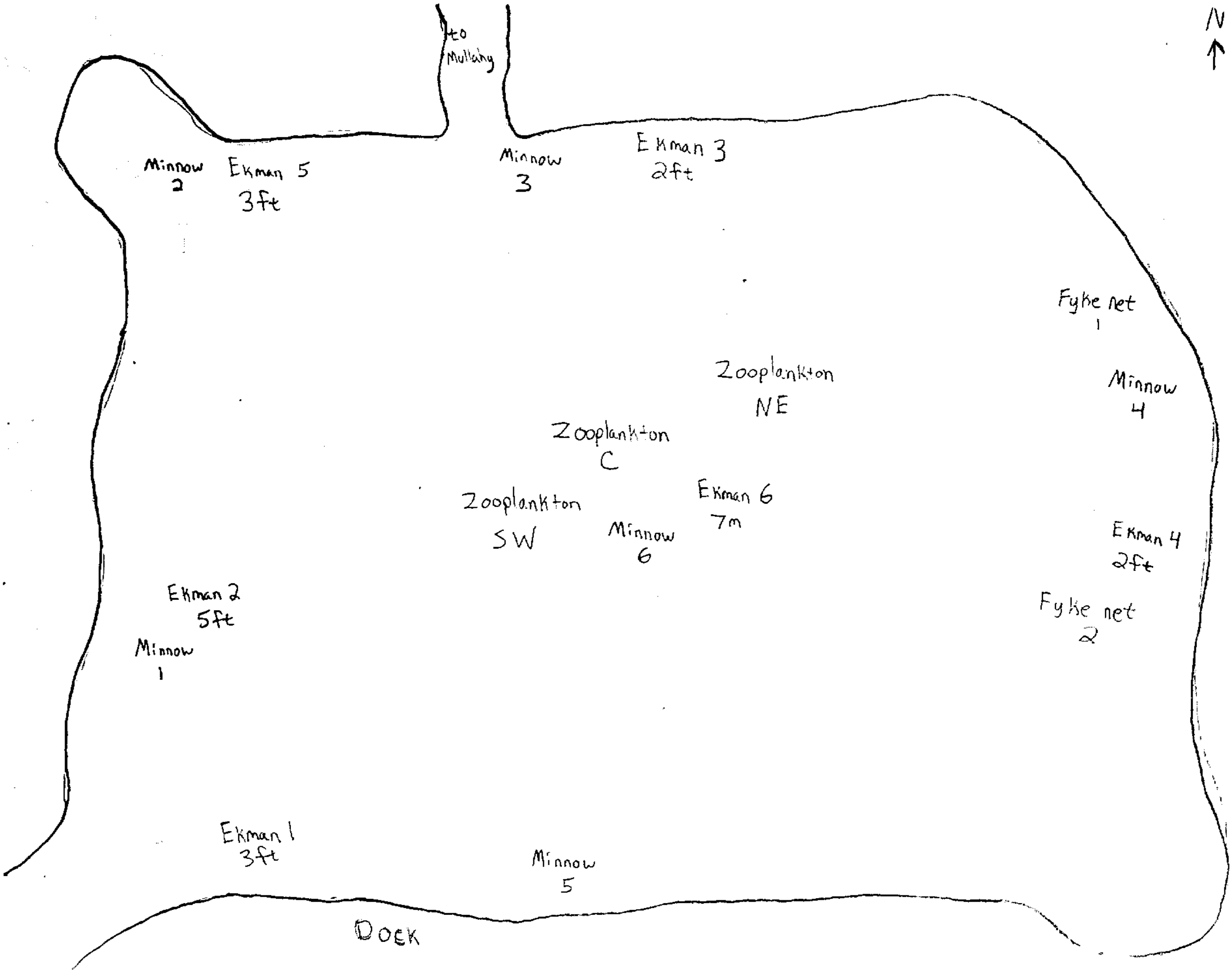
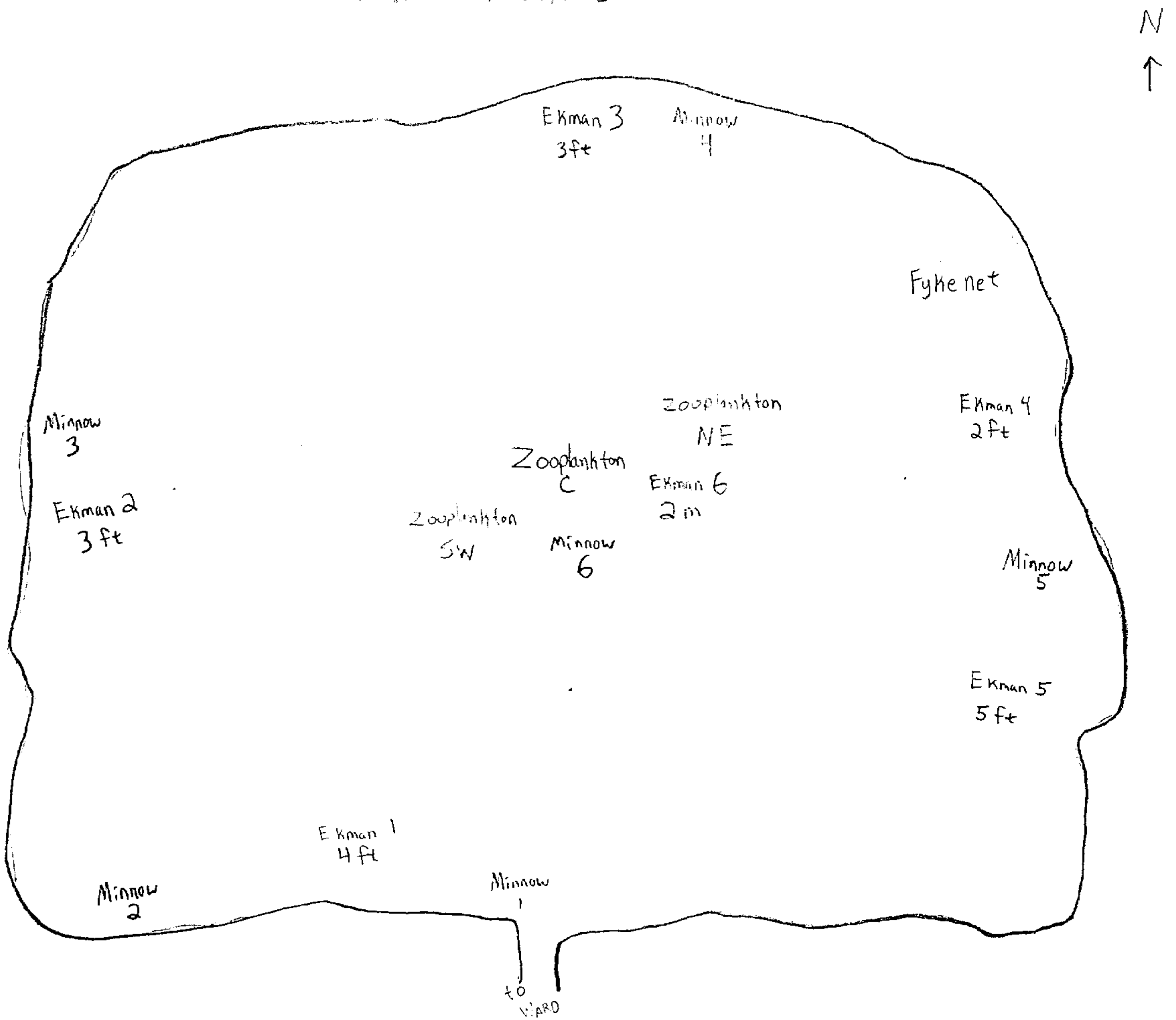
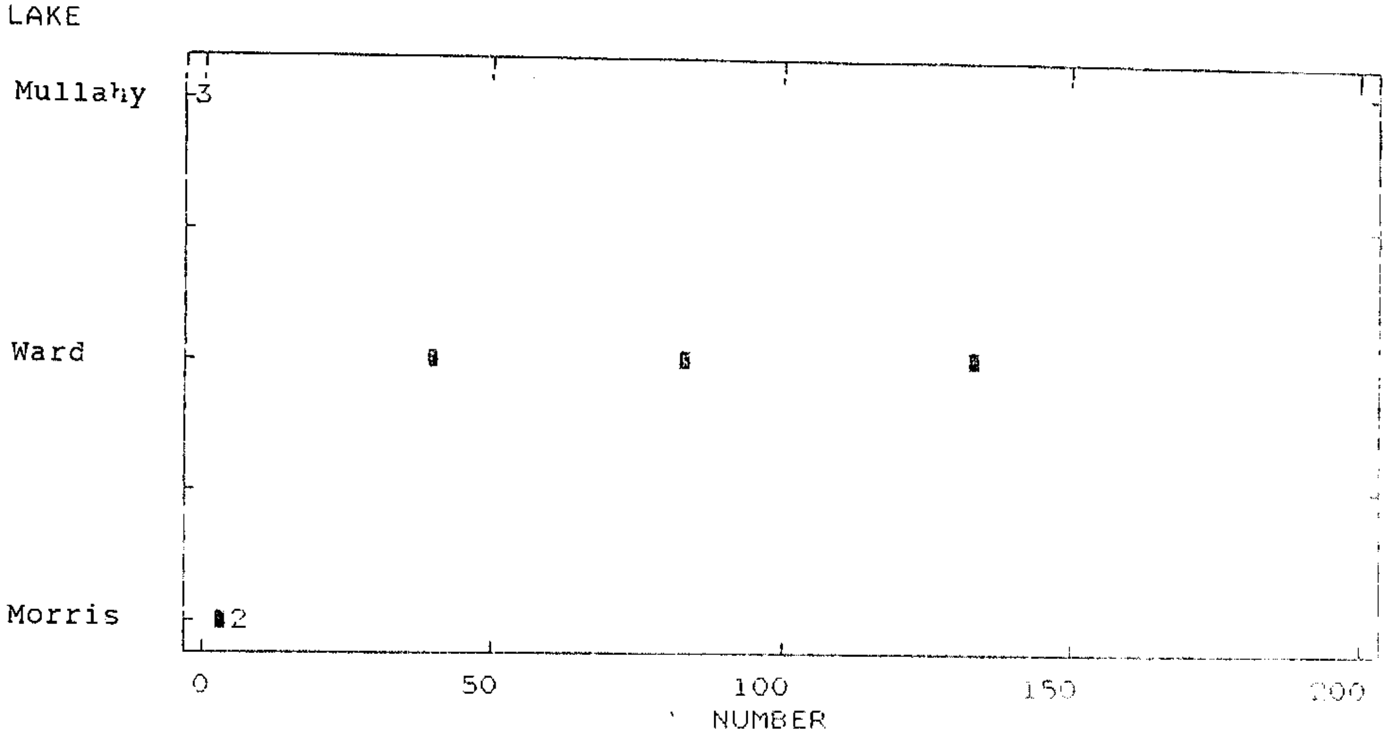

WARD L KE
N
to Mullahy
Minnow 2
Ekman 5 3ft
Minnow 3
Ekman 3 2ft
Fyke net 1
Zooplankton NE
Minnow 4
Zooplankton C
Zooplankton SW
Ekman 6 7m
Minnow 6
Ekman 4 2ft
Fyke net 2
Ekman 2 5ft
Minnow 1
Ekman 1 3ft
Minnow 5
DOCK

Figure 3.

# MULLAHY LAKE



Kellicotia longispina

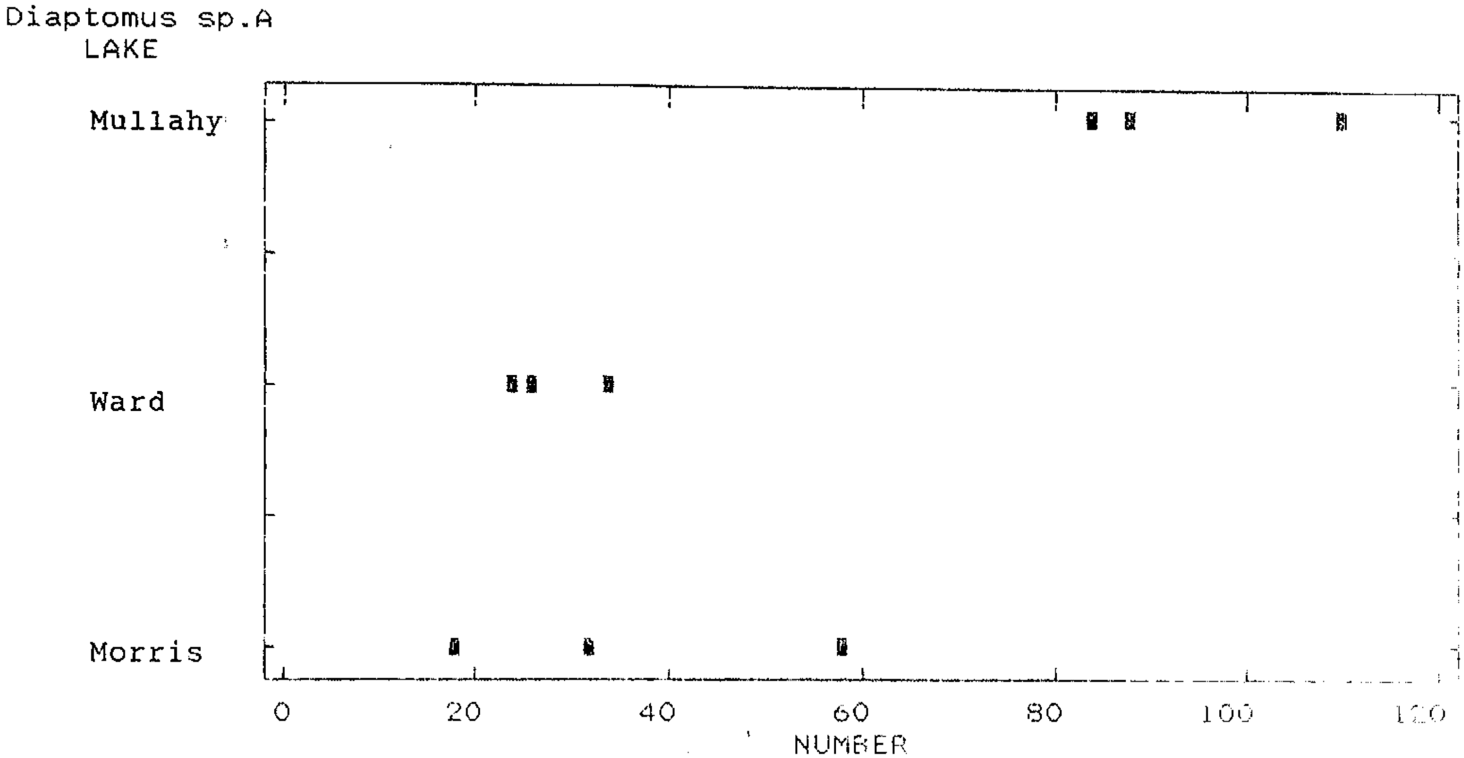



DEP VAR: NUMBER N: 9 MULTIPLE R: .864 SQUARED MULTIPLE R: .747

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| LAKE | 13503.207 | 2 | 6751.603 | 8.850 | 0.016 |
| ERROR | 4577.153 | 6 | 762.859 | | |

Figure 4. One way analysis of variance design and graph showing the number of K. longispina per lake.

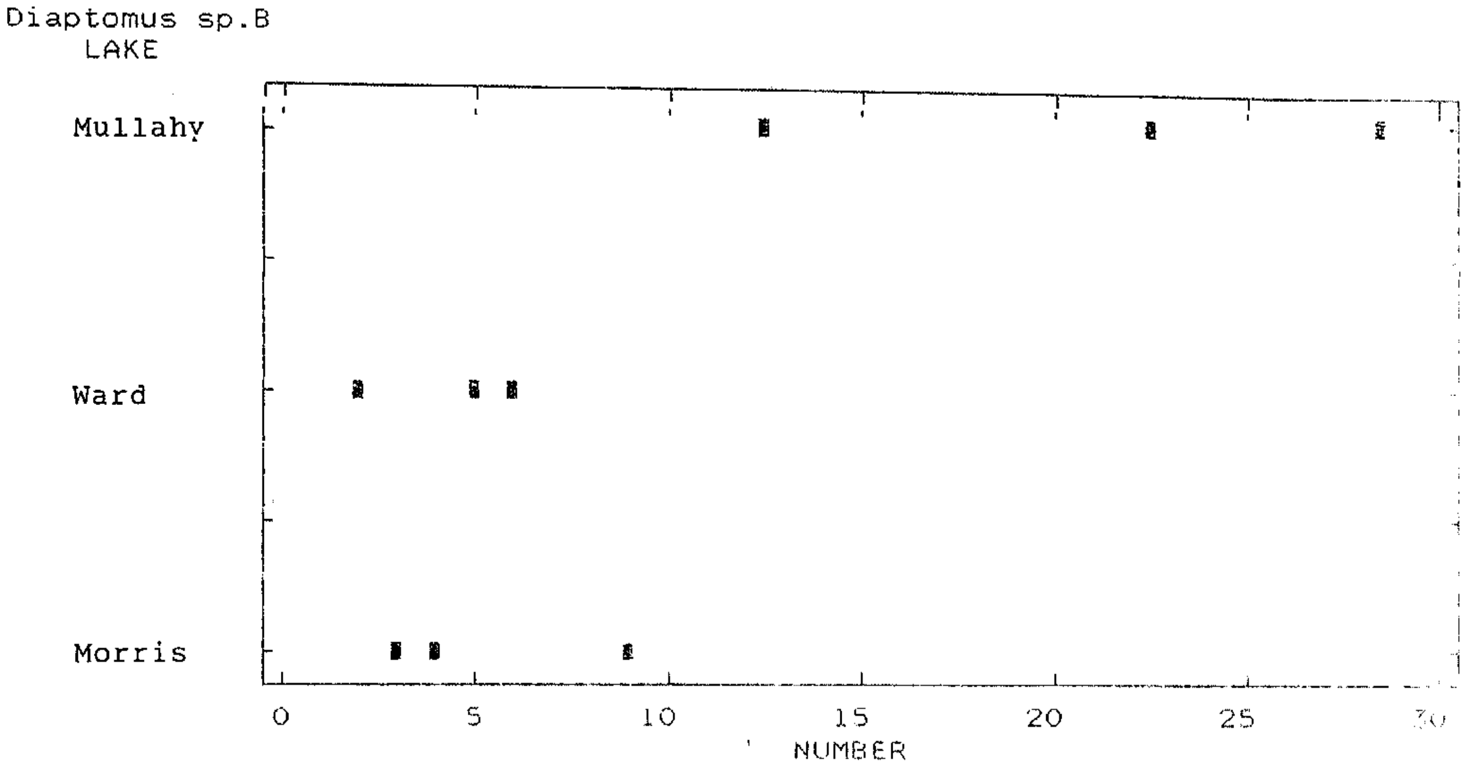



DEP VAR: NUMBER N: 9 MULTIPLE R: .927 SQUARED MULTIPLE R: .860

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| LAKE | 7759.136 | 2 | 3879.568 | 18.365 | 0.003 |
| ERROR | 1267.507 | 6 | 211.251 | | |

Figure 5. One way analysis of variance design and graph showing the number of Diaptomus sp. A per lake.

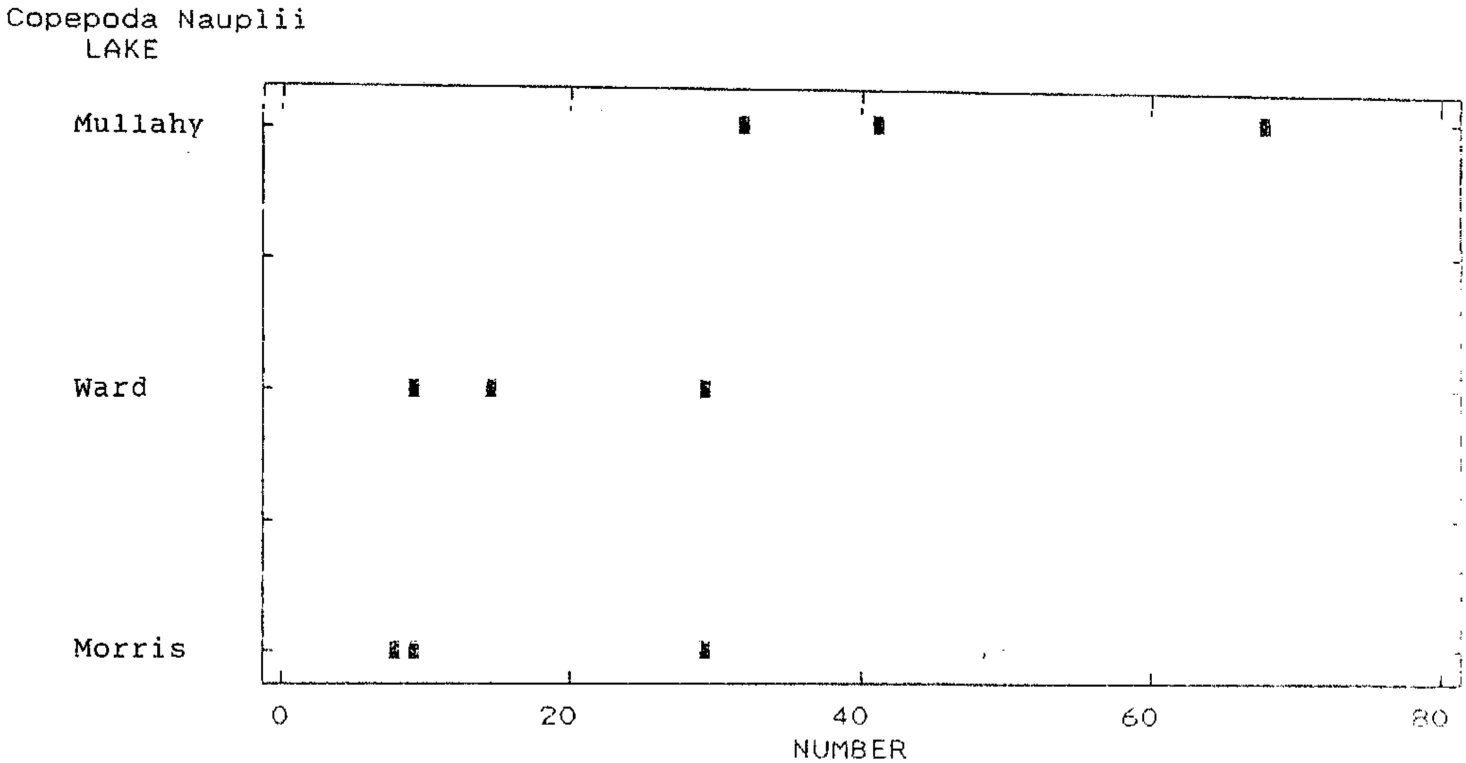



DEP VAR: NUMBER N: 9 MULTIPLE R: .880 SQUARED MULTIPLE R: [illegible]

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| LAKE | 536.696 | 2 | 268.348 | 10.249 | 0.012 |
| ERROR | 157.093 | 6 | 26.182 | | |

Figure 6. One way analysis of variance design and graph showing the number of Diaptomus sp. B per lake.

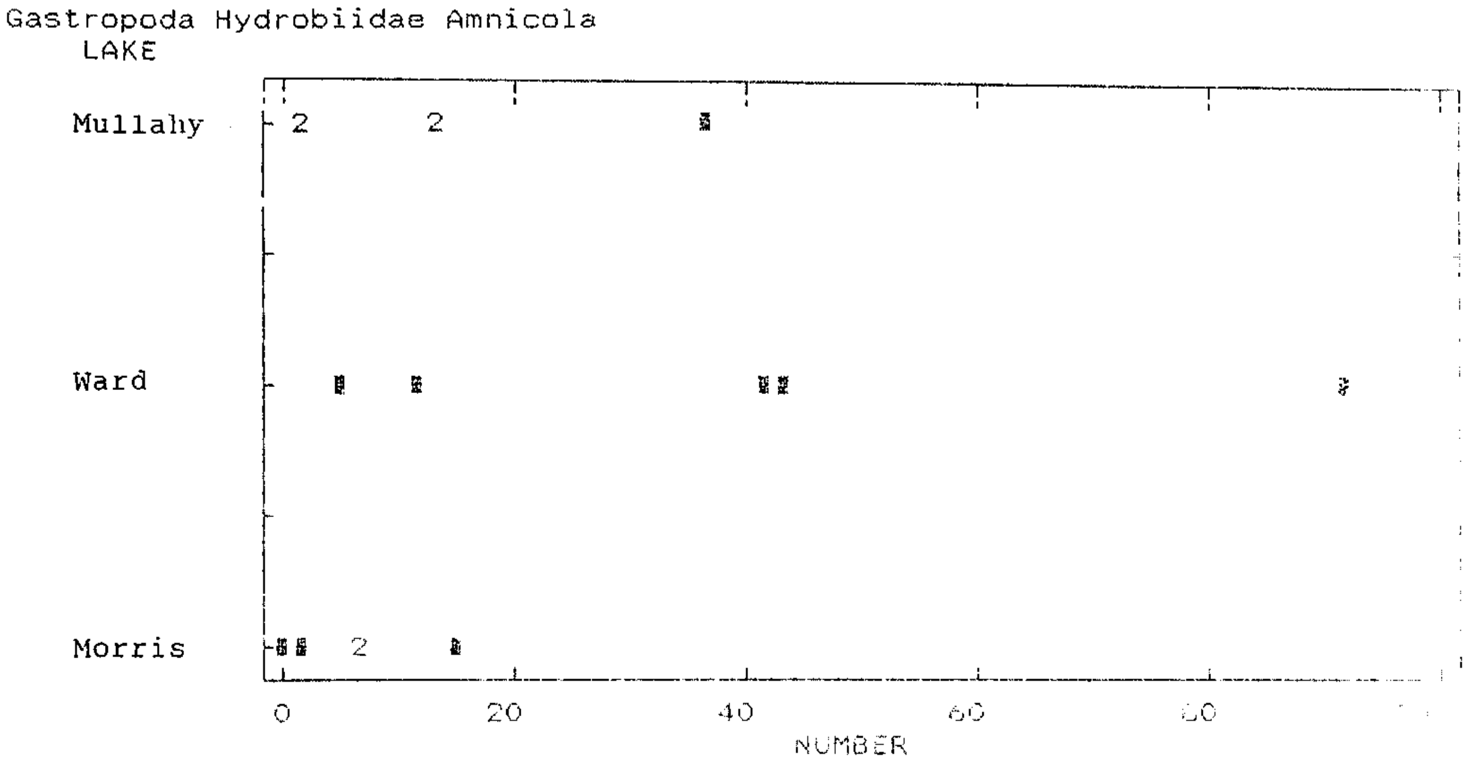



| DEP VAR: | NUMBER | N: | 9 | MULTIPLE R: | .781 | SQUARED MULTIPLE R: | .610 |
|---|---|---|---|---|---|---|---|

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| LAKE | 1818.709 | 2 | 909.354 | 4.693 | 0.059 |
| ERROR | 1162.733 | 6 | 193.789 | | |

Figure 7. One way analysis of variance and graph showing the number of Copepoda Nauplii per lake.




DEP VAR: NUMBER N: 15 MULTIPLE R: .588 SQUARED MULTIPLE R: .346

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| LAKE | 3002.133 | 2 | 1501.067 | 3.173 | 0.078 |
| ERROR | 5677.600 | 12 | 473.133 | | |

Figure 8. One way analysis of variance and graph showing the number of Gastropoda Hydrobiidae Amnicola per lake.

Gastropods: Amnicola, Helisoma, Menetus

DF VAR: NUMBER N: 45 MULTIPLE R: .718 SQUARED MULTIPLE R: .515

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| LAKE | 968.311 | 2 | 484.156 | 2.995 | 0.063 |
| SPECIES | 3145.911 | 2 | 1572.956 | 9.729 | 0.000 |
| LAKE* SPECIES | 2072.[illegible]22 | 4 | 518.156 | 3.205 | 0.024 |
| ERROR | 5820.400 | 36 | 161.678 | | |

Figure 9. One way analysis of variance design comparing gastropods between lakes and comparing overall species abundance. Also, a two way analysis of variance considering lakes across species and species across lakes.

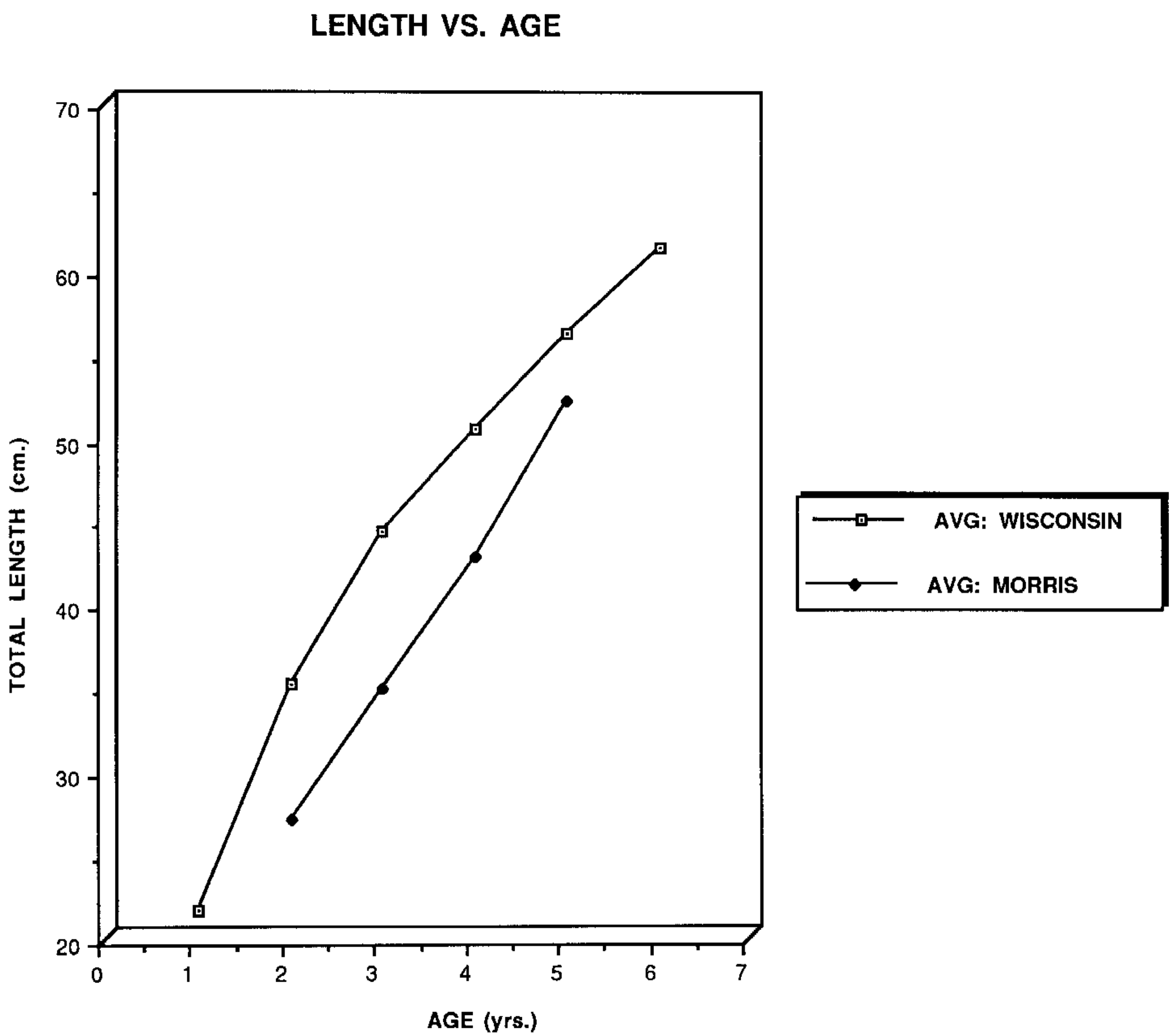



**Figure 10.** Line graph showing the total length per age of Northern Pike in Wisconsin and Morris Lake.

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## ACKNOWLEDGEMENTS

I would like to thank the Bernard J. Hank family for funding the UNDERC course, which gave me the opportunity to do this project. I would also like to thank Dr. Ronald A. Hellenthal, for his guidance in the planning and development of this project. Also, thanks to Dr. Martin B. Berg, for teaching me specific techniques. Finally, I would like to thank Christine Taafe for her daily assistance in the field and for her study, which added the dimension of water chemistry knowledge about the three lakes.