DRAFT Management Update for Kinderhook Lake, Columbia County, NY

Amanda Setteducate

Biology Department and Biological Field Station, State University of New York College at Oneonta, NY 13820

Executive Summary

Background

Kinderhook Lake, is a small, public waterbody spanning multiple towns in Columbia County, NY. Locally, it is a popular location for boating and fishing during the open water season. The lake is drawn down during winter months to prevent damage to the shoreline and docks. The Kinderhook Lake Corporation contacted the State University of New York at Oneonta, about the possibility of updating the management plan for the lake. In response to this need, I prepared an interim plan that can serve as a stand-alone document or be used to update the existing management plan for Kinderhook Lake. As part of this work, I i) conducted meetings and public opinion surveys to gauge stakeholder concerns, ii) analyzed land use and soils data in the watershed to determine potential sources of nutrients, iii) measured limnological parameters and nutrients in the lake to better understand trophic status, iv) conducted aquatic plant surveys to document presence and absence of submerged plants, and v) analyzed historical fisheries data for the lake from the New York State Department of Environmental Conservation.

Preliminary Stakeholder Input

Individual interviews were initially conducted with individual stakeholders to determine obvious concerns associated with the management of Kinderhook Lake. I attended a Kinderhook Lake Corporation board meeting to widen my perspectives about stakeholder concerns during fall 2018. Finally, I created and distributed a short survey to residents of the Kinderhook Lake watershed to collect information about perceptions related to particular management issues, and to verify that the larger stakeholder group aligned with smaller groups of involved citizens. A total of 130 surveys were completed, allowing for some confidence in results. The primary finding of this survey was that invasive plants and harmful algal blooms were the most prominent concerns associated with Kinderhook Lake.

Watershed use and soils

Land use and soil suitability for various uses are important in determining expectations for many lake management techniques, and can offer valuable perspective with minimal capital investment. I analyzed publically available data sources to classify major land use types, their distributions, and abundances in the Kinderhook Lake watershed. I also compiled information about soil septic suitability ratings (USDA 2017) to characterize landscape suitability for conventional septic systems. Most of the Kinderhook Lake watershed is forested lands. There is some agriculture at the north end of the lake in proximity to the inlet. Most of the Kinderhook Lake watershed was classified as “very limited” in soil suitability for septic systems, as is common in NY. This indicates that these soils may be prone to nutrient leakage from leach fields, and that extensive modification to the soils would be needed to make them suitable.

Water Quality

Kinderhook Lake appears to experience high rates of external nutrient loading from the watershed, specifically phosphorus. The highest concentration of phosphorus was found at the inlet, indicating that this may be a major source of nutrients from the surrounding landscape. The highly productive (eutrophic) lake experiences anoxia in the hypolimnion in summer through the end of the growing season, and mixes fully during fall. Turnover appears to be relatively unaffected by winter drawdown, and the water column becomes homogeneous in terms of temperature and dissolved oxygen. Nutrient concentrations have been variable, but consistently high since 2002, and water clarity (measured as Secchi depth) has decreased consistently since 1982.

Macrophyte Survey

A brief presence-absence survey was conducted to qualitatively assess the aquatic plant community in Kinderhook Lake during October 2018. The majority of the macrophyte community at that time was composed of invasive Eurasian watermilfoil (*Myriophyllum spicatum*), and what appeared to be a small population of invasive water chestnut (*Trapa natans*). Multiple native plants were also observed in lower densities, including water lilies and duckweed, and wetland plants found primarily at the inlets.

Current management strategies

Currently, Kinderhook Lake management strategies include weed harvesting and hand pulling to reduce invasive macrophytes, copper sulfate to reduce harmful algal blooms, and drawdown to reduce shoreline erosion.

1. Introduction

1.1 Kinderhook Lake

Kinderhook Lake is a public lake that spans across the towns of Kinderhook, Chatham, and Niverville in Columbia County, New York. As a small, natural lake with a local history dating back to the 1600s, the current elevation of Kinderhook Lake was raised by several feet following the construction of a grist mill in the early 1800s. At 375 acres in area, it has a maximum depth of 32 feet and an average depth of approximately 7 to 8 feet (KLC). The lake has one primary inlet, the Valatie Kill, which extends north to Pikes Pond near the edge of the watershed at Bailey Mountain. The Valatie Kill flows through Nassau Lake, in the Town of Nassau, NY, before reaching Kinderhook Lake. A second, smaller inlet flows from a small pond into Kinderhook Lake. The lake has a single outlet, the Valatie Kill, which flows out of the lake through the dam at the southern end.

The watershed associated with Kinderhook Lake is 24,805 acres, located in Columbia and Rensselaer counties in New York. This results in very large watershed-to-lake area ratio (66:1), which indicates that even under natural conditions Kinderhook Lake is expected to have a highly productive (eutrophic) status. Most of the watershed associated with Kinderhook Lake is forested and agriculture lands, but there is some private, residential development around the lake (Fig 1). Columbia County has a median household income about $59,916 while Rensselaer has a median household income of $61,754. Both Columbia and Rensselaer counties have median household incomes that are below the New York State median of $62,909 (US Census).

Since settlement of the area, Kinderhook Lake has been a locally popular destination for recreation, starting with the creation of Electric Park in the early 1900s. Today, the lake is used for a variety of purposes, including swimming, boating, and fishing. The lake is managed by the Kinderhook Lake Corporation and the New York State Department of Environmental Conservation (NYSDEC). The Kinderhook Lake Corporation (KLC), a 501(c)(3) non-profit organization, was created in 1953 by area volunteers and the (then) Kinderhook Lake Improvement Association to purchase the grist mill dam and the bottom of the lake following dam failure. The KLC has been successful in raising significant capital used for lake and dam improvements over the years, largely through support from membership dues and donations. In the last two decades alone, the KLC has raised more than $300,000 to support dam maintenance and aquatic plant and algae management.

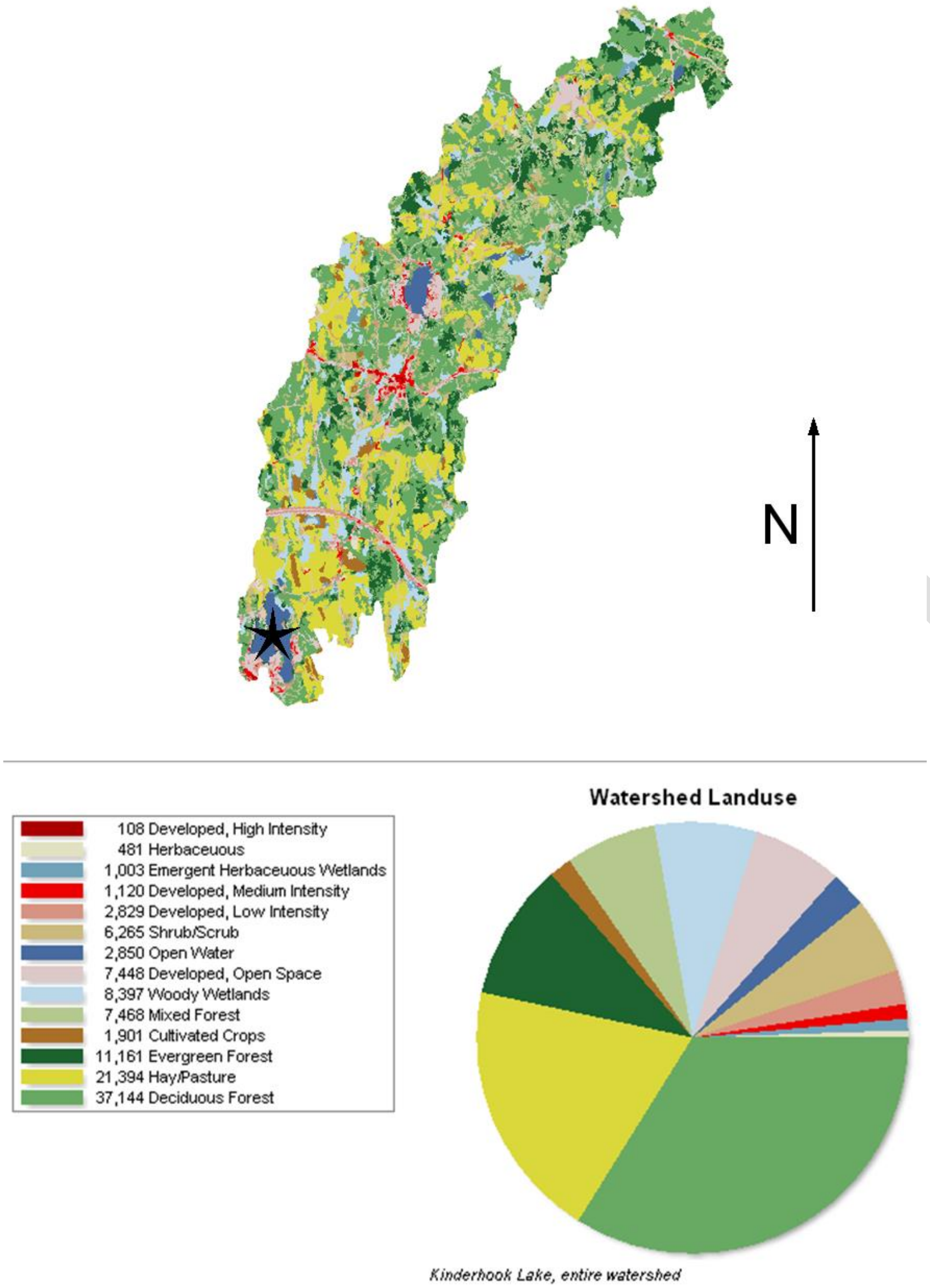

Fig 1 Composition of land use within the Kinderhook Lake watershed (top) and the percentage of the total watershed comprising each land use category (bottom). Map data from USGS (2011).

1.2 Management background

Kinderhook Lake has had management plans in place since 1997, with updates every two to three years (Kinderhook Lake Corporation [KLC], personal communication). In recent years, harmful algal blooms (HABs) comprising blue-green algae, have become a significant impediment to use of the resource. Kinderhook Lake has been treated with copper sulfate to control toxin-containing blooms. This method has been mostly successful when the treatments are applied, but the blooms continue after August in some years, when copper sulfate is no longer applied for the year (KLC, personal communication). For a time, copper sulfate was used in conjunction with aluminum sulfate added to the Valatie Kill (the inlet), until aluminum sulfate was later designated as a non-registered pesticide in New York.

Excessive aquatic plant growth in the lake has also been a prominent management concern in recent years, as nuisance abundance of plants can interfere with desired uses such as swimming, boating, and fishing. The primary plants of concern in the lake are two invasive species, Eurasian watermilfoil (*Myriophyllum* spicatum), and water chestnut (*Trapa* natans). In 2016, about 70 acres of aquatic plants were documented, primarily comprising Eurasian watermilfoil, water chestnut, and curly leaf pondweed (*Potemogeton crispus*), which also is an invasive species.

Eurasian watermilfoil has the potential to outcompete native plants by forming dense mats that reach the surface in shallow water, and is difficult to control because it can spread through fragmentation as well as through sexual reproduction (seeds). The KLC has raised funds to purchase a mechanical harvester to physically remove Eurasian milfoil from the lake, and is already permitted to do so for water chestnut through NYSDEC. The permit allows harvesting in about 40 acres of navigation channel. In addition to these efforts, annual drawdown (about 4.5 ft) is also thought to reduce Eurasian watermilfoil propagule pressure by freezing sediments in large areas of the littoral zone. Water chestnut was pulled by hand on multiple occasions (Langer 2018), and has been managed using a mechanical cutter in the past. At one point, floating bog islands that were considered a nuisance to power boaters on Kinderhook Lake were removed by hand and with tools by the residents surrounding the lake. While Kinderhook Lake is public, with public boating access, the only boat sanitation management performed was public education about the possible effects of invasive organisms introduced by watercraft in the form of newsletters, social media posts, and website pages.

Due to fluctuating water levels, shoreline maintenance is an ongoing management process at the lake. Timber and concrete barriers have been constructed along shorelines by residents and the KLC to reduce shoreline erosion (KLC, personal communication). However, in recent years this practice was not continued and the barriers were not repaired as neither private residents nor the KLC has obtained current permits from NYSDEC to maintain them.

1.2.2 Stakeholder concerns

Inclusion of relevant stakeholders in the management of natural resources held in public or private trust has the potential to improve efficacy of management. Stakeholder perceptions are essential for understanding management concerns, and for formulating solutions that will be acceptable. Therefore, it is important to gauge stakeholder perceptions using some combination of in-person meetings and public opinion surveys to understand what are the prominent management issues.

After a personal interview with representatives to the KLC Board and the Water Quality Committee, it was evident that continued harmful algae blooms (HABs) and invasive plant species management were the largest concerns of the board, and the Water Quality Committee. Despite years of copper sulfate treatment, harmful blue-green algae blooms are still prominent when treatment is not being actively applied. Boaters and swimmers have also expressed concern with the large, standing beds of Eurasian milfoil found in the littoral zone of Kinderhook Lake, as well as the occasional growth of water chestnut. One individual emphasized that there are multiple unidentified plants commonly found in the lake, and there is concern that they may be invasive species.

Following initial meetings with KLC Board members, a public opinion survey was designed and distributed to stakeholders, residents, and visitors of Kinderhook Lake. The survey was available on paper, and online using a web-based survey platform. This survey received approximately 130 responses. The majority of responses came from residents that live directly on the lake. The results from the survey provided a wider insight on the concerns of those that utilize Kinderhook Lake for recreation (Fig 2). In general, stakeholder concerns appeared to be consistent with those expressed by the KLC Board and the Water Quality Committee, and the two most prominent concerns related to HABs and invasive plants, followed by concerns related to fishing and boating conditions.

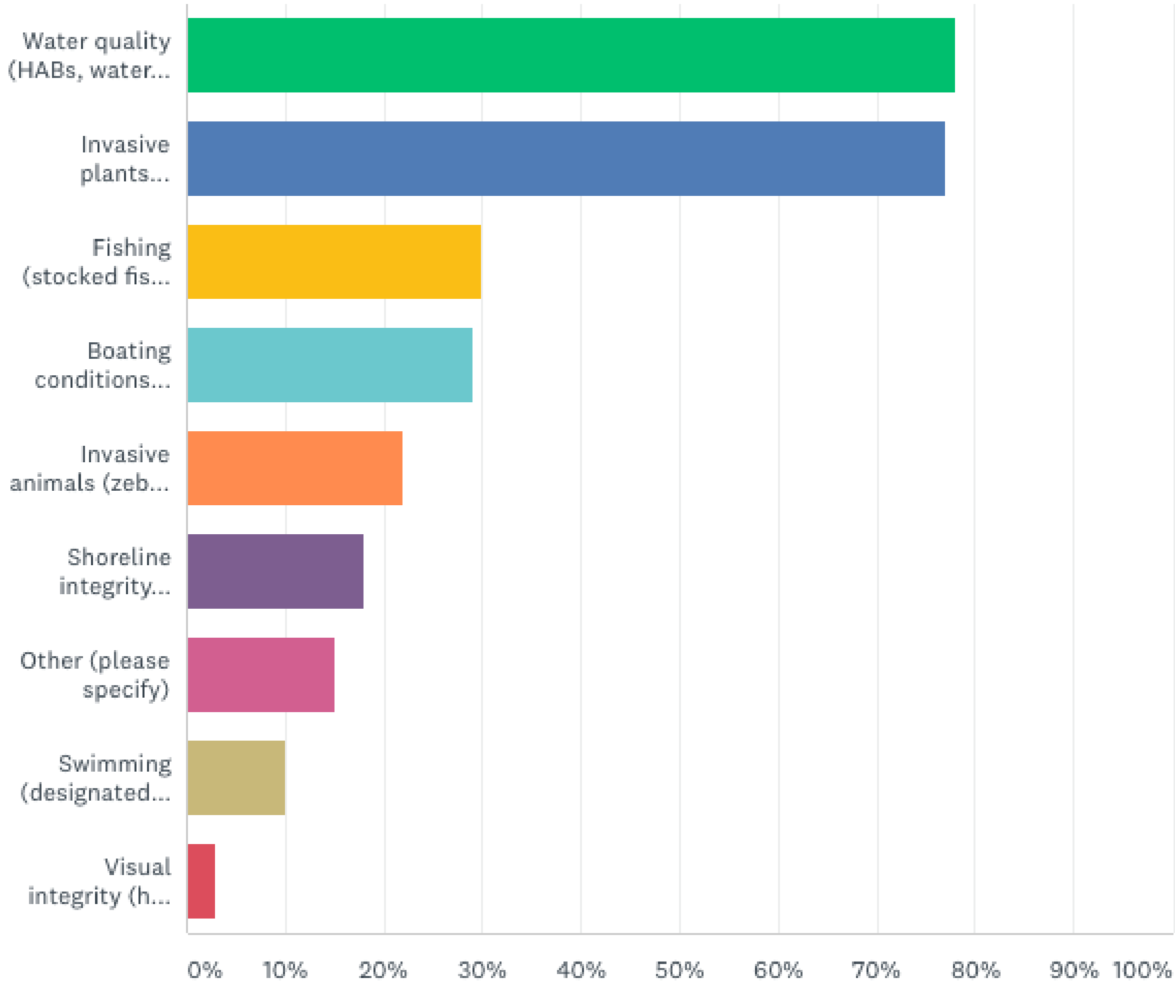

Fig 2 Stakeholder concerns about Kinderhook Lake, ranked. Percentages based on the first 100 survey responses. The top three concerns were water quality, which includes harmful algal blooms, invasive macrophytes, and fishing/boating conditions.

1.3 Goals and Objectives

The goal of this study was to provide information to the Kinderhook Lake Corporation and Water Quality Committee in order to provide updated procedures and methods for the management of Kinderhook Lake so this public access waterbody can continue to be utilized and enjoyed by its residents and visitors. Using prioritized goals determined by KLC board members, Water Quality Committee members, and the stakeholder survey my primary objectives were to i) compile existing plant survey data with an updated 2018 survey to determine the aquatic plant density, abundance, and identification of both native and invasive species, and ii) compare past water nutrient data with an updated 2018 nutrient analysis to examine fluctuations in nutrient input in Kinderhook Lake from various inputs, specifically Nassau Lake and Valatie Kill, that lead to harmful algae blooms. The data from this study combined with historical data and past surveys, studies, and management plants were used to create an updated interim management plan with a focus on harmful algal blooms and invasive macrophyte management.

2. Watershed Soil Susceptibility

2.1 Summary of Physical Geography

Kinderhook Lake has a surface area of approximately 375 acres (KLC). Its associated watershed is 24,378 acres (USGS). This means the watershed area to lake area ratio is approximately 71:1. With such a large ratio, and extensive watershed, it is anticipated that there would be a large amount of nutrient input from the surrounding areas of the lake, even in the absence of anthropogenic influences. A survey indicating the land uses of areas within the watershed can help to understand the condition of Kinderhook Lake and provide insight to any apparent anthropogenic problems (Fig. 1).

2.2 Summary of Soil Information

Upon analyzing the soil constituents within the Kinderhook Lake watershed, there is no one type of soil that dominates the area. The watershed is very large and contains a number of soil types, with no single constituent compromising more than 7.1% of the entire area (USDA). Because the types of soils are so evenly dispersed, what is more important while analyzing the soils within the watershed are characteristics that can influence the lake, such as soil septic suitability.

The watershed draining into Kinderhook Lake is large and contains many residential areas, and thus many septic systems used to treat wastewater. Septic tank absorption fields are the areas around septic tanks where the soil and its associated organisms use natural processes to treat wastewater (Texas A&M). The quality of soils for this use range from “not limited” to “very limited”. A soil described as “not limited” is acceptable to be used as a septic tank absorption field, with little to no modification needed. Soils described as “somewhat limited” or, more severely, “very limited” tend to be prone to nutrient leakage and may require extensive modification to accommodate conventional septic systems. Steep slopes or large rocks can make soils more susceptible to seepage, and shallow depth to the underlying bedrock may not provide an adequate filtration system for the wastewater leaving a septic tank. The vast majority of soils fall into the categories of “very limited” or “somewhat limited” (Fig. 3). Only a small area (0.4%) of watershed is described as “not limited” with respect to soil septic suitability (Table 1).

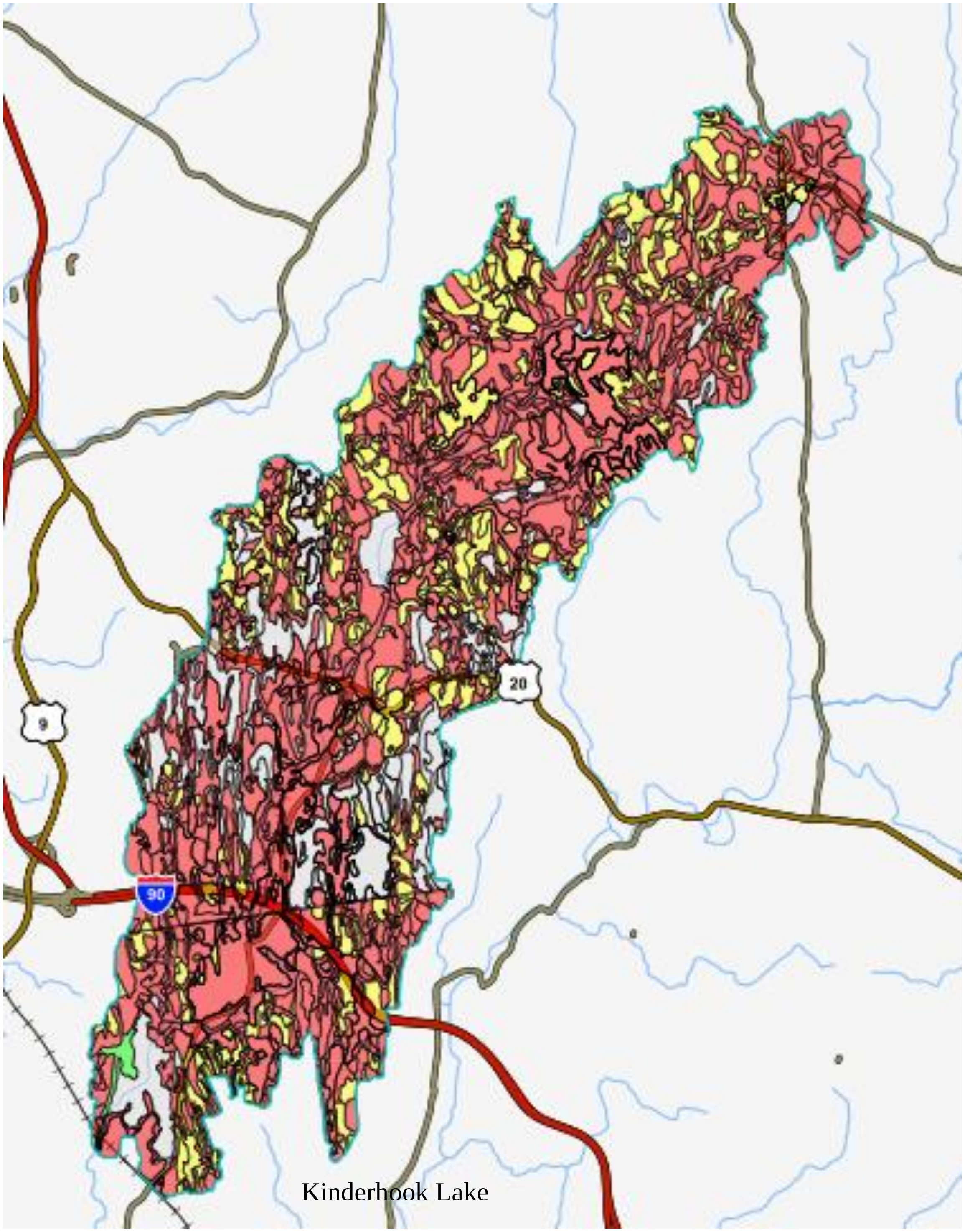

Fig 3 Kinderhook Lake watershed showing soil septic suitability classifications. Red areas indicate “very limited” soil rating. Yellow areas indicate “somewhat limited” soil rating. Green areas indicate “not limited” soil rating. Gray areas indicate water bodies or soils that were not rated (USDA 2017).

Table 1 Summary of soil septic suitability ratings in the watershed (AOI) by acres and percent. The majority of soils within the watershed for Kinderhook Lake are very limited or somewhat limited in regards to septic suitability. The soil constituents within the watershed are high draining and prone to septic leakage, with high levels of nutrients (particularly phosphorus) entering Kinderhook Lake (USDA 2017).

Rating	Acres in AOI	Percent of AOI
Very limited	15,836.5	65.0%
Somewhat limited	4,896.0	20.1%
Not limited	85.4	0.4%
Null or Not Rated	3,560.1	14.6%
Totals for Area of Interest	**24,378.0**	**100.0%**

3 Water Quality

3.1 Introduction

Water quality monitoring is an important part of managing any lake. The water quality of a given waterbody can give insight to what is causing undesirable conditions, or why the lake is thriving. Water quality monitoring includes the measurement of nutrient levels, water clarity, and other factors depending on the specific lake's concerns.

Historically, Kinderhook Lake has participated in the Citizens Statewide Lake Assessment Program (CSLAP) in the years 1997, 1998, 1999, and 2001. Additionally, samples have been submitted for 2018. Kinderhook Lake has historically been considered eutrophic (productive), increasingly so in recent decades.

The goal of this study was to provide an updated report on the limnological conditions and water quality of Kinderhook Lake. With the last CSLAP assessment being done in 2001, information may be outdated and the limnology of the lake may have changed. With studies done in 2018, a secondary goal is to understand the limnological qualities of Kinderhook Lake that lead to the concerns expressed by stakeholders, with an emphasis on invasive Eurasian Water Milfoil and abundant algae. This study will also provide insight to desirable conditions of the lake, such as factors contributing to the absence of invasive zebra mussels despite public access to the lake for boating, which facilitates the spread of these animals.

3.2 Methods

3.2.1 Field Methods

Multiple parameters were measured within the field. Measurements and samples were taken on two separate occasions, October 5th 2018 during late summer stratification, and November 13th 2018, after fall turnover.

To measure physical water quality parameters, a YSI sonde was used on both occasions. YSI sondes house multiple probes to measure depth, temperature, pH, conductivity, and dissolved oxygen. The YSI was lowered into the water column and measurements were taken at specified depths at multiple locations including the inlet, outlet, and deepest basin of Kinderhook Lake. A Secchi disk was used to measure water clarity. The disk is lowered into the water column, and the Secchi depth is the depth at which the observer loses sight of the disk. To collect samples for nutrient analysis, a Kemmerer sampler was used. An open collection unit is lowered to a specified depth, and a weight is dropped to close the unit and collect the water from depth. Samples were taken from the inlet, outlet, and multiple depths at the deepest basin of the lake to analyze phosphorus and nitrogen content.

3.2.2 Lab Methods

Samples taken from Kinderhook Lake were first preserved with H2SO4. To determine the levels of nutrients (phosphorus and nitrogen) within each sample, a Lachat autoanalyzer was used at the SUNY Oneonta Biological Field Station. To determine the level of calcium in Kinderhook Lake, a calcium titration was performed on samples collected after fall turnover.

Historical data

Previously collected data were used to determine changes occurring in Kinderhook Lake over the years. CSLAP data from 1997-2001 were used as a baseline for comparison with 2018 values collected.

3.3 Results

The two 2018 sampling and profiling events displayed different results. Data from the YSI sonde showed distinct summer stratification on the October 5th sampling period with a distinct thermocline at approximately 7 meters with epilimnion temperatures around 17°C and hypolimnion temperatures around 12°C. Kinderhook Lake also experienced hypolimnetic anoxia, or lack of oxygen in the lower layer of the lake, with bottom dissolved oxygen levels reaching as low as 0.47 mg/L. Values below 1 mg/L are considered anoxic. On the November 13th sampling date, there was no thermocline or anoxia observed, and temperature and dissolved oxygen were consistent throughout the water column with averages of 6.6°C and 10.3 mg/L respectively.

The average pH reading on the October 5th sampling date was 7.4, while the average on November 13th was 6.7, both of which fall within suitable New York State levels. Conductivity was consistent throughout the water column on both sampling dates at averages of 0.344 and 0.268 consecutively. Calcium levels were determined to be 12 mg/L. Overall, these parameters seem to be consistent with observations from historical CSLAP monitoring.

Secchi depth on the October 5th sampling date was 1 meter, and 1.5 meters on the November 13th sampling date. The 2018 Secchi depth is shallower than those collected in past CSLAP data, indicating that Kinderhook Lake's water is becoming less clear with time (Fig. 5).

The October 5th sampling yielded nutrient values for inlet, outlet, and pelagic zones of the lake. The inlet sample showed nitrogen levels of 0.34 mg/L and phosphorus levels of 0.110 mg/L. The outlet sample showed nitrogen levels of 0.55 mg/L and phosphorus levels of 0.03 mg/L. The pelagic water column showed an average nitrogen level of 0.45 mg/L and an average phosphorus level of 0.042 mg/L. Past CSLAP data for Kinderhook Lake has shown fluctuating total nitrogen and phosphorus values throughout the period 1982-2018 (fig 4).

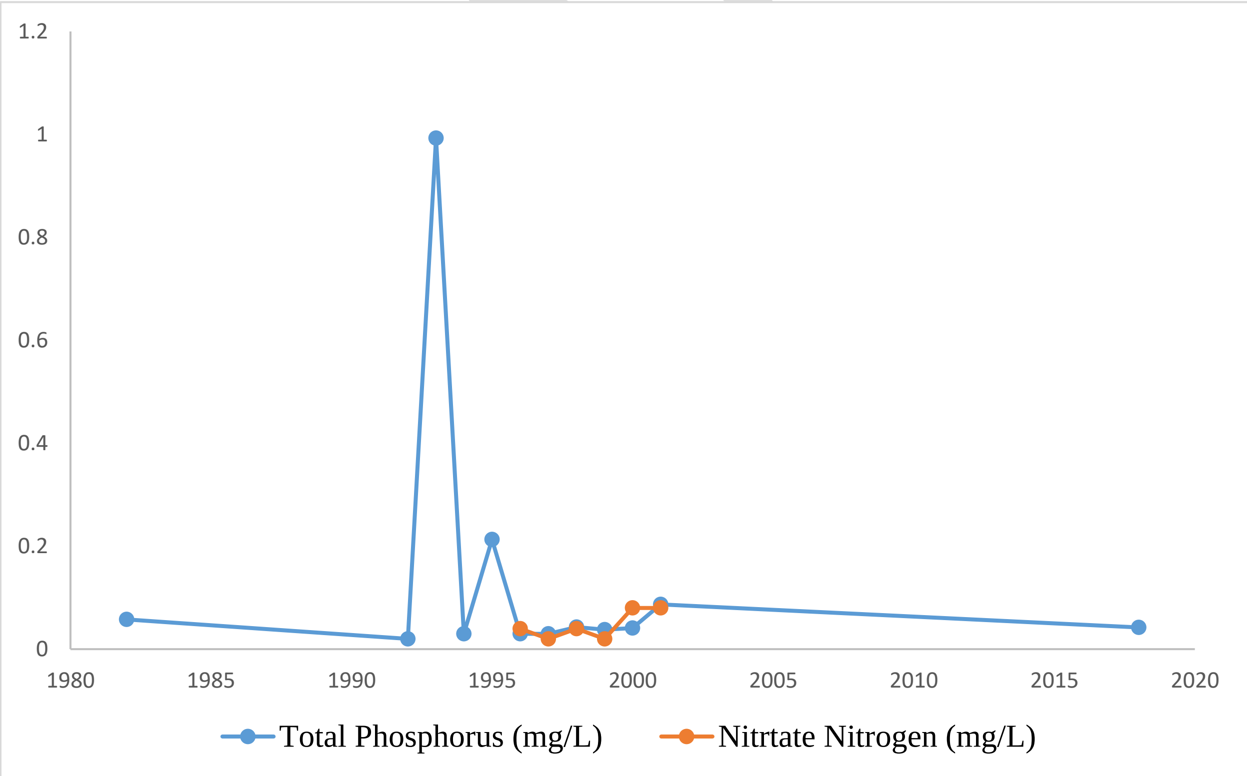

Fig 4 Total phosphorus and nitrogen as NO_3 from historical CSLAP data, with 2018 total phosphorus levels added (NYSDEC 2002).

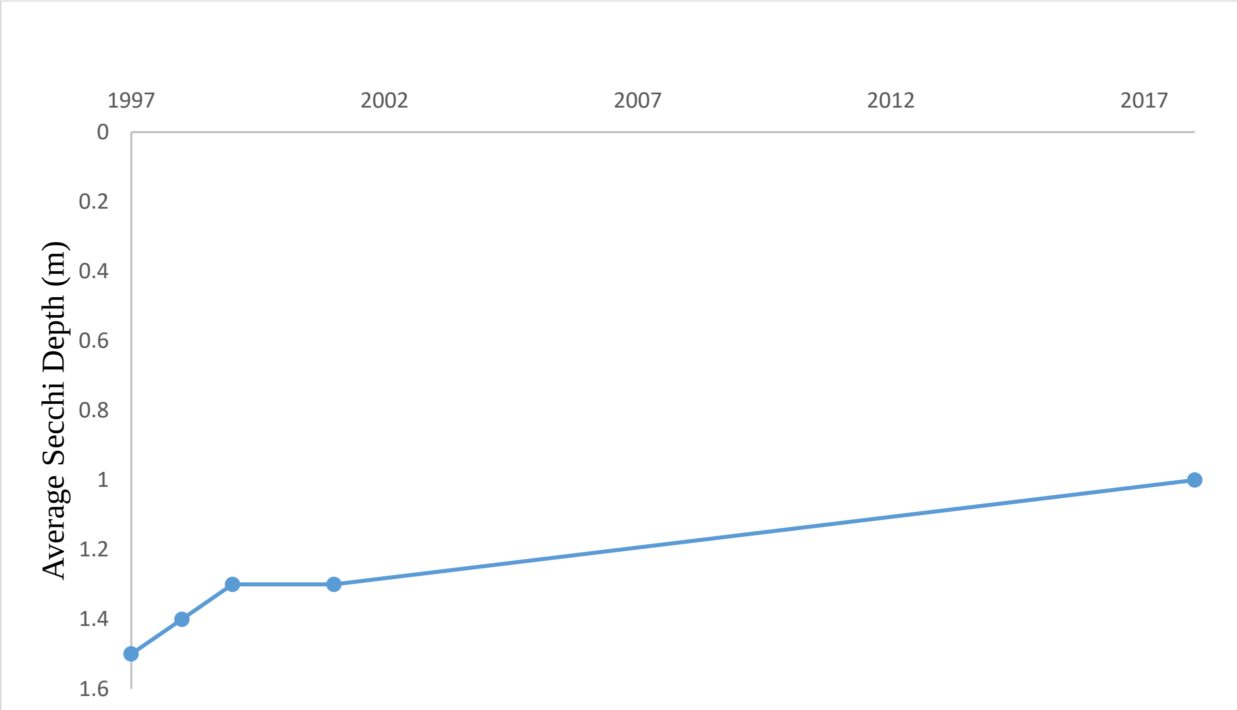

Fig 5 Average Secchi depth according to historical CSLAP data for years 1997-2001, with 2018 measurements added. Average Secchi depth has consistently been decreasing (NYSDEC 2002).

3.4 Discussion

The water quality data collected during this monitoring provide updated information to the stakeholders of Kinderhook Lake for the year 2018, with the last water quality data being collected and analyzed for 2001. This gap in sampling time can allow for many changes to occur to the lake, thus altering the needed management strategies. According to 2018 testing, Kinderhook Lake experiences summer stratification and hypolimnetic anoxia. This is common in eutrophic, nutrient rich lakes in New York. The lake experiences fall mixing between October and November, eliminating the hypolimnetic anoxia and causing dissolved oxygen levels in the lake increase. This mixing event allows fish and other aerobic organisms to survive the winter months, although at this time it is unclear to what degree anoxia occurs during ice cover.

Kinderhook Lake does not currently experience infestations of the invasive zebra mussel. This is unusual for public access lakes in New York that do not require boat sanitation, as zebra mussels are easily transported through boat hulls. The absence of zebra mussels may be due to low ambient calcium levels within the lake. The calcium level in Kinderhook Lake in 2018 was found to be 12 mg/L, while zebra mussels are unable to form calcium carbonate shells below the minimum threshold of 13 mg/L.

Nutrient levels have fluctuated in Kinderhook Lake throughout the years, and these fluctuations may be due to sampling dates. Nutrients are more likely to be higher in summer months when sunlight and temperatures are high. Despite the fluctuations nitrogen and phosphorus levels are consistently high, and both nutrient concentrations and Secchi depth indicate that this is a eutrophic (highly productive) system. The high level of nutrients can facilitate the harmful algal blooms the lake experiences. These algal blooms also contribute to the low Secchi depth in the lake, likely in concert with other factors such as suspended sediment.

To control the main concerns associated with the water quality and nutrient levels of Kinderhook Lake, multiple strategies can be utilized. To target high nutrient levels and subsequent excessive/harmful algal blooms, in-lake treatments such as the currently used copper sulfate should be continued. A special permit from the NYSDEC for aluminum sulfate (alum) use may be approved for Kinderhook Lake if further nutrient profiling is conducted and it is determined phosphorus levels are high enough to be of extreme concern. In addition to in-lake treatment, watershed management can greatly reduce nutrient input into Kinderhook Lake both on large and small scales. Riparian buffers around agricultural land north of the lake inlet can reduce phosphorus runoff from fertilizers and animal waste. Residents that live on the lake can update their septic systems to reduce their nutrient outflow.

4. Macrophyte survey

4.1 Introduction

Macrophytes are an important indication of the state of any body of water. Their presence or absence, abundance, and composition can give insight to other characteristics and conditions of a lake. Changes in macrophyte populations over time can serve as warning signs of potential problems arising. Despite their importance in aquatic ecosystems, excessive plant growth can become a nuisance for both the people who use the lake and the other organisms within the water body if left unchecked. Invasive macrophytes can outcompete natives for light, space, and nutrients. Even overgrowth of native species can become problematic for stakeholders, potentially causing damage to motor boat propellers, and reducing the capacity for recreational uses of a waterbody such as swimming. Plant surveys can provide information needed to analyze the macrophyte community within a lake and help to understand the quality and condition of the body of water being surveyed.

Aquatic plants were among the highest priority concerns in Kinderhook Lake according to responses to the stakeholder survey. While there is information available regarding the primary invasive species of concern, there is little information about native species present in the lake.

The goal of this survey was to provide stakeholders with a current list of aquatic plant species observed in the lake during fall 2018. Identification of invasive species and analysis of the native populations can provide insight to potential management techniques that will work best with Kinderhook Lake without harming desirable native populations. The list of species provided here should be useful in developing future surveys for regular macrophyte monitoring.

4.2 Field Methods

Submerged macrophytes were observed on a presence/absence basis. On the October 5th sampling date, a plant rake was thrown at randomly selected points within Kinderhook Lake, and species collected were observed and recorded (Fig 6). On the November 13th sampling date, post winter drawdown, previously submerged macrophytes along the shoreline were also observed visually.

Fig 6 Plant rake used to collect macrophytes. Line is attached to a point on the watercraft, and rake is tossed into the water. Once the rake has hit the sediment, is it retrieved into the boat and macrophytes collected are observed.

4.3 Results

The October 5th plant rake collection, along with visual observation, indicated qualitatively that invasive Eurasian watermilfoil constituted the vast majority of the macrophyte community in Kinderhook Lake. Two other invasive species that were not recorded on the sampling date, but are known to be historically present in the lake via stakeholder observation and control efforts were curly leaf pondweed and water chestnut (Langer 2018).

Native species that were visually observed during these surveys included yellow water lily (*Nuphar sp.*), white water lily (*Nymphaea sp*.), and duckweed (*Alismatales sp*.) near the wetland inlet of the lake. The November 13th observation of shoreline plants was composed exclusively of Eurasian watermilfoil.

4.4 Discussion

After the macrophyte survey, it is apparent that the macrophyte community in Kinderhook Lake has a large biomass of invasive aquatic plants dominated by Eurasian watermilfoil. The watermilfoil appears to have out-competed most native plants in the waterbody, except for limited populations of some wetland natives near the inlet. On the one hand, this presents a significant challenge to restoring native plant communities in the littoral zone of the waterbody. However, the dominance of invasive species in the macrophyte community also suggests that selectivity of control methods may not be of immediate importance for management because most of the biovolume of submerged plants in the lake are invasive species. This means that the plant community might be efficiently managed, at least initially, through the use of non-selective tools that otherwise can present challenges for retaining native aquatic plants. Examples of such non-selective techniques include mechanical harvesting, broad-spectrum herbicides, or benthic barriers, all of which are discussed further at the end of this document.

Potential risks associated with large-scale removal of invasive macrophytes with dense populations include reduction of fish forage and cover, increased light attenuation that can increase photosynthesis by green algae, and increasing nutrients available for production of bloom-forming cyanobacteria, which are already an issue in Kinderhook Lake. Maintenance of invasive macrophytes must be carefully planned and executed to reduce unintended consequences on other biological communities in the lake that are desirable and that rely on macrophyte populations.

5. Historical Fisheries Analysis

5.1 Introduction

Recreational fisheries are widely utilized throughout the world. These fisheries attract ecotourists to freshwater systems, and can increase property value of lakeside homes by contributing to local economies and state and local taxes. Fish populations can also be indicators of the waterbodies they inhabit. Their absence can be indicative of habitat constraints related to temperature and oxygen, and in extreme cases may even correlate with prolonged pollution or degradation. Likewise, the quality of a recreational fishery can be dependent on the productivity of an aquatic ecosystem. In nutrient poor, oligotrophic systems, oxygen in the water is high and fish populations are abundant, although individual growth may be slow because those systems lack productivity (e.g. nutrients like phosphorus and nitrogen) necessary to promote fast growth. More productive lakes support faster growth and larger abundances of fish. But, these systems are often warmer, and may deplete dissolved oxygen more rapidly than their unproductive counterparts, and fish may be more likely to incur winter kills or recruitment failures in particularly challenging years.

Historically, Kinderhook Lake, NY, has been classified as a eutrophic (highly productive) system as a result of high nutrient concentrations and other limnological qualities. The lake supports popular catch and release fisheries for smallmouth and largemouth bass. The fishery is a publically managed resource, and the lake is publically accessible. As a result, the fishery in Kinderhook Lake has been surveyed in the past by the New York State Department of Environmental Conservation (NYSDEC). These surveys lend themselves to at least some basic understanding of the fish community that can be used in the future management of Kinderhook Lake.

The objective of this study was to use data collected by NYSDEC to understand the recent status of recreational fisheries in Kinderhook Lake, NY. To do this, I analyzed proportional size distribution (PSD) and relative weight of several species to understand the size structure and condition of popular fishes. This analysis of historical data will provide a more detailed discussion of previously collected and reported information.

5.2 Methods

Data were collected from the NYSDEC Statewide Fisheries Database for all previous fisheries surveys available. Size structure and condition of smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*). These species were chosen because they are popular gamefish (smallmouth and largemouth bass) and panfish (black crappie), and their population structures and condition can provide insight to the condition of the recreational fishery in Kinderhook Lake.

Proportional size distribution (PSD) is a species-specific index that is used to analyze the proportional representation of fish of different sizes in a population. Mathematically, it is the proportion of stock size fish that also achieve some larger size (e.g., “quality size”):

$$\text{PSD} = \frac{\text{Number of fish} \geq \text{quality size}}{\text{Number of fish} \geq \text{stock size}} \times 100$$

The size categories include stock, quality, preferred, memorable, and trophy, in increasing size order. Stock size is considered to be the minimum catchable size of fish for that species, and others are based on percent of world-record lengths and angler perception of what constitutes a 'quality' (or other size) fish (Gabelhouse 1984). Although PSD provides a useful snapshot of fish populations, a given PSD can have multiple interpretations, so it is important that other sources of information (such as length-frequency histograms and relative weight) also be considered in population assessment.

The relative weight index (Wr) was used to quantify the condition, or 'plumpness' of the selected species. Relative weight is calculated as the ratio of the weight of a fish compared to a global standard weight for a fish of the same length and the same species:

$$W_r = \frac{\text{Weight}}{W_s} \times 100$$

A Wr of 100 is equivalent to the 75th percentile of the global standard weight (Ws). Fish with high relative weights indicate that the waterbody in which they are present has sufficient food to support the population and environmental conditions needed to sustain growth.

5.3 Results

Overall, PSD and Wr indices indicate that both predator and prey species in Kinderhook Lake appear to have size structures and condition that should be desirable for most anglers that visit the lake. The mean PSD for smallmouth bass (62, 95% CI = XX-XX) indicates a predator population that is slightly skewed toward larger fish. However, the length-frequency distribution for the species indicates consistent representation of individuals across all size classes sampled (Fig 7). The relative weight of smallmouth bass in Kinderhook Lake was calculated to be approximately 84 (95% CI = XX-XX). This places the weight of an average smallmouth bass to at about the 50th percentile of the global standard.

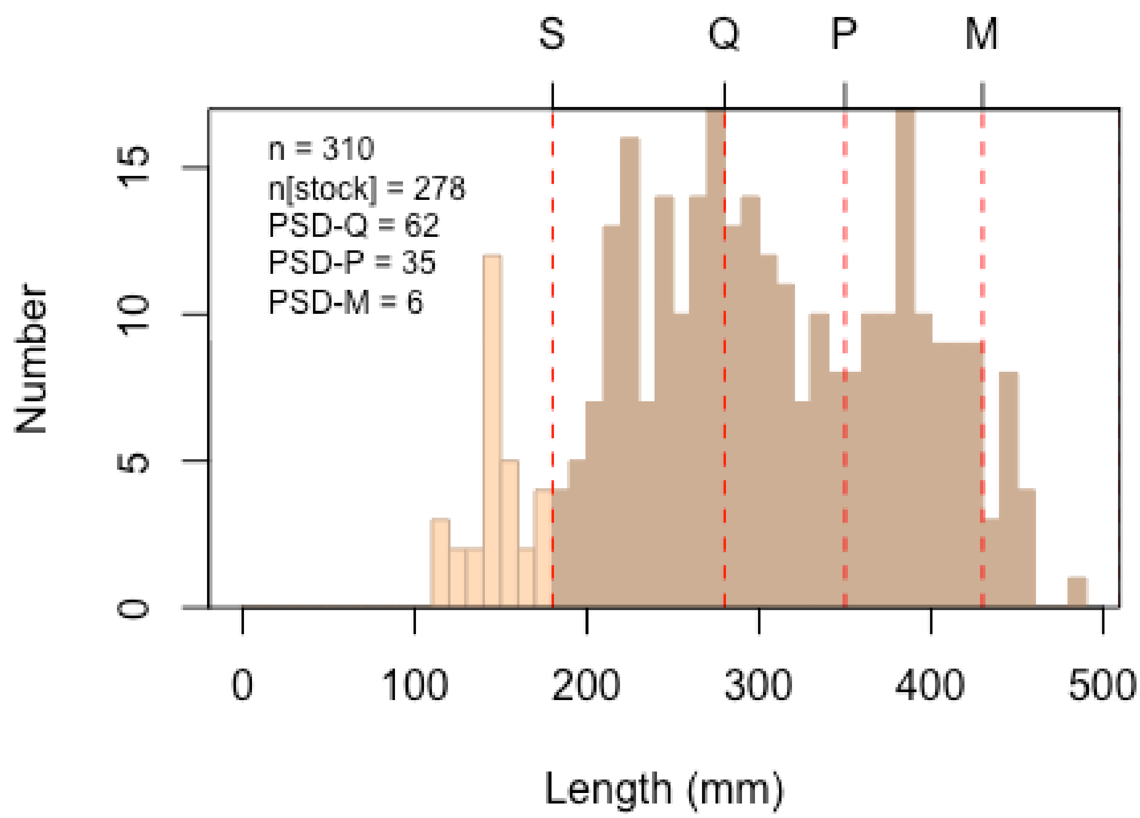

Fig 7 Smallmouth bass length-frequency histogram showing threshold values for Gabelhouse (1984) size thresholds for stock, quality, preferred, and memorable lengths (red dashed lines). PSD-Q was 62, meaning most smallmouth bass of stock size were also of quality size.

Proportional size distribution for largemouth bass (mean = 62, 95% CI = XX-XX) indicated that this predator population also was skewed toward larger individuals at the time of last sampling (Fig. 8). While the PSD of largemouth bass was virtually identical to that for smallmouth bass, the Wr was substantially higher, with a mean of 97 and a 95% CI of XX-XX. This places an average largemouth bass in Kinderhook Lake in the 75^{th} percentile of the global standard, and indicates near-optimal growth for this population over a large range of sizes.

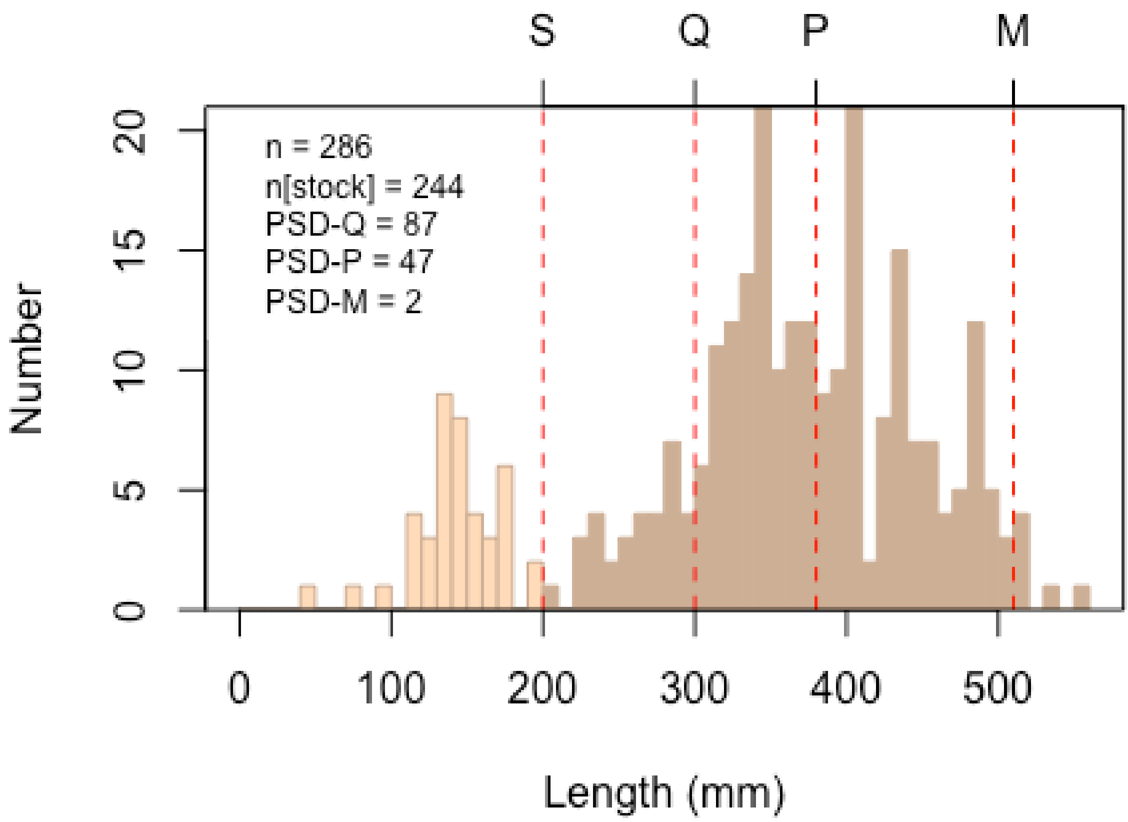

Fig 8 Largemouth bass length-frequency histogram showing threshold values for Gabelhouse (1984) size thresholds for stock, quality, preferred, and memorable lengths (red dashed lines).

Black crappie, the only prey species investigated, had a mean PSD of 58, with a 95% CI of XX-XX. This PSD indicates that the population of black crappie in Kinderhook Lake is skewed toward large individuals (Fig. 9). The lack of large individuals in this population may be indicative of high mortality once preferred size is attained, which in this case, aligns with legal harvest size for the species. This does not seem to relate to slowed growth, because the relative weight of Black Crappie in Kinderhook Lake was calculated to be approximately 88 (95% CI = XX-XX). This places an average black crappie in Kinderhook Lake at about the 60th percentile of the global standard.

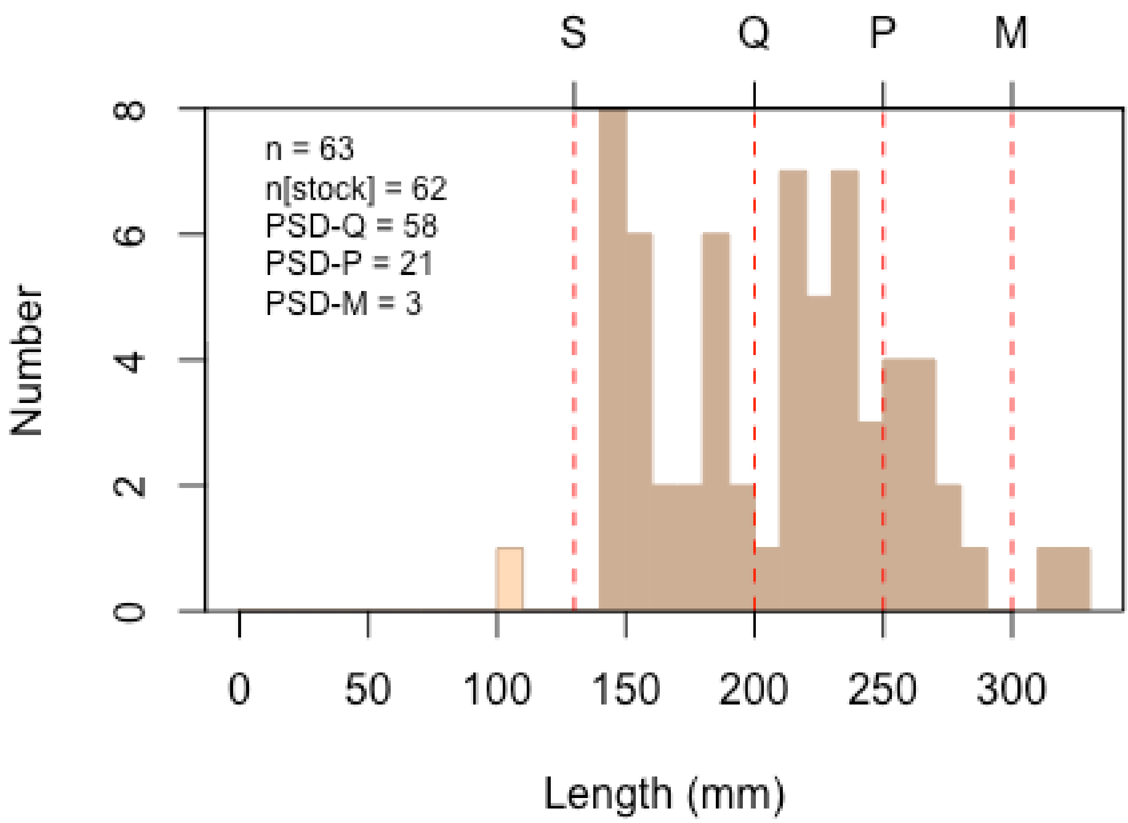

Fig 9 Black crappie length-frequency histogram showing threshold values for Gabelhouse (1984) size thresholds for stock, quality, preferred, and memorable lengths (red dashed lines).

Predator and prey PSD can be plotted against each other to understand community dynamics (fig 10). These types of plots have specific interpretations for each general area of the plotting region (Green 1989). In the case of largemouth bass (predator) and black crappie (prey), the result of this plot indicates that the warm water fish community in Kinderhook Lake should provide opportunities to catch large bass, with the occasional smaller fish, and numerous black crappie of quality size. The location of the point on Fig 4 corresponds to a somewhat 'ideal' fishery for the casual angler, but is susceptible to overharvest in some cases. This seems to be well supported by species-specific analyses.

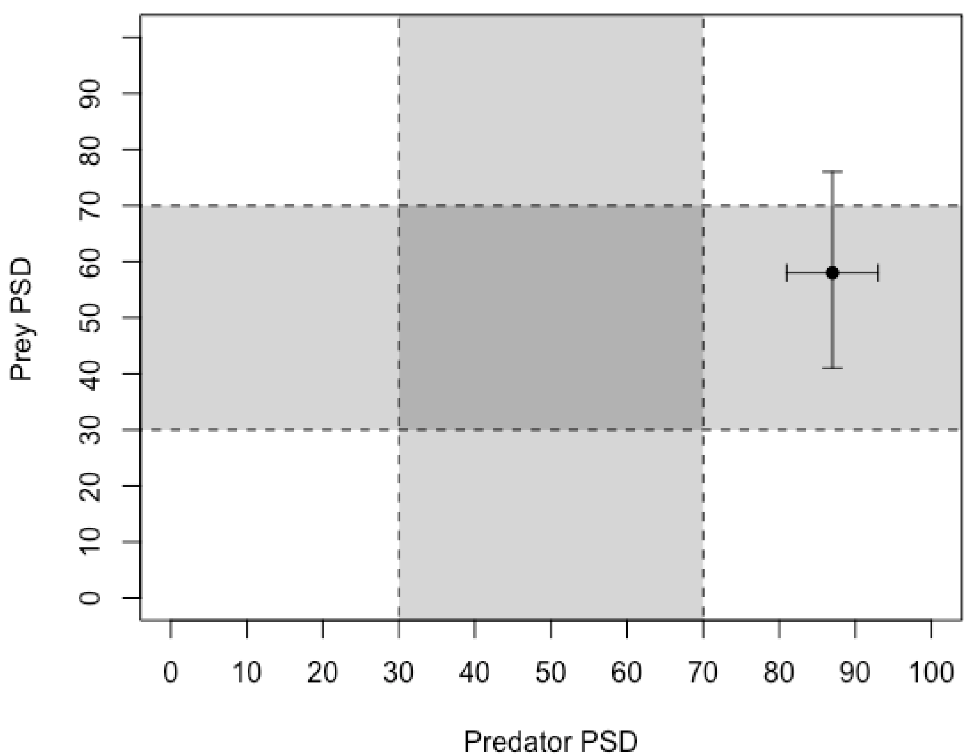

Fig 10 Interaction between a selected predator species (Largemouth Bass) PSD and selected prey species (Black crappie) PSD. Largemouth Bass populations are skewed towards longer fish while Black crappie populations are generally balanced.

5.4 Discussion

Overall, the populations of desirable gamefish for recreational fisheries in Kinderhook Lake are skewed toward relatively large individuals. This indicates that catch rates may be somewhat lower than what might be desirable for novice anglers, but that the fish that anglers do catch should be of quality size and good condition. With relative weights of 84, 97, and 60 for smallmouth bass, largemouth bass, and black crappie respectively, the conditions of popular gamefish and panfish in Kinderhook Lake are generally high indicating healthy and thriving populations. This is an indication that foraging conditions for prey fish and hunting conditions for piscivorous fish are generally good. Likewise, length-frequency histograms indicates the presence of consistent year classes during the time period of the survey, and suggests that winter fish kills have not had a pronounced impact on fish populations in recent years.

Management goals for Kinderhook Lake's recreational fisheries should focus on maintenance of existing fish populations as long as the current conditions meet stakeholder needs. Current stocking levels and catch-and-release policies for smallmouth and largemouth bass will continue to support desirable fish numbers, lengths, and weight.

6. Interim Management Plan

6.1 Nutrient Management

In order to reduce the excessive amounts of phosphorus and other nutrients entering Kinderhook Lake, multiple strategies can be utilized. Watershed management strategies can be helpful in the reduction of nutrients entering the lake. Individual homeowners within the Kinderhook Lake watershed can reduce their homes' nutrient input by keeping septic systems up to date. Out of date septic systems can begin to leach nutrients into the surround soil, which is already "very limited" in most of the Kinderhook Lake watershed. Kinderhook Lake Corporation can also work with local farmers within the watershed to spread awareness about their nutrient input and how they can help. Farmers can plant riparian buffers along their property to help stop nutrient runoff from their land. Programs such as Trees for Tributaries provide free riparian buffers to farmers that want to reduce their impact on waterways. This program is run through the New York State Department of Environmental Conservation and works with lake associations and farmers from all over the state (NYSDEC). Homeowners can also utilize a small-scale version of the riparian buffer on their own homes, planting tall emergent grasses close to the shoreline to stop nutrient runoff from their own homes. If homeowners along the Kinderhook Lake shoreline have gardens, a reduction in synthetic fertilizers can reduce their nutrient input.

6.2 Invasive Macrophytes

Kinderhook Lake's population of invasive macrophytes was cited as one of the highest concerns according to stakeholders, residents, and users of the lake. The lake's macrophyte population is nearly entirely invasive Eurasian watermilfoil. Current management techniques for invasive macrophyte control include hand pulling and weed harvesting. These practices should be continued and paired with other macrophyte management techniques. Benthic mats can provide targeted control of invasive plants, especially around docks where littoral submerged plants can damage powerboat propellers, the most used kind of watercraft according to the stakeholder survey. Native aquatic plants such as watershield (*Brasenia sp*.) on top of said benthic mats can reduce invasive macrophyte populations without reducing plant biomass, while reintroducing native species to the community. Herbicides are another technique to reduce invasive macrophytes, but can be expensive. Additionally, herbicides can quickly kill large mats of plants, and cause a fast depletion of oxygen within the water column, effecting other animal populations in the water.

6.3 Harmful Algal Blooms

The best way to reduce harmful algal blooms is to focus on the reduction of nutrients entering the waterbody. Techniques for management of nutrients can be found in section 6.1. In addition to nutrient reduction, the continuation of copper sulfate application should be utilized to control algae blooms during the summer. Summer applications of copper sulfate are a short term solution to reducing cyanobacteria and the toxins they can produce, making the water safe for recreation. In the long term, copper can build up in the sediment, making management techniques for other concerns (such as dredging for macrophyte control) not feasible. Other in lake treatments such as aluminum sulfate provide longer-term solutions by binding to phosphorus in the water and removing the source of HABs, however permits for these chemicals are difficult to obtain in New York State. Therefore, watershed nutrient management is the most feasible management technique to control harmful algal blooms.

6.4 Shoreline Erosion

Shoreline erosion is a continuing concern among stakeholders and landowners surrounding Kinderhook Lake. In order to reduce erosion along the shoreline, methods such as shoreline rebuilding using rocky substrate that does not erode as easily as loose sediments can help. Individual homeowners can reduce shoreline erosion by avoiding mowing lawns close to the shoreline, and planting tall grasses near the waterline. Plant roots hold sediments in place, and reduce the chance of erosion. Native trees such as willows have large root systems that can hold large amounts of sediments in place. Winter drawdown using the dam associated with Kinderhook Lake should be continued. The drawdown allows shoreline to avoid erosion from water and ice during the winter while the lake is not being used for recreation as often as the summer months.

6.5 Recreational fisheries

Recreational fisheries in Kinderhook Lake are in generally desirable conditions. Popular gamefish and panfish populations have high relative weights and substantial populations.

Management of these populations includes continuing current strategies. Catch and release practices for small and largemouth bass keeps populations of these popular gamefish in high number, by not removing individuals from the population. Though most macrophytes are invasive, they still provide forage and shelter for fry and juvenile fish. Invasive macrophytes should be replaced with native species upon removal in order to keep plant density consistent, to maintain fish populations.

References

"Web Soil Survey." *Web Soil Survey - Home*, websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.

"Septic Tank/Soil Absorption Field." *Texas A&M Agrilife Extension*.

Kinderhook Lake Corporation, B. (2012, September). *Kinderhook Lake Management Plan*. Kinderhook NY.

Kinderhook Lake Corporation. (2014). *Chemical Analyses of Water and Bottom Sediments in Kinderhook Lake*. Kinderhook NY.

NYS DEC, The CADMUS Group, Inc. (2011, September 15). *Total Maxiumum Daily Load (TMDL) for Phosphorus in Kinderhook Lake*. Albany NY.

Kinderhook Lake Corporation. (n.d.). *Map of Kinderhook Lake*. Kinderhook NY.

Collins, J. (2012, October 1). *Kinderhook Lake Corporation Aquatic Plant Management Plan*. Kinderhook NY.

Kinderhook Lake Corporation. (2013). *Kinderhook Lake Surveys 2001-2013*. Kinderhook NY.

US Census. (2017)

Langer, Daniel. (2018, September 16). *Personal interview*. Niverville NY.

NYSDEC. (2001). *2001 CSLAP data.* Schenectady NY.

NYSDEC. *Trees for Tributaries*. Saratoga NY. https://www.dec.ny.gov/animals/113412.html

NYSDEC. *Statewide fisheries database*.

Green, David. (1989) *Centrarchid Sampling Manual*. Bridgeport NY.

Gabelhouse, Donald. (1984). *A Length-Categorization System to Assess Fish Stocks*. Emporia, KS.

USGS. (2011*). Land cover data.*

Cohen, Andrew. (2004). *Calcium Requirements and the Spread of Zebra Mussels*. San Francisco, CA.