Comparisons of Lake Characteristics with the Fish Species Present

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The fish species and lake characteristics of seven Minnesota lakes, Vermilion, Bemidji, Cass, Rainy, Kabetogama, Upper Red, and Leech were studied. Fish species present in these lakes were cross referenced with the physical and chemical characteristics, then patterns were then identified. The data was obtained from the Minnesota Department of Natural resources (MNDNR) using both the MNDNR website and the MNDNR staff. The Minnesota Pollution Control Agency (MPCA) website also contained data on lake characteristics that were used in the study. Many different characteristics of the lakes appeared to have a possible effect on fish species present. This was evident with the sauger and the small mouth bass species. These species seemed to prefer more distinct ranges such as lower pH and higher water clarity than other fish.

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Introduction

The lakes of the Bemidji region are an important economic resource for the community and the state. Each year, many dollars are spent in the state and region by fishermen. In Ditton et. al (1996) it was found that Minnesota was in the top five fishing destination for non-resident anglers. That means that more people travel to Minnesota to fish than almost any other state (Ditton et. al. 2002). Along with the economic ramifications, having a healthy water system and healthy ecosystem for the region is a priority for everyone, even if they have never wet a line.

Many biotic and aboitic characteristics are going to have an affect on local fish species populations, and this study will examine a few of these specific characteristics: average depth, maximum depth, water clarity, pH levels, chlorophyll, and alkalinity mean. This study will examine how certain fish species relate to the different lake characteristics.

According to Hatzenbeler et. al. (2000), fish have definite areas that they prefer to inhabit with regards to maximum depth and average depth. These preferences may change over the season, but will remain fairly constant from one year to the next. Hatzenbeler et. al. (2000) also states that changing water levels over time do have an effect on the areas that certain fish prefer to inhabit. The rise in chlorophyll in the water column is an indicator of algal concentrations. Many fish kills that occur during the summer result from excessive algal levels during algal blooms (Saiki et al. 1998). Saiki (1998) also points out that high pH levels can have adverse effects. Obviously, some fish are more susceptible to the conditions than others. Salmonoids were found to be less fit when exposed to more murky waters and were also found to be less territorial and feed less efficiently under those conditions (Berg et. al. 1985). Sand-Jenson et. al. (1991) points out that water clarity is important for plant growth and Crowder and Painter (1991) point out that plant growth is necessary for many fish species.

This research project was conducted primarily using data gathered from the Minnesota Department of Natural Resources (MDNR) and the Minnesota Pollution Control Agency (MPCA) website. Data on fish species present in a lake was cross referenced with the characteristics of that lake.

There should be a clarification that this study has a limited scope. This study was conducted on a very limited basis in terms of lakes and fish species being studied. There were only seven lakes, and these lakes are all in the same geographical area. This is too small a sample to make any broad, sweeping conclusions. Jurgen Dengler touched on this in his paper titled "Pitfalls in Small-Scale

Species-Area Sampling and Analysis". In his paper, Dengler writes "This article highlights – with a focus on smallscale SARs of plants in continuous ecosystems – how inappropriate sampling methods or theoretical misconceptions can create artifacts and thus may lead to wrong conclusions" (Dengler 2008) The study outlined in this paper was not nearly deep enough to make definitive conclusions. It only focused on a few specific abiotic factors of the lakes. Other abiotic and biotic factors could be in play as well and could be responsible for the findings.

What this study does do, however, is give a starting block for further work and research on this subject. As was previously outlined, fish are important. This study gives a starting place for further research into the viability of those fish over the long term.

Methods

Fish species in northern Minnesota lakes were compared with physical characteristics in an attempt to identify patterns. The lakes in the study were: Lake Vermilion, Kabetogama Lake, Upper Red Lake, Leech Lake, Cass lake, Rainy Lake, and Lake Bemidji. Ten different fish species were assessed: largemouth bass, smallmouth bass, yellow bullhead, black bullhead, brown bullhead, lake whitefish, sauger, red horse sucker, pumpkinseed, and blue gill. Six characteristics were assessed: average depth, maximum depth, water clarity, pH level, chlorophyll, and alkalinity mean.

Data used in the study was obtained from the MDNR website, interviews with MDNR employees, and from the MPCA website. The fish species present in each lake were gathered from MDNR 2006 netting surveys found on the MDNR website. The lake characteristics were found from the MDNR website, MPCA website, and interviews with MDNR employees.

When comparing the data, ranges of each characteristic were established for each fish. Ranges for each fish were then compared to each other and patterns were identified from the data.

Results

The average depth signifies the average depth of all the lake bottom area. The range of average lake depth in this study ranged from 8 feet to 35 feet (Fig 1A). Smallmouth bass were found in lakes with an average depth of between 26 and 35 feet; they were on the higher ends of the spectrum. Sauger had a very similar range of 26 to 35 feet. Lake whitefish had a range of between 8 to 25 feet. Redhorse sucker had the widest range of 8 to 35 feet. Brown bullhead had the second widest range of 8 to 34 feet (Fig. 1B).

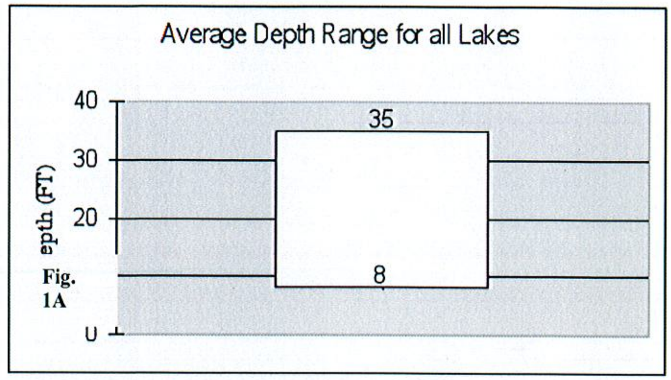

Fig 1A Range of average depths for all lakes.

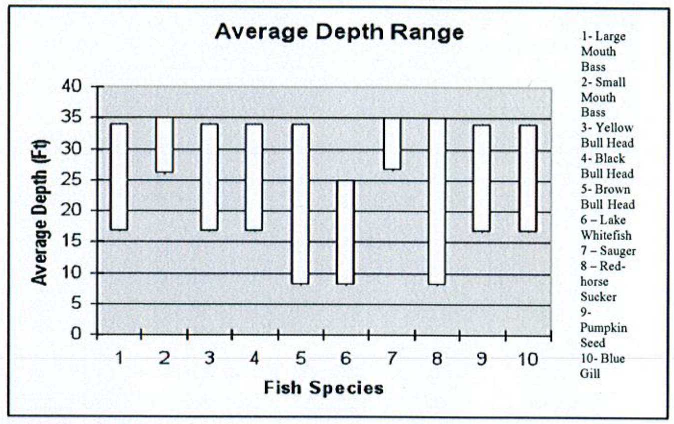

Figure 1B Range of average depths for individual species..

The maximum depth is how deep it is at it's deepest spot in the lake. The maximum depth range for all the lakes was from 18 to 161 feet (Fig 2A). In the results for maximum depth, redhorse sucker again had the largest range, inhabiting lakes that have a maximum depth of between 18 to 161 feet. Brown bullhead had the second largest range of 18 to 150 feet. Once again, the lake whitefish had the shallowest overall range of depths from 18 to 120 feet. The yellow bullhead had a deep overall range and also had the narrowest, from 150 to 161 feet. The rest of the fish species all had similar sized ranges that were between 76 and 161 feet (Fig. 2B).

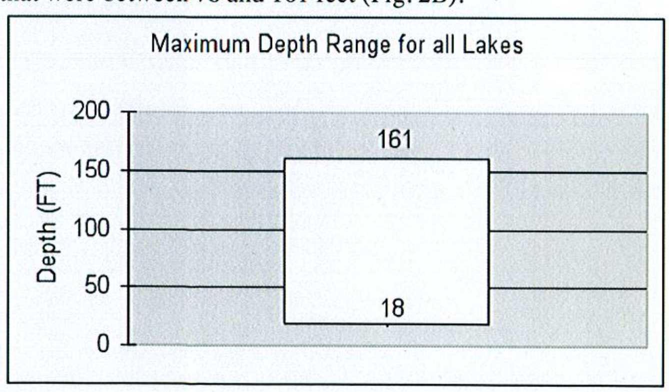

Fig. 2A Range of maximum depths for all lakes.

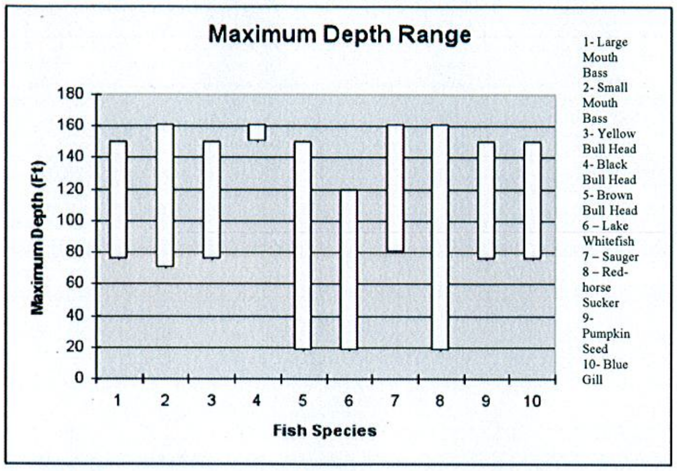

Fig 2B. Range of maximum depths for the individual species

Water clarity is a number that represents how clear the water is, specifically the level of visibility in the water of that lake. The overall range of water clarity for the lakes in the study was between 3.6 and 10.17 feet (3A). When examining the water clarity ranges, the smallmouth bass, sauger, and black bullhead had higher clarity levels. The smallmouth bass had a range of 7.5 to 10.17 feet. The sauger had a range of 9.0 to 10.17 feet. The black bullhead occupied a range from 9.0 to 9.2 feet. Once again, the black bullhead also had the most narrow range. The brown bullhead, lake whitefish, and redhorse sucker had the largest ranges. The brown bullhead had a range between 3.6 to 9.2 feet. The lake whitefish's range was from 3.6 to 9.84 feet. Water clarity of between 3.6 to 10.17 was the range of the redhorse sucker (Fig 3B).

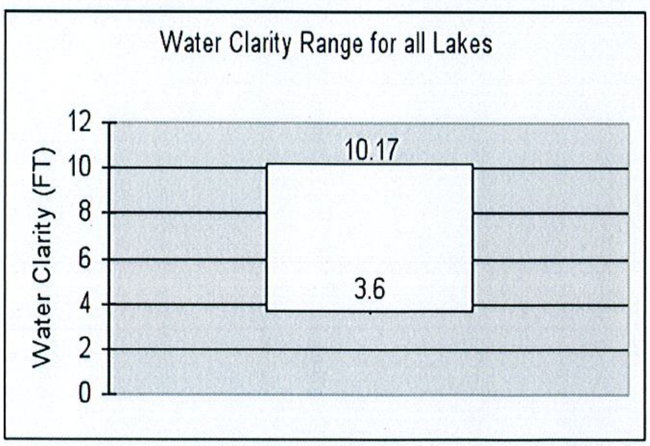

Fig. 3A Range of water clarity for all lakes.

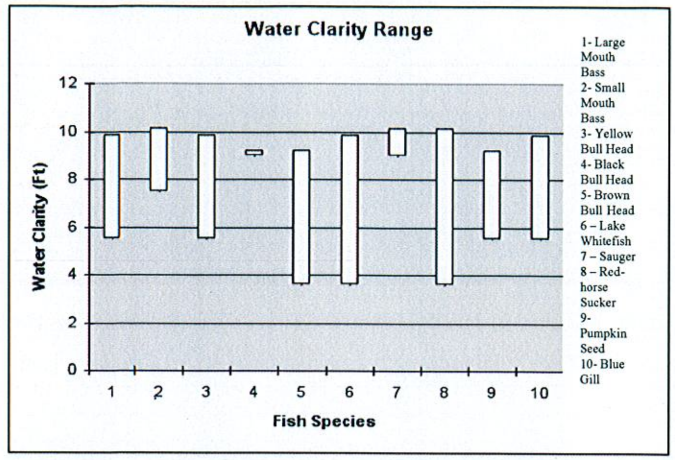

Fig 3B. Range of water clarity for individual fish species

PH is a measure of the acidity of the water. The lower the pH the more acidic and the higher the pH the more basic the water is. The range of pH for the lakes in the study was between 7.2 and 8.6 (Fig 4A). When it came to the range of pH levels, the sauger and smallmouth were again closely related, but this time on the low ends of the scale. The smallmouth had a range between 7.2 to 7.4. The sauger's range fell between 7.2 to 7.8. On the other hand, the yellow bullhead and lake whitefish had narrow ranges on the high end of the pH scale. The yellow bullhead's range was between 8.5 and 8.6. The lake whitefish had a range of 8.6 to 8.6. The black bullhead had the largest range from 7.2 and 8.5. The rest of the species had a pH range of between 7.6 and 8.6 (Fig. 4B).

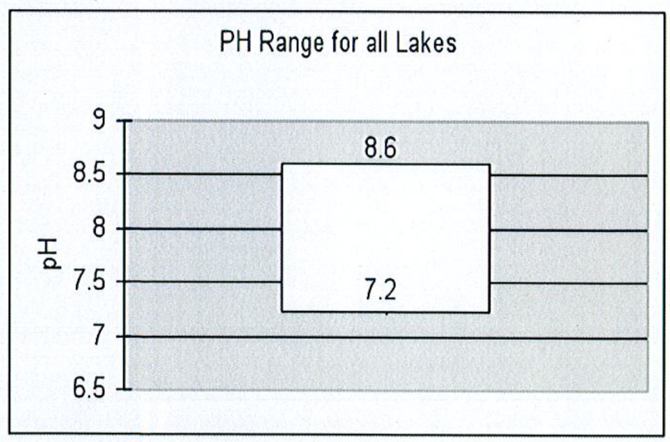

Fig. 4A. Range of pH for all lakes.

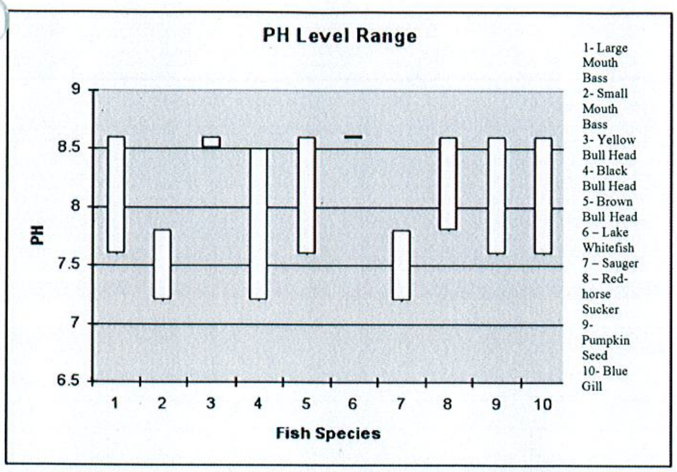

Fig. 4B. Range of pH level for individual species.

Chlorophyll-a is a measure of the amount of chlorophyll in the water column. Chlorophyll is a pigment in plants and other photosynthetic organisms and usually is a measure of how much algae is in a lake. The more algae the higher the nutrient level. The chlorophyll-a mean for the lakes in this study was between 2.85 and 14.56 parts per billion (ppb) (Fig 5A). In respect to chlorophyll levels, the black bullhead has a range of 2.85 and 3.6 ppb, a range that was the overall lowest and narrowest. The brown bullhead, lake whitefish, and sauger had the widest ranges of the fish. Brown bullhead's range was 2.85 to 14.56 ppb. The lake whitefish had a range between 4.0 and 14.56 ppb. The sauger's range was from 2.6 to 11.4 ppb. The other fish had ranges that fell in the middle (Fig. 5B).

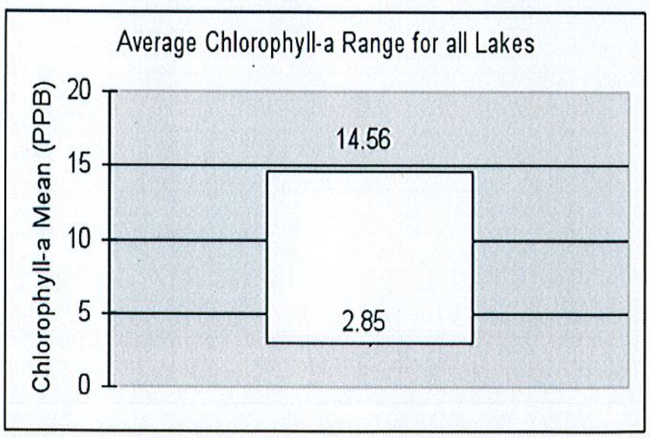

Fig. 5A. Range of chlorophyll-a for all lakes.

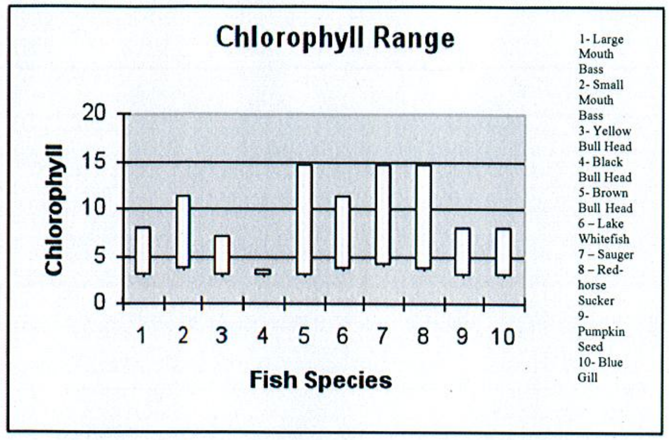

Fig. 5B. Range of chlorophyll levels for individual species.

Alkalinity mean is a measure of the amount of alkalinity in the lake and is the lake's ability to resist changes in pH. The higher the number is, the higher the lake's ability to resist changes in pH. The alkalinity mean of the lakes in the study was between 17 and 176 (Fig 6A). For alkalinity mean, the largemouth bass, brown bullhead, pumpkin seed, and blue gill had very wide ranges compared to the other fish, all fish had a range of between 38 and 176 ppb. The smallmouth bass and lake whitefish had the smallest ranges. The smallmouth's range was between 38-38 ppb. The lake whitefish's range was 152 ppb. Because of lack of data, black bullhead and sauger could not be accurately shown (Fig. 6B).

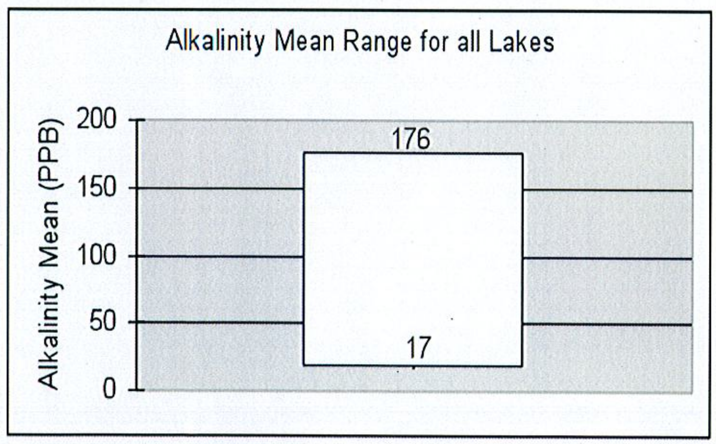

Fig. 6A. Range of alkalinity mean for all lakes.

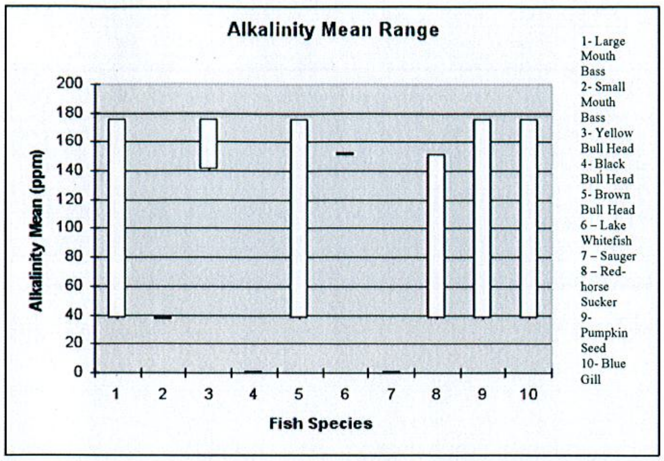

Fig. 6B Range of alkalinity mean levels for individual species.

In overall trends, one trend was the similar ranges of the smallmouth bass and the sauger. Their ranges seemed to always be pretty similar and were usually on one end of the graph or the other. They also rarely had wide ranges when compared to the other fish, usually having some of the more narrow ranges. The black bullhead appeared to have some specific ranges as well for many of the characteristics.

It appeared that the blue gill and pumpkin seed were very closely linked in their preferences. They had more broad ranges than the sauger, smallmouth, yellow bullhead, or black bullhead on most of their characteristics and never appeared to be very polarized to one end or another. The brown bullhead and redhorse appeared to have the widest ranges and appeared to be the most hardy, tolerating a wide range of characteristics.

Discussion

It appears that certain fish species had certain preferences for some of the factors that were examined. The black bullhead had some very narrow ranges in maximum depth, water clarity and chlorophyll for the seven lakes observed. The fact that the fish is found in lakes with low chlorophyll and high water quality suggest that the fish may be found in deeper, more clear, oligotrophic lakes. If the water quality were to decrease and the chlorophyll increase, it may possibly make it less desireable for the species to live there. This is similar to what Berg found in his study with the salmoniods, when the water became more murky the salmon were not as healthy (Berg et. al. 1985).

Sauger and smallmouth bass appeared to prefer more distinct ranges, especially with regards to water clarity, pH, maximum and average depth. Once again, changes in these factors have the possibility of adversely affecting both species. Changes in pH and alkalinity could possibly affect the yellow bullhead. This is especially true if the levels dropped, as the fish appeared to favor a higher range of both.

In this study the two most hardy fish appeared to be the brown bullhead and the red horse sucker. These two had the largest ranges for average depth, maximum depth, water clarity, pH level (brown bullhead), alkalinity mean, and chlorophyll (brown bullhead).

There are many other studies which suggest that the changing of lake characteristics can affect fish populations. One major study by Kangur et. al. (2006) found major changes in long term patterns of fish in Lake Peipsi due to changes in lake characteristics. Kangur et. al. (2006) state that the results of their long term study suggested that the fish in Lake Peipsi reacted to changes in the water quality and biota. Eutrophication and weather driven changes led to vast declines in vendance and other clean- and cold- water species and increases in the number of murky and warm water species. Kangur et. al. (2006) found that because of natural and human processes there were many fundamental structural changes in the fish community of the lake. This study by Kangur e.t al is very important because it gives on example of changes in lake characteristics affecting changes in the fish species that inhabit those lakes. In this study the entire population of fish changed because of changes in the lake characteristics.

Fisher and Paukert (2008) revealed a decline in some fish species and the rise in other species over the years when compared to historical numbers. The studied was looking specifically at the abundance of the plains topminnow (a native species) with the abundance/presence of nonnative and introduced species compared to changes in lake characteristics and human interference. The study found a decline in the topminnow and other native species and a rise in the number of more hearty and invasive species.

Fang and Stephen (1999) concluded that the changes in water temperature, because of global climate change, could result in changes in fish patterns. Fang and Stephen (1999) said that water temperatures are projected to increase as much as 5.2 degrees Celsius. This chance could greatly affect fish species and their distribution. Even though this study did not deal with factors of global climate change, it should be noted that global climate change is another important factor in the long term health of our fish populations.

Again, this study was not nearly broad enough to make any conclusive findings with only seven lakes from a limited area. Because there were only seven lakes studied, and these lakes only contained a specific range for each trait, it is hard to come up with conclusive data. There could be fish living in lakes that have characteristics outside the observed ranges of this study. A conclusive study would have to have far more lakes with a wider range of characteristics. Other biotic and abiotic factors would have to be taken into account as well in order to make it more effective.

This study outlines the possibility that changes in the characteristics of a lake could possibly result in changes in fish species. The characteristics and patters in this paper could be used for further study. They could be used as a starting point for a longer and more in depth effort that studied the effect changes in lakes have on fish species.

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Addendum I

The DNR conducts fish surveys by using gill nets and trap nets to catch fish species. Gill nets are nets that hang in the water and snare fish by their gills when fish try to swim through the net. Trap nets are cage like nets that are anchored to the ground. The fish are enticed into swimming into the cage and then can not get back out. The DNR then looks at the catches from each net to determine which fish are present in the lake and at what levels.

The data for average lake depth and maximum lake depth are taken from depth readings by DNR officials. These depth readings are usually taken using an electronic depth finder. The depths in a lake undergo normal fluctuations throughout the year and from one year to the next.

The pH levels for the lakes were obtained from studied done by the MDNR and MPCA employees. The employees take and test water samples from the lakes. This is also how the alkalinity mean is obtained.

The water clarity is obtained by MPCA and MDNR employees and volunteers using a secchi disk measurements. The secchi disk is a large white disc that is lowered into the water. The observer records the depth right before they can no longer see the secchi disk and that data is how they determine the water clarity.

The measurements for chlorophyll-a levels come from MDNR and MPCA employees taking water samples. They analyze the water samples for the presence of algae and use those numbers to determine the amount of chlorophyll in the water column.

The data from the DNR on fish species that were present in the lake came from the 2006 survey year. The surveys have since been updated from some of the lakes in this report. The data from the MPCA on the chemical components of the lake came from the 2006 survey year as well. They to have been updated from some of the lakes.

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