Shea Lake
Kewaunee County, Wisconsin

Management Plan
September 2015

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Introduction

Shea Lake (Figure 1) is a shallow seepage lake located in the southwest corner of Kewaunee County, Wisconsin. Shea Lake has a length of 612 meters, width of 268 meters, surface area of 28.3 acres and a maximum depth of 7 meters. The bedrock of the area is dolomite, which has implications for alkalinity—the lake's ability to resist acidification. Shea Lake is fairly productive, which is indicated by its stratified water column, shoreline algal and aquatic plant growth, and light brown water color. Historically, the lake has been a warm water fishery supporting bass, pike, and panfish predominately. Shea Lake has a history of winter fish kills occurring several times per decade starting in the late 1960's to present. The most recent winterkill happened in 2014.

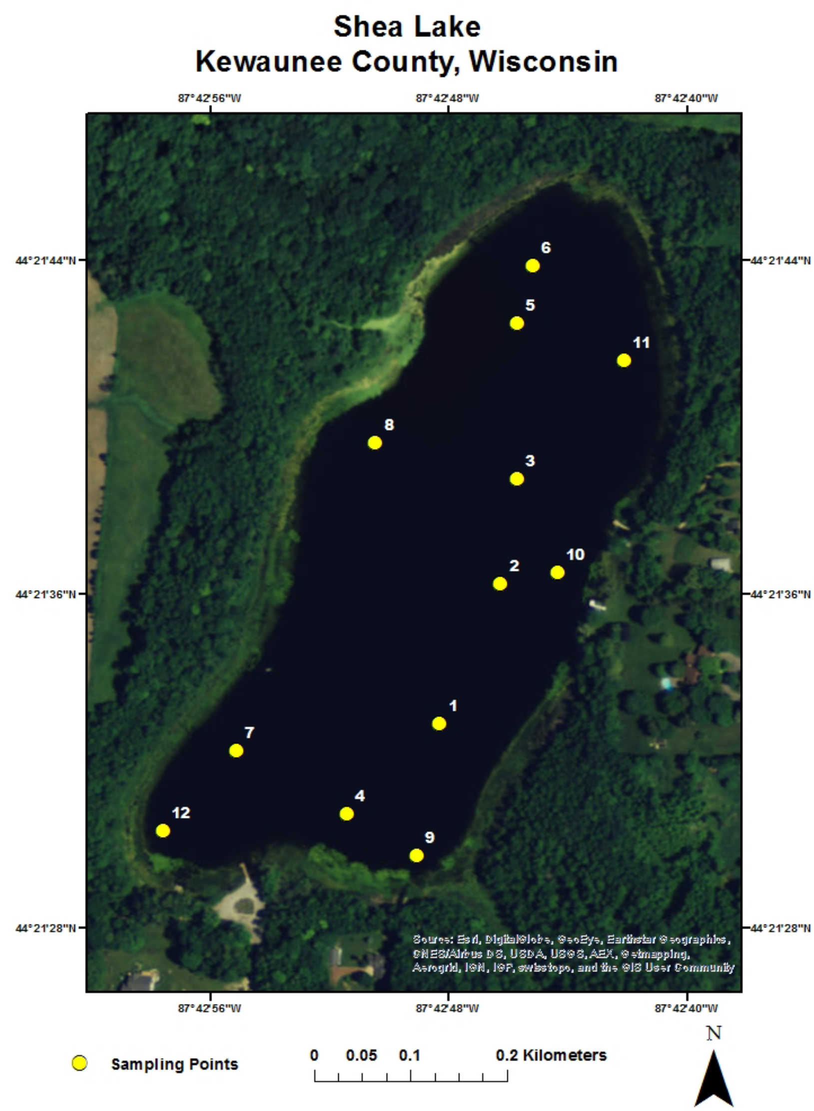

Figure 1: Shea Lake sampling area located in Kewaunee County, Wisconsin. Yellow dots indicate the 12 sampling points where data were collected on September 28th and October 12th, 2015.

<u>Background Information and Study Results</u>

Trophic Structure and Water Quality

Water quality of a lake is often assessed by comparing it to comparable lakes in the same region. However, there is subjective analysis in determining lake health because not all lakes have the same land usage or watershed quality or quantity. There are numerous parameters that can be assessed and compared to determine water quality and trophic structure as it relates to ecosystem health and recreational desirability such as: water clarity, alkalinity and pH, zooplankton and macroinvertebrate composition and abundance, water temperature, conductance, dissolved oxygen, total dissolved solids, phosphorus, and aquatic plants. The research team collected these parameters from twelve different sampling points across Shea Lake. In addition to these parameters, the fishery status is an indicator of lake health. In this study, the Wisconsin Department of Natural Resources (DNR) provided data on the history of fish species that inhabit the lake.

Water Clarity

Water clarity is a direct indication of how much light is penetrating the water column. Water clarity has a direct influence over a lake's productivity and its ability to support aquatic life by limiting or allowing sunlight for photosynthesis. Suspended solids and algae block or absorb sunlight and cloud the water, which in turn makes the lake much less desirable for recreation and lowers the productivity of the lake. Water clarity can be affected naturally by storm events and wind, or by human influences such as fertilizer (nutrient) runoff and construction. The water clarity of Shea Lake was measured using a Secchi Disk. Greatest water clarity was observed in the southwest cove of the lake near the boat dock and had Secchi visibility at 2.9 meters. In comparison, water clarity was minimal in the eastern portion of the lake and had Secchi visibility of 0.7 meters, but it should be noted that on October 12—the day the eastern measurements were taken—wind gusts reached 40 miles per hour in the area. Average Secchi reading of the entire lake was 1.3 meters.

Alkalinity

The alkalinity of a lake is best described as the lake's ability to resist acidification or rapid pH changes; pH is a measure of how acidic or basic a substance is by measuring the concentration of hydrogen ions. If the lake fails to buffer itself from the effects of acidic precipitation and the bombardment of carbon dioxide from the atmosphere, then its organisms will fail to regulate basic vital processes such as gas exchange and salinity content. The typical pH range for a healthy freshwater ecosystem is between 6.5 and 8.5 units. The pH of water determines the solubility and biological availability of nutrients and heavy metals because hydrogen ions affect the forms that these cations have in water. Shea Lake is a seepage lake, which means it gets its water mostly from groundwater recharge, but can be supplemented with precipitation and runoff. The groundwater of the area is laden with calcium because the underlying bedrock is dolomite; the calcium coming into the lake system accounts for the lake's high alkalinity and basic pH of 8.03.

Phosphorus

Phosphorus is a primary control factor in plant and algae growth. Small increases in phosphorus may stimulate the growth of aquatic plants and algae, which in turn decreases dissolved oxygen content. Exponential algal growth can cause dissolved oxygen levels to decrease below aquatic life-sustaining levels, leading to large-scale fish kills, invertebrate, and other aquatic animal premature death. Human health can be compromised through elevated toxins and bacterial growth from phosphorus-polluted waters. Monitoring phosphorus content can predict plant and algae growth rates, which in turn may help protect fish and human health. Wisconsin State Legislature chapter NR 102.06(4)(a) sets the total phosphorus limits for water quality standards in stratified lakes at 30 μg/L. In this case, sampling points 1 and 12 are above state limits at 40 μg/L and 80 μg/L, respectively.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) is necessary for the survival of fish, zooplankton, and macroinvertebrates and is directly related to temperature: the higher the water temperature, the less dissolved oxygen the water can hold. Over the course of a year, deep eutrophic lakes stratify in the summer months and homogenize in the spring and fall due to mixing of the water column. Even though Shea Lake is relatively shallow and may not stratify as prominently as deep eutrophic systems, stratification is observed in both temperature and DO profiles (Figure 2). Over the course of this study, the lake began to mix and the water column began to homogenize in both parameters. On September 28, DO content in the epilimnion was markedly lower than on October 12, especially at sampling point 1 (Figure 2). The discrepancy in the DO profiles between sampling points on September 28 and October 12 can be attributed to the additional 1.5 meter depth mark which was found at sampling point 1. It is no doubt that sampling point 1 requires more time to mix because of its greater depth. Average surface water temperatures cooled by six degrees Celsius from September 28 to October 12, and DO increased by 0.5 mg/L. Dissolved oxygen is not only a function of water temperature (Figure 3) but is also directly linked to pH: as pH increases, DO decreases (Figure 4). Regression analysis returned an R^2 value of 0.705, which means that roughly 71% of the variations in DO can be explained by the independent variable that is pH (Table 1).

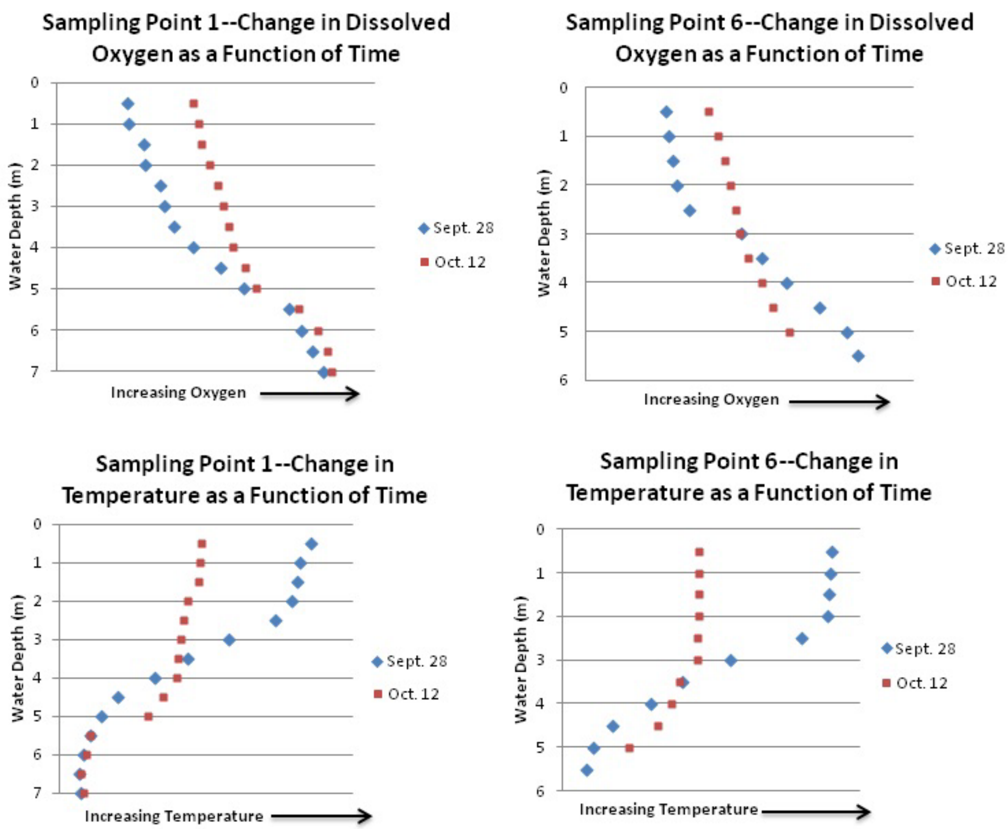

Figure 2: Stratification of the water column is apparent on September 28 because both dissolved oxygen and temperature follow a cubic-shaped curve from the epilimnion (surface) to the hypolimnion (lake bottom). Homogenization is nearly complete by October 12, which is indicative of the straightening curves in both DO and temperature.

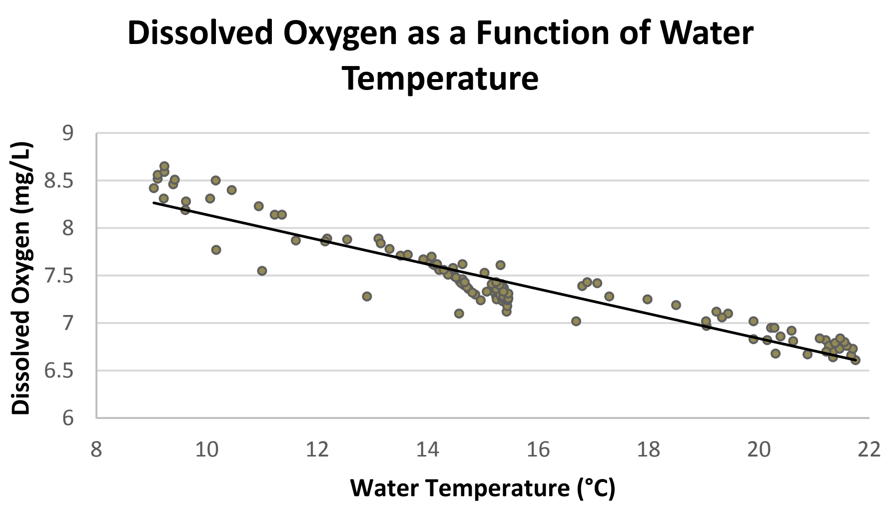

Figure 3: Shows the correlation between decreasing DO with increasing water temperatures.

Table 1: Regression analysis of dissolved oxygen (dependent variable) and pH (independent variable). The pH explains approximately 71% of the variation in DO, which is indicated by R^2. The infinitesimal *Significance F-value* further validates the test and ensures that this conclusion is reliable.

Regression Statistics	
Multiple R	0.839800561
R^2	0.705264982
Adjusted R^2	0.702849121
Standard Error	0.267505048
Observations	124

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	20.89028546	20.89028546	291.9311326	3.69469E-34
Residual	122	8.730191958	0.07155895		
Total	123	29.62047742			

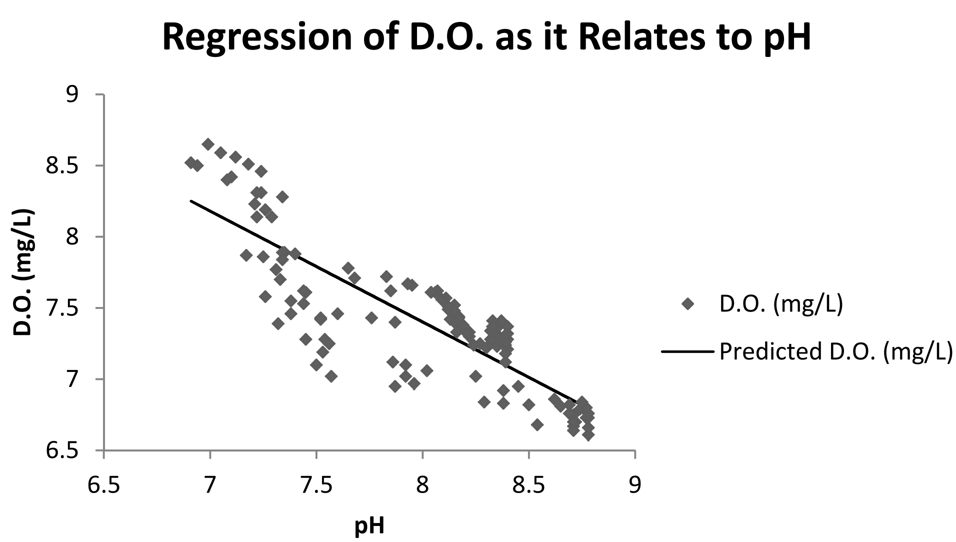

Figure 4: The relationship between pH and dissolved oxygen is clear: as water pH increases from the center of the pH scale (0-14) water becomes more basic and dissolved oxygen decreases.

Zooplankton

Four different groups of zooplankton were observed during two separate counts of the 12 sampling points. The taxa recorded were Copepoda and Daphnia (Figure 7), however Amphipoda and Chironomidae were also present in diminutive numbers. Relative zooplankton abundance, density, and composition differ spatially and possibly temporally, as well (Figure 5). The potential temporal difference in zooplankton assemblages is not well captured in our data; more long-term sampling would be required to better elucidate this pattern. Sampling points 5 and 6 in the central area of the lake had the largest concentration of zooplankton and were collected on September 28 (Figure 5 and Figure 6). Additional research and collections of the zooplankton community, along with the forage base and fish populations, may reveal a better understanding of Shea Lake's condition.

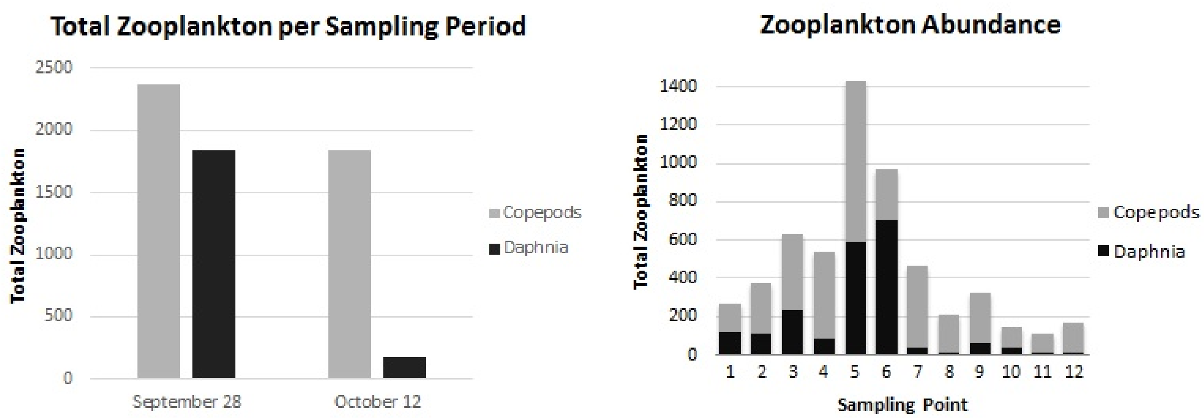

Figure 5: The first graph shows the total number of Copepods and Daphnia observed in samples collected on September 28th and October 12th. Zooplankton abundance was greater on September 28th, the first sampling period. The second graph shows total zooplankton abundance across the 12 sampling points. Points 5 and 6 are in the center of Shea Lake.

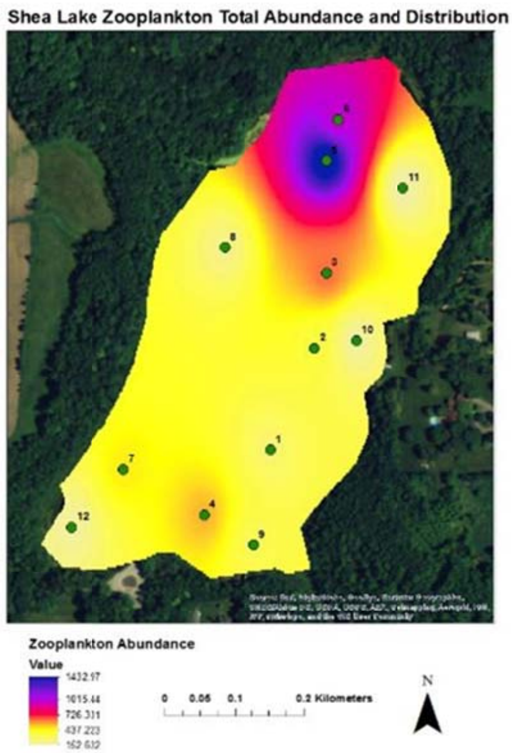

Figure 6: Zooplankton abundance (total count) and distribution in Shea Lake, Kewaunee County. Zooplankton abundance is much more prevalent in the north portion of the lake.

Figure 7: Daphnia found in Shea Lake during specimen-scope analysis.

Macroinvertebrates

Aquatic macroinvertebrates are often used as indicators of water quality because of their sensitivity to certain water parameters such as dissolved oxygen, temperature, and pH. Ephemeroptera, Plecoptera and Trichoptera (EPT) are known as indicator species and mainly live in clean waters with high dissolved oxygen (Stoyanova et al. 2014). In other words, their presence in indicative of good water quality. Because EPT were not present in Shea Lake, it could suggest that the dissolved oxygen is too low to sustain them or because the substrate lacks heterogeneity. Amaral et al (2015) found that EPT richness and abundance increased in waters with higher oxygenation and substrate heterogeneity. It makes sense EPT were not present at Shea Lake because the bottom substrate of the littoral zones was soft muck, sometimes up to 5 feet deep. The seven aquatic macroinvertebrates we found in Shea Lake were midge larvae (chironomidae), snails (gastropoda), dragonfly/damselfly larvae (odonata) (Figure 8), scuds (amphipoda), water boatman (hemiptera), isopods, and leeches (hirudinea).

(A)  (B) 

Figure 8: Odonata (A) dragonfly and (B) damselfly larvae in Shea Lake, Kewaunee County.

Fishery

On the evening of May 20, 2009 Shea Lake was electroshocked by the DNR and found that the lake was dominated by Bluegill and Largemouth Bass (Figure 9). Dominance by Bluegill and Largemouth Bass is not surprising because Shea Lake is relatively shallow and has an extensive shallow littoral zone with aquatic vegetation. Bluegills commonly nest in water depths of 0.2 m to 1.2 m and Largemouth Bass commonly nest in water depths between 0.3 m and 1.3 m. Both fish species prefer warm water and prefer to nest in gravel or sand, which is not particularly abundant in Shea Lake. Additionally, both species prefer sparsely vegetated areas for nesting, which is abundant at Shea Lake and may contribute to survival during early life stages. Bluegill are a preferred prey for Largemouth Bass which no doubt contributes to their sustained population, however, diminished water clarity at Shea Lake may inhibit predation because Largemouth Bass typically feed by sight. The Largemouth Bass in Shea Lake tend to be middle-aged and seldom reach the 7^{th} age class. During the electroshock fishing in 2009 no Largemouth Bass in the age classes 1 or 2 were captured, which indicates that either the younger fish were not present in the area of the electroshock or that there is a failure in early life stages or reproduction (Figure 10).

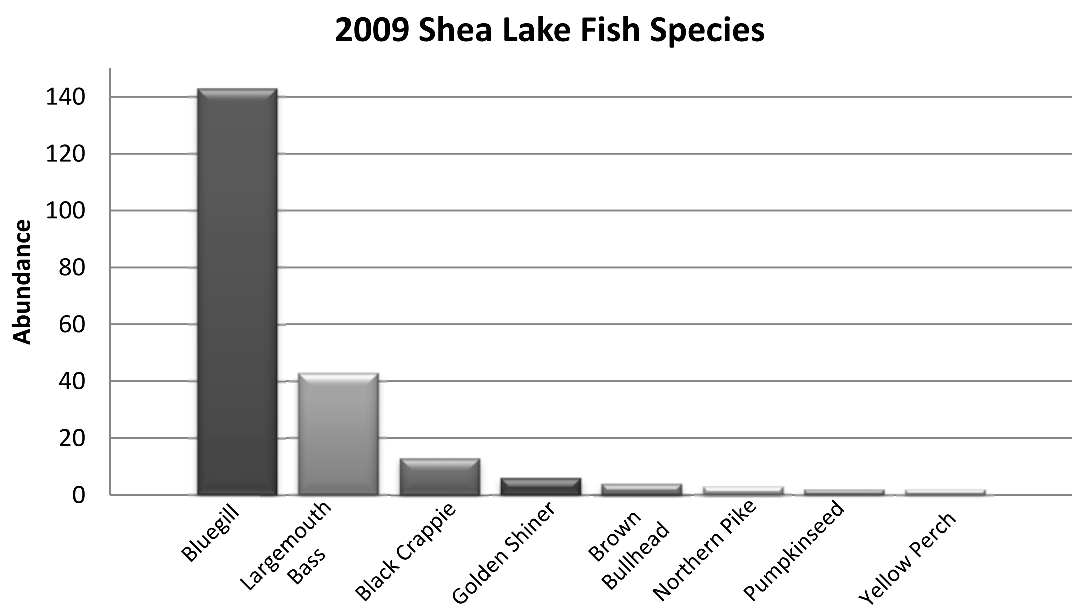

Figure 9: 2009 species diversity of fish in Shea Lake. There were eight species observed during the surveys but Bluegill was clearly the most abundant.

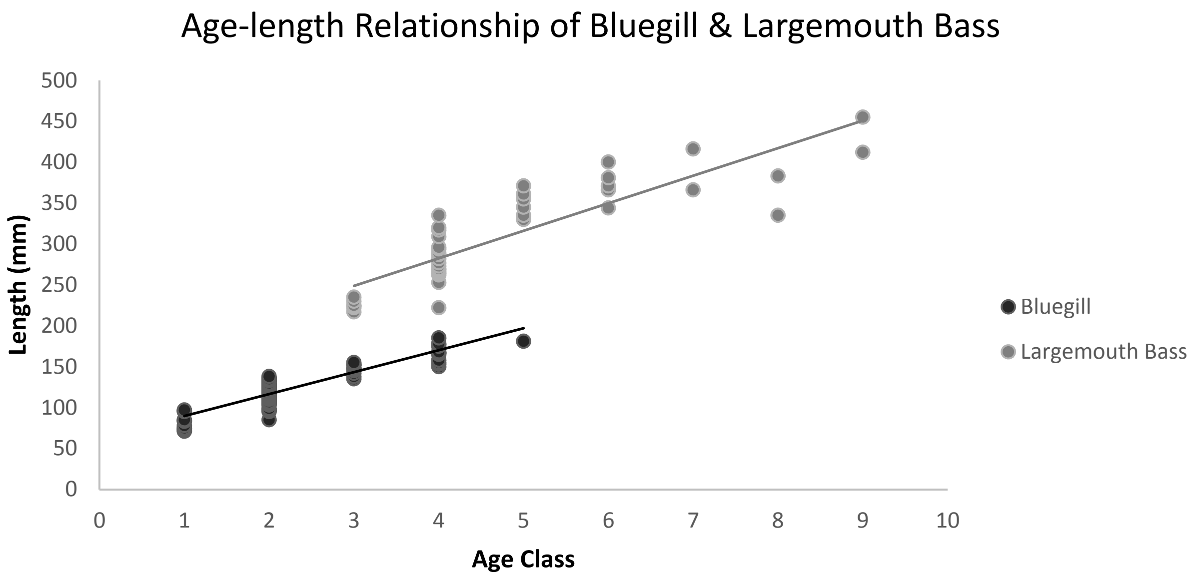

Figure 10: Bluegills have a relatively uniform correlation between age and length. Largemouth bass have more variation between age and length, which may be attributed to a difference in sex or available prey the fish are able to consume; females tend to be larger than males and eat their prey whole. If older populations tend to have more males than females or adequately sized food is unavailable to older bass their size will be restricted. Note the lack of largemouth bass in age classes 1 and 2.

Aquatic Plants

Shea Lake contains a number of aquatic plants that are important to the lake's ecosystem. Most of these plants are commonly found in Wisconsin, and they play a vital role in the chemical, physical, and biological components of the lake. They help to create habitat for terrestrial and aquatic organisms, balance nutrients, and serve as an important food source for many species. The plants we found in Shea Lake include: Coontail (*Ceratophyllum demersum*), Muskgrass *(Nitella*), White Water Lily (*Nymphaea odorata),* Lesser Duckweed (*Lemna minor),* Softstem Bulrush (*Schoenoplectus tabernaemontani)*, and filamentous algae.

All of these aquatic plants serve an important purpose in some fashion. Coontail has continued growth throughout the year, including the cold seasons, so it is a vital food and habitat source for fish and other wildlife. Ducks and geese feed on it during the warm months, and it is an ideal habitat for aquatic and terrestrial insects. Although it is a valuable plant for a lake ecosystem, it can sometimes grow to nuisance levels. Duckweed is another plant that frequently grows to nuisance levels. This free-floating perennial plant is an indicator of water that is of less-than-average quality. If Lesser Duckweed is overabundant on a lake, oxygen exchange can be inhibited and it can also block sunlight needed for photosynthesis in other plants. As far as Shea Lake is concerned, Lesser Duckweed does not seem to be affected by it in an uncontrollable manner. Filamentous algae is similar to Lesser Duckweed in the way that it can quickly become overabundant under the right conditions and can contribute significantly to fish kills. Again, although Shea Lake contains this algae, it is not a significant problem for the lake at this time. Filamentous algae can be beneficial as a food source for fish, aquatic and terrestrial invertebrates, and protozoans. Muskgrass, another plant that is an important food source for waterfowl, grows abundantly in Shea Lake. It helps to stabilize sediments at the bottom of the lake, which helps to combat muddy water. This plant is indicative of acidic water with soft sediments, both characteristics of Shea Lake.

Two very important plants that are found on Shea Lake are the White Water Lily (Figure 11) and Softstem Bulrush (Figure 12). The lily provides pristine habitat for Largemouth Bass and panfish and the Bulrush provides cover and nesting habitat for waterfowl. Waterfowl also eat the seeds of White Water Lilies. Both plants are important for erosion prevention and help stabilize banks. Shea Lake has an extremely mucky bottom and is unstable along most shoreline areas, making White Water Lilies and Softstem Bulrush an important component of the ecosystem.

Aquatic plants are sometimes negatively perceived because they can interfere with swimming or recreation, make areas inaccessible by boat, or make a lake aesthetically unpleasant. However, when they are managed correctly they are biologically indispensable to a lake and are necessary for an aquatic ecosystem to thrive.

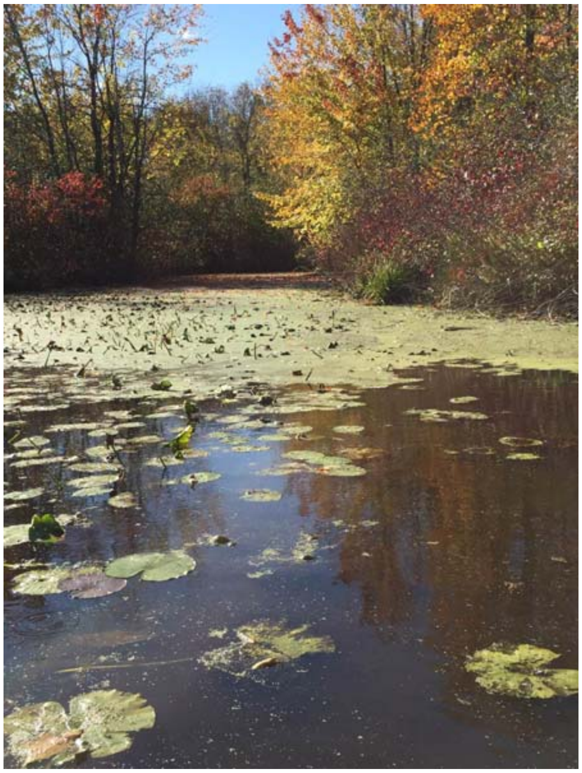

Figure 11: White Water Lily (*Nymphaea odorata)* in Shea Lake, Kewaunee County. White Water Lily dominates the west littoral area of the lake.

Figure 12: Softstem Bulrush (*Schoenoplectus tabernaemontani)* in Shea Lake, Kewaunee County. Bulrush dominates the northern edge of the lake but can be found throughout the shoreline.

Methods

Sampling Dates

The sampling team collected samples from 12 points across Shea Lake on two different days: September 28, 2015 and October 12, 2015. Samples 1-6 were collected on September 28 and samples 7-12 were collected on October 12. Wind patterns for the two days varied slightly; September 12 had an average western wind speed of 14 mph, maximum wind speed of 31 mph, and gusts of up to 40 mph; September 28 had an average southwest wind speed of 6 mph, maximum speed of 17 mph, and gusts of up to 22 mph. Air temperatures were slightly above average but roughly the same for both days—fluctuating near 70°F. Precipitation was negligible both days, each recording less than 0.1 inches.

Water Quality Parameters

At each location, an array of different samples were collected including: surface water, zooplankton, benthic samples using a 50-pound ponar, and various water specifications using a Hydrolab Quanta monitoring system (temperature, specific conductance, dissolved oxygen, pH, oxidation reduction potential, and total dissolved solids).

Surface water was collected by submerging a Nalgene bottle and capping it while it was still below the surface to ensure that additional oxygen was not introduced to the sample. From these water samples the team measured orthophosphate using Hach's orthophosphate test kit PO-19, which measures both dissolved and suspended orthophosphate. The kit uses ascorbic acid as a reagent, which turns the sample blue in proportion of the amount of orthophosphate in the sample. The team performed the mid-range detection test (0 to 5 mg/L) on three of the twelve samples because of time constraints. The kit had two tubes, both of which were filled with 5 mL of the collected surface water sample. One tube was inserted into a viewing chamber provided with the kit and the other tube received the ascorbic acid powder and then inserted in the viewing chamber next to the other tube. If phosphate is detected the ascorbic acid sample will turn blue. By using a color comparator wheel on the two samples, the user obtains a reading from the viewing chamber, which is then divided by 10 to obtain the mg/L phosphate.

Alkalinity was measured with the same surface water samples using the Hach alkalinity test kit AL-DT. The team used the kit-provided digital titrator and sulfuric acid to directly measure carbonate, bicarbonate and hydroxide. 100 mL of surface water was placed in a 250-mL Erienmeyer flask. The reagent package (containing Phenolphthalein) provided with the kit was added to the sample and the titration tube was inserted. The delivery knob on the digital titrator was turned 5 mL at a time, swirled, and repeated until the solution began to turn light pink. At that point, sulfuric acid was titrated at 1 mL until the solution turned and remained light pink. The amount of sulfuric acid added was recorded from the digital counter window. This number was then multiplied by 1.0, which is the multiplier digit provided with the kit and takes into account the sample dilution and titrant strength.

Two LED meters gathered physical characteristics of Shea Lake. One person deployed the meters simultaneously to ensure both diodes were at equal height in the water column and read the measurements to a separate person who recorded the data. Suspected deviations in dissolved oxygen measurements, likely due to calibration issues with the primary meter's reader, warranted the use of a secondary meter; other parameters measured with this meter—temperature, ORP, and TDS—may be skewed as well. The trends that can be inferred from the measurements are still accurate, however, and should not be discounted. The discrepancy in depths for point 6 samples is due to the effect of high winds during sampling; the team was unable to keep the boat centered over the original sampling location and the sampling meter was influenced by increased wave activity. The temperature ranges of profiles were mapped in ArcGIS using an interpolation to show the distribution of surface water temperature (Appendix A- Figure 13) and bottom water temperature (Appendix A- Figure 14) across all sampling points. Depth ranges were also mapped and interpolated across all sampling points (Appendix A- Figure 15).

Zooplankton

Zooplankton was collected by towing a 63-micrometer net through the water column. Attached to the bottom of the net was a wide-mouthed jar, which collected the filtered plankton from the water. The contents of the wide-mouthed jar were filtered through a 20-micrometer funnel into a smaller collection jar. The sides of the funnel and the filter were rinsed with deionized water to ensure capture of all specimens. The resulting collection was labeled with Rite-in-the-Rain paper and placed inside a glass jar with the sample. The jars were filled with ethanol to preserve the organisms until analysis. Laboratory analysis began by inverting the jars to homogenize the samples and decanting 100 mL into a beaker. From the beaker, 10 mL was immediately pipetted and placed in a petri dish for analysis under a Bausch & Laumb specimen scope. Zooplankton densities may have been influenced by high winds on October 12. Measurements of zooplankton size were not taken during the sample analysis. The abundances of zooplankton across sampling points were mapped in ArcGIS using an interpolation to show the distribution of organisms (Figure 6).

Macroinvertebrates

Using an aquatic d-framed dip net, we found seven different types of aquatic macroinvertebrates on the shores of Shea Lake. The seven aquatic macroinvertebrates we found were midge larvae (chironomidae), snails (gastropoda), dragonfly/damselfly larvae (odonata) (Figure 8), scuds (amphipoda), water boatman (hemiptera), isopods, and leeches (hirudinea). Since we only recorded the presence of the different types of aquatic macroinvertebrates we found at Shea Lake, we were unable to run any statistical analyses. Although we did not record the abundance, the presence of aquatic macroinvertebrates are still important for inferring the quality of Shea Lake.

Benthic samples from points 1, 2, 4, and 5 were collected via 50-pound ponar grab. The sediment from the ponar was placed on a metal sorting tray and a one gallon ziplock freezer bag was filled with the sample. The samples were immediately frozen to preserve the sample. Laboratory analysis of the benthic samples revealed the presence of no organisms. Exoskeleton-like structures, approximately 5 mm in length, were common in the samples and may have belonged to worms.

Fishery Data

Fish data for 2009 was provided by the DNR by Steven Hogler, a Wisconsin State fisheries biologist. Mr. Hogler reports that electroshocking and Seine Hauls surveys were conducted in conjunction with the data he provided the research team.

Implementation Plan

Aquatic Plants

Aquatic plants growing in ponds and lakes are beneficial for fish and wildlife. They provide food, dissolved oxygen, and spawning and nesting habitat for fish and waterfowl. They also trap excessive nutrients and detoxify chemicals. However, dense growths of algae and plants can seriously interfere with pond recreation and threaten aquatic life. Aquatic plants can restrict swimming, boating, fishing, and other water sports. Through photosynthesis, plants produce oxygen during the daytime but consume oxygen at night, therefore dense growths of plants can cause nighttime oxygen depletion and fish kills.

Different types of aquatic plants (algae, floating-leaf plants, emergent plants, and submersed plants) require different treatments (Helfrich et al. 2009). Selection of the best treatment or combination of treatments depends on the species of aquatic plant and also the local environment. Depending on the type of weed and the severity of the problem, one or a combination of the following control methods can be very effective:

- Dredge and deepen the lake
- Harvest (manual or mechanical removal) weeds
- Manipulate water levels
- Shade, dye
- Install pond bottom liners
- Use biological controls
- Use chemical controls

Fishery

As winter fish kills are a major problem in this lake, the implementation of an aeration system may be very beneficial. The aeration system would better circulate the water, keeping it from freezing and keeping the fish alive over winter. Any potential future winter aeration program would probably need to continue indefinitely, and it would be helpful to take dissolved oxygen readings frequently throughout the winter. Another future project could involve a fish manipulation plan in an attempt to improve water clarity. Increasing gamefish with stocking and removing panfish by netting could help to restructure the fish community. Then, maintaining channels through the aquatic vegetation would allow gamefish better access to panfish and aid in sustaining panfish control.

Several strategies are available to provide fishing enjoyment in small lakes, but goals must be realistic. Due to the relatively small size of Shea Lake, it could not be productive enough to maintain large numbers of big, healthy game fish to be harvested year after year, such as Northern Pike (*Esox lucius*), Muskellunge (*Esox masquinongy*) and Walleye (*Stizostedion vitreum*). It is possible to have lower numbers of such gamefish, but it is likely that the top predators in this system will remain Largemouth Bass (Micropterus salmoides). From an ecosystem perspective, it is important to keep the system in balance by having enough shiners and other minnows (family Cyprinidae), Bluegill sunfish and other sunfish (*Lepomis* spp.), and also enough gamefish such as bass (*Micropterus* spp.).

Shiners and other Minnows (family Cyprinidae)

Minnows are usually stocked to serve as forage fish for game species. Minnows are also commonly sold and used as live bait; many ponds and lakes have been inadvertently stocked by the release of bait fish. Most minnows eat microcrustaceans and insects, and some eat just about anything they come into contact with (such as Fathead minnows). Fathead minnows (Pimephales promelas) are considered an opportunist feeder. They eat algae, protozoa (like ameba), plant matter, insects (adults and larvae), rotifers, and copepods. The Golden shiner (*Notemigonus chrysoleucas*) has a very high tolerance of turbidity and high temperatures and therefore is a good forage fish to have in shallow water ponds and lakes.

Bluegill sunfish and other sunfish (Lepomis spp.)

As juveniles, most sunfish feed on zooplankton, gradually switching to a diet of small insects. Pumpkinseeds (*Lepomis gibbosus*) have special pharyngeal crushing teeth that allow them to prey on small crustaceans such as snails and clams. Bluegills mature at age 1 or 2 and have high fecundity; sometimes more than one brood per year is possible. Males clear small depressions to make nests, which they guard from predators. Sunfish can grow to 8 inches or more, but rarely do so because of stunting when they become overpopulated. Young sunfish serve as forage fish for Largemouth Bass and other predator fish.

Largemouth Bass and other bass (Micropterus spp., etc.)

Probably the most widely distributed and popular warm water sport fish in Wisconsin is the Largemouth Bass (Micropterus salmoides). Largemouth Bass regularly grow to 12 inches in length and sometimes up to 28 inches (usually only in larger lakes). A 12-inch fish weighs approximately one pound, though they have the potential to grow much larger (state record fish from Wisconsin is 11 lbs.). As juveniles, they feed on zooplankton and insects, adding fish to the diet as soon as they become large enough to engulf and swallow them. Similar to sunfish in their spawning habits, the male Largemouth Bass clears a nest into which the female may deposit 10,000 eggs or more. They become sexually mature at age 2 or 3. Other bass, such as the Rock Bass (Ambloplites rupestris) and Smallmouth Bass (Micropterus dolomieu), are not stocked very frequently because of their smaller size and lower tolerance for muddy, weedy ponds.

Having a variety of species from each of these classes of fish, all with established populations in Shea Lake, would be the optimal situation for maintaining a small, healthy freshwater lake ecosystem.

Habitat Protection

Establishing a fine balance between species and classes of fish will only occur if fish have the habitat necessary to spawn and grow. In general, fish need spawning areas with a firm bottom of sand, mud or gravel, beds of rooted aquatic weeds or other heavy cover to provide protection from predators, adequate dissolved oxygen, and reasonably clear water. It is important that landowners and the state protect these kinds of habitats in a number of ways.

Shore-land zoning regulations restrict shoreline development that might cause pollution in the watershed. Effluent from land development contributes to eutrophication, which decreases water clarity and dissolved oxygen. The DNR requires landowners to obtain a permit before developing, or removing aquatic weeds that provide cover for spawning, nursery areas and feeding. Various state laws also prohibit or limit various kinds of industrial or sewage-plant pollution that deprive fish of oxygen or poison them. Other forms of pollution such as soil erosion, pesticide runoff from farmland, manure runoff from feedlots, and storm runoff from city streets and lawns also consume oxygen and contribute to algae blooms and other signs of eutrophication. These "nonpoint sources" of pollution are extremely tough to correct but should be regulated as much as possible in the Shea Lake watershed.

Appendix A

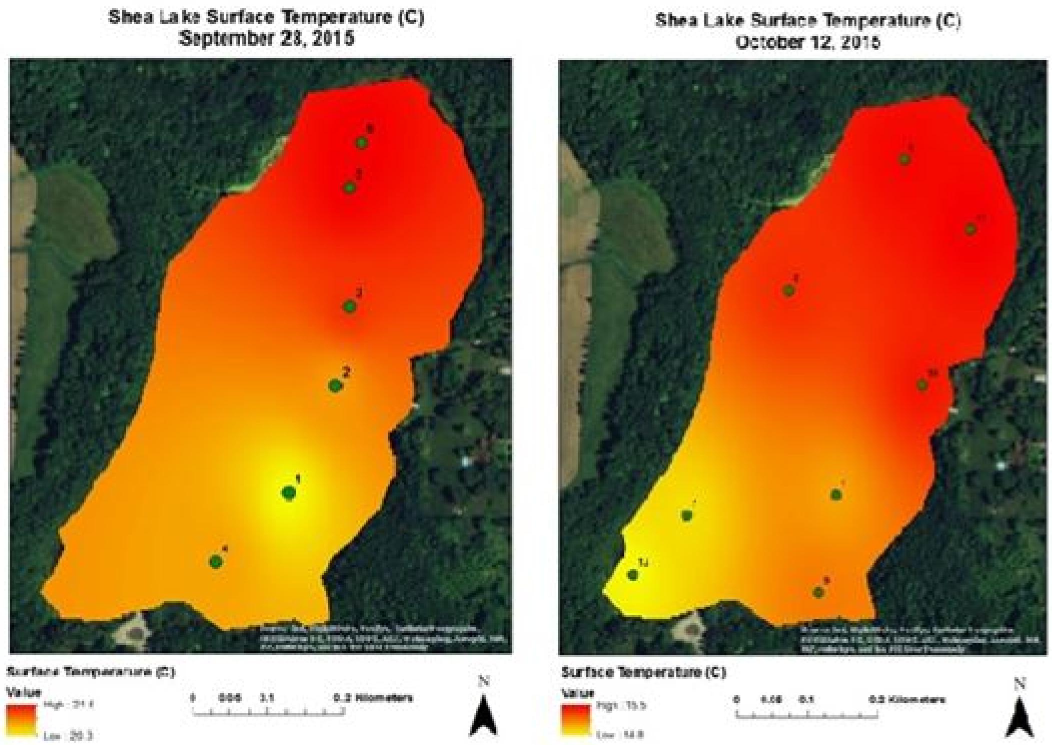

Figure 13: Surface water temperature (Degrees C) in Shea Lake, Kewaunee County, on September 28, 2015 and October 12, 2015.

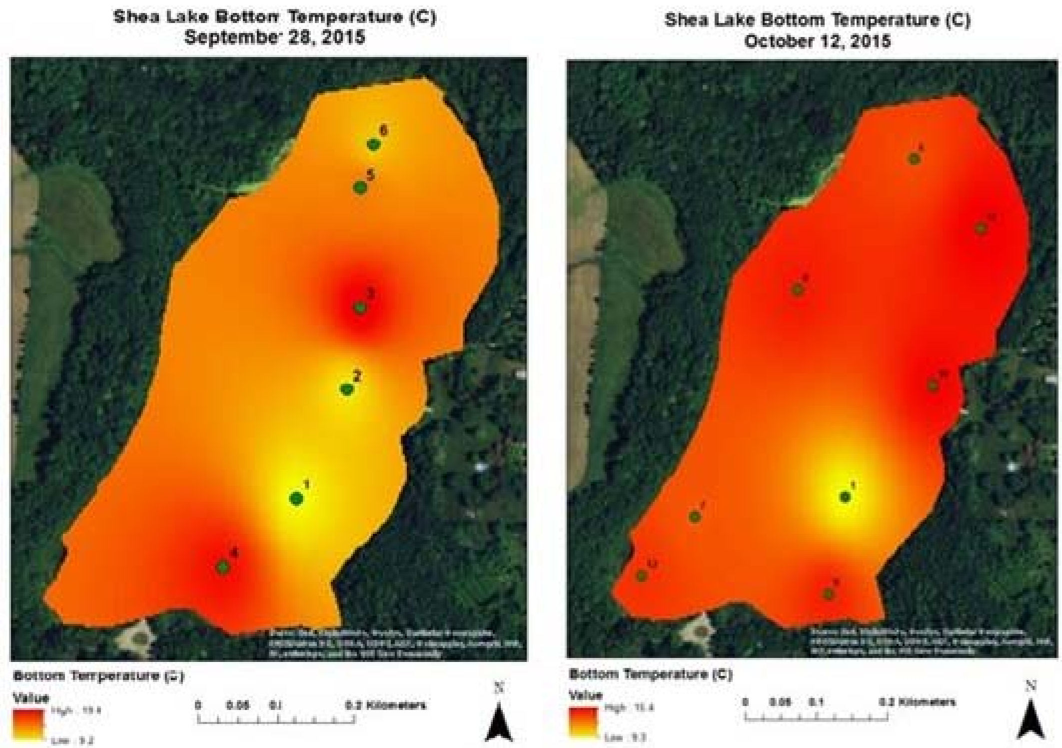

Figure 14: Bottom water temperature (Degrees C) in Shea Lake, Kewaunee County, on September 28, 2015 and October 12, 2015.

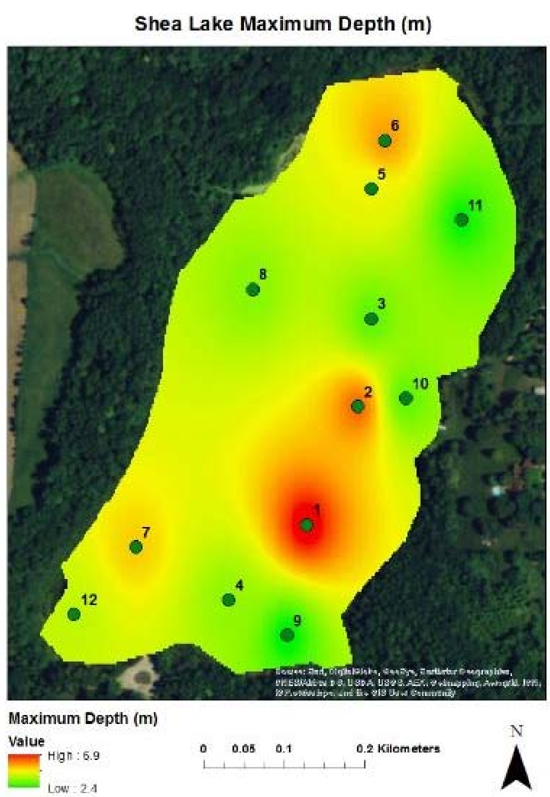

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Figure 15: Maximum depth (m) in Shea Lake, Kewaunee County.

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