THE STATE OF SIXBERRY LAKE AND A PLAN FOR THE MANAGEMENT OF SIXBERRY LAKE

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AND
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STATE UNIVERSITY COLLEGE
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The State of Sixberry Lake

Sixberry Lake is located in Jefferson County, NY about 13 kilometers (km) from the St. Lawrence River. The lake is part of the Indian River Lakes region, which includes the Indian River and a network of 18 natural lakes, 17 of which are in the Saint Lawrence River watershed. The lake is about 27 meters (m) deep, cold, and oligotrophic with much of the incoming water believed to be from groundwater sources (NYSFOLA and NYSDEC 2016a). It has a mean depth of 14 m and a surface area of 51.8 hectares (ha).

The most recent study of water quality in Sixberry Lake was undertaken in summer 2004 (NYSFOLA and NYSDEC 2016a). The 350 ha. watershed contains little development or agriculture. Therefore, the lake has not undergone obvious cultural eutrophication to the degree that other lakes in the region have. Based on observational reports collected in a survey of watershed residents (K. Marean, unpublished data) there has been an increase in algae, and in September 2014 residents noted the first occurrence of an algal bloom in recent memory.

As a first step in a larger effort to preserve the lake's character, the Sixberry Lake Association (SLA) and Indian River Lakes Conservancy (IRLC) made an arrangement with State University of New York (SUNY) Oneonta Biological Field Station to develop a long-term, comprehensive lake and watershed management plan. The following chapters describe watershed, biological, and limnological characteristics, based upon field surveys and desktop analysis, used to develop the Lake Management Plan (included as Appendix A).

Chapter 1 History of Area (Sinclair 1980)

1.1 The Town of Theresa

Sixberry Lake lies within the Village of Redwood in the Town of Theresa in Jefferson County, part of a greater region of New York referred to as the "North Country". According to Sinclair, prior to settlement by New Yorkers and Europeans, the Indian River area was used by Native Americans for hunting, fishing, and trapping. By the end of the Revolutionary War the area was still mostly uninhabited and Jefferson, Lewis, Oswego, and St. Lawrence Counties were all considered Oneida and Onondaga territory. In 1786, New York State created a land commission to raise funds for the state government through the sale of state lands and in 1788 the Oneidas signed the Treaty at Fort Stanwix with New York State, which gave a majority of Oneida territory (all of what is now northern New York) to the State. This land was then sold by the previously mentioned land commission to settlers. In addition to raising money, the goal was to increase local settlement to provide security for citizens already occupying the area.

By the time of the Civil War, the community had grown to a considerable size because of lumber and flour mills. These mills were generally hydro-powered and run off of the Indian River. Historically, manufacturing in the area never lasted long.

The early twentieth century saw wealthy New Yorkers heading to the Thousand Islands. Redwood thrived during this time, supplying livestock for resorts and restaurants. After World War II there was a building boom, logging increased, and much of the area was potentially harvested (Muller 2015).

1.2 Immigration to the Area

During the Reign of Terror in France, many loyalists and aristocrats left France for safe havens in other countries. Jacques LeRay, a member of the bourgeoisie, made his new home in Jefferson County and nicknamed it "Castorland". He built his home in Theresa and developed large areas of land, which ultimately became Brownville, Cape Vincent, and Alexandria Bay. LeRay encouraged immigration to the area with financial incentives for farmers and funded the development of churches and schools. The town of Theresa is named for LeRay's daughter.

Sinclair documents that the area was also settled by New Englanders and Germans. There was a religious revival in New England in the early 1800s, which lead to people in opposition to the revival leaving and some settling in Theresa. The German immigration began in the 1830s following the Revolution in Germany, with most migrants settling in Orleans, LaFargeville, and the Clayton area. There were several later waves of German migrants, all coming to the USA for better living conditions, to escape military duty, avoid higher taxes and to reunite with relatives already settled in the States. These Germans mainly came from the Hess-Darmstadt region of

Germany and were mostly skilled in trades like carpentry, shoemaking, watchmaking, cheese-making, and farming.

1.3 "Ole Six"

Robert Sixberry (sometimes spelled "Sixbury", and nicknamed "Ole Six") was one of the first Americans to explore and settle within what is now the town of Theresa. Born in 1761, Sixberry ran away from indentured servitude in the Catskill Region at the age of 14. He traveled north and made friends with Dutch settlers along the Hudson and Native Americans living in the North Country. He spent time with the Natives in the area, staying in their camps along the Black and Indian Rivers. Sixberry began making money by trapping in the North Country with the Natives and selling his furs south in the Mohawk Territory. It was during this time that Sixberry Lake was "discovered":

> "There is a beautiful lake in the Theresa group that is now called Sixbury Lake. The story is told that when Robert Sixbury, who came to this section to live with the Indians some years before the white men started settling the region, he asked the Indians, when going down the Indian River, how many lakes there were in the group. They told him of the several that were joined directly to Indian River, but failed to name a lake a little back from the others. In hunting through the woodlands, Robert Sixbury came upon this body of water and thought it was a lovely spot. He told the Indians of it, as he did others in later years, and the lake was named after the man who, in a way, discovered it".

1.4 Development of Sixberry Lake

According to a long-time shoreline resident (Muller 2015), in the 1950s much of the shoreline had little development. There were few camps, the west shoreline was entirely undeveloped, and the northeast portion of the lake was owned by the YMCA Camp Tousey. During this time there was no electricity to any of the camps and they all had outhouses. Development of the shoreline increased over time, and Camp Tousey was shut down and sold in 1997. Many of the parcels along the northeast side of the lake that are now privately owned were originally part of Camp Tousey.

Chapter 2 LAKE AND WATERSHED CHARACTERISTICS

2.1 Bedrock Geology (Muller 2015)

Between the Precambrian shield in Canada and the Precambrian Adirondack Mountains lies the Frontenac Axis, a strip of Precambrian rocks with varying levels of resistance to weathering and erosion. Where there was marble, metamorphosed from limestones, there are now valleys, and where there were gneisses and migmatites (rocks more resistant to erosion), there are hills. Over time, the Frontenac Axis has been warped and folded resulting in a Northeast to Southwest trend. The Indian River Lakes align with this orientation, suggesting that these Precambrian rocks are in part responsible for their formation. These lakes have formed where water has eroded some of the rock layers of the Axis away, similar to how the St. Lawrence River eroded through and formed the Thousand Islands. Approximately 500 million years after the rocks of the Frontenac Axis had formed and were folded, a layer of Potsdam sandstone was deposited on top, and later other rocks were deposited on top of that. In the more recent geologic past, there was the advance and retreat of numerous glaciers, further influencing the layers of rock presently found there.

The Indian River Lakes, and specifically Sixberry Lake, are also known as the Alexandrian lakes, which are a group of distinct and localized waterbodies. These lake beds lie in either Precambrian or Potsdam sandstone, with little to no limestone. Sixberry Lake is partially walled by the characteristic cliffs of and valley heads cut in Potsdam sandstone, but with lake bed in Precambrian rock; in this case the Precambrian rock is a type of quartzite (Figure 2.1). To date, there is no evidence of limestone in the lake bed (Cushing 1910) and what lies at depth in the lake may be somewhat different than the surrounding quartzite.

There is no definitive explanation for how the Sixberry Lake basin was formed; it may have been scoured by ice or a result of warping. There is also a possibility that the lake basin was partially formed by dissolving limestone, also explaining the absence of limestone in the watershed (Cushing 1910). Some claim that Sixberry and the two neighboring deep lakes (Millsite and Lake of the Woods) were plunge pools in meltwater streams active as the glaciers retreated, much like the deep lakes of Green Lakes State Park, Syracuse, NY. However, the formation of these lakes through plunge pools does not explain the presence of the complex geologic fabric; this complexity is better explained by folding. Another theory is that these three deep lakes formed as the result of the collapse of caves, and there are examples of features that geologists consider the remains of ancient caves in the area. It is hypothesized that these caves, which had formed near the surface of the Precambrian rock, were a result of the solution or weathering of rocks no longer present in large amounts. This rock (a limestone [marble] inter-layered with sandy layers) can still be found in spots along the Southeast shore of Lake of the Woods .

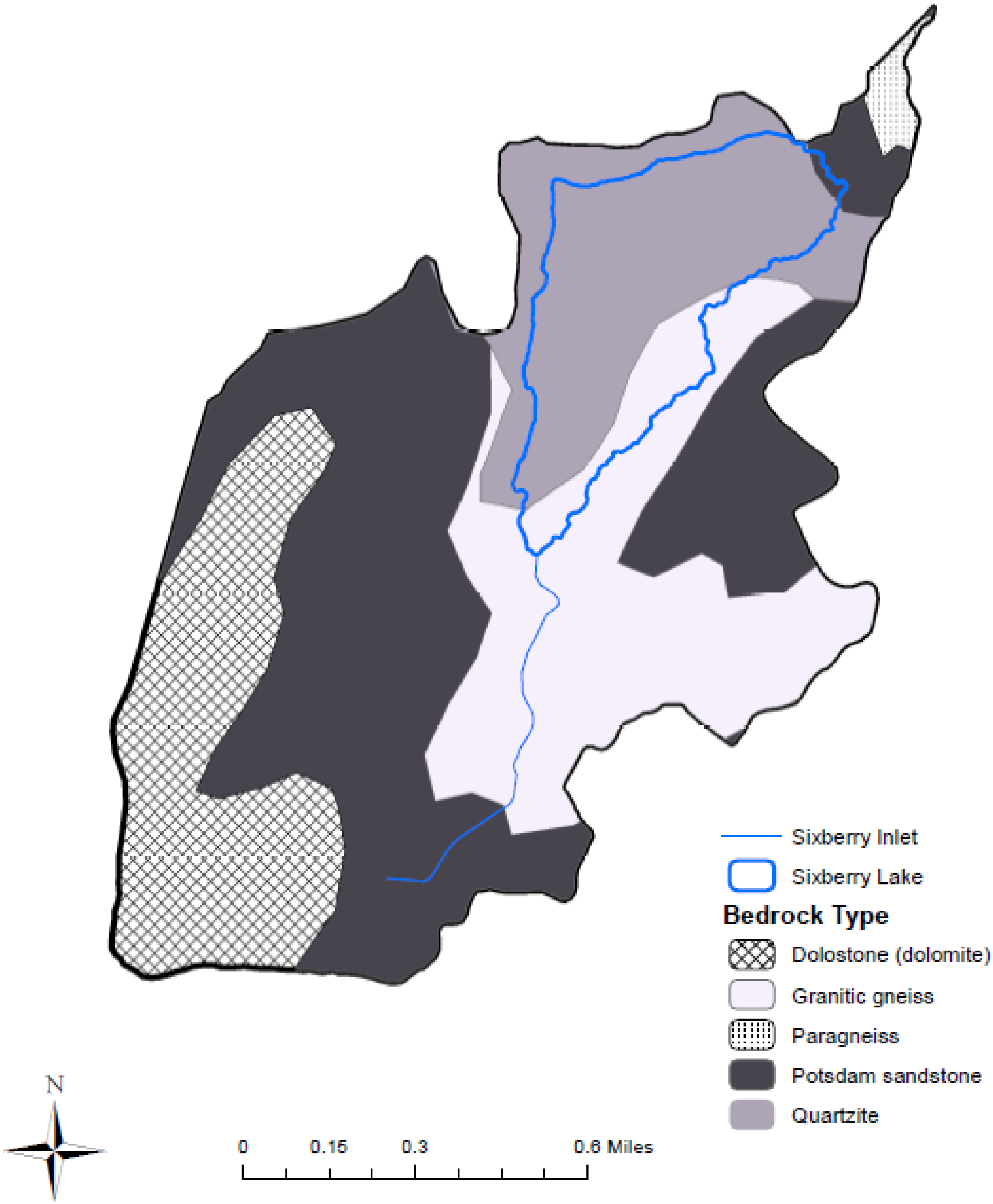

Figure 2.1 Bedrock geology in the Sixberry Lake watershed (New York State Museum 1999).

2.2 Soils

The soils found in the Sixberry Lake watershed are composed of glaciofluvial or glaciolacustrine deposits, or loamy till parent material (Homer et al. 2015). There are 14 different types of soils in the watershed, and four comprise 73.27% of the total area (Table 2.1, Figure 2.2, and Table B.1, Appendix B). Of these four, three are rock outcrop complexes and the fourth is a gravelly loam (Table 2.1 and Table B.1, Appendix B).

Table 2.1 Summary of Soils within the Sixberry Lake Watershed (NRCS 2015).

Soil Symbol	Map Unit Name	Septic Tank Absorption Fields Limiting Features	Rating	Percent of Watershed
CIA	Chaumont silty clay, 0 to 3 percent slopes	Depth to saturated zone, slow water movement, depth to bedrock	Very Limited	5.27%
CIB	Chaumont silty clay, 3 to 8 percent slopes	Depth to saturated zone, slow water movement, depth to bedrock	Very Limited	0.96%
HeB	Heuvelton silty clay loam, 3 to 8 percent slopes	Depth to saturated zone, slow water movement	Very Limited	3.76%
HpB	Hollis-Galoo, acid variant, complex, rocky, 0 to 8 percent slopes	Depth to bedrock, seepage (bottom layer), depth to bedrock	Very Limited	1.59%
InB	Insula-Rock outcrop complex, 0 to 8 percent slopes	Depth to bedrock, seepage (bottom layer), depth to bedrock	Very Limited	2.67%
IoB	Insula-Rock outcrop complex, 0 to 8 percent slopes	Depth to bedrock, seepage (bottom layer)	Very Limited	15.48%
KgA	Kingsbury silty clay, 0 to 2 percent slopes	Depth to saturated zone, slow water movement	Very Limited	4.88%
Lc	Livingston mucky silty clay	Depth to saturated zone, slow water movement	Very Limited	1.82%
Ma	Madalin silt loam, 0 to 3 percent slopes	Depth to saturated zone, slow water movement, depth to saturated zone, slow water movement, ponding	Very Limited	2.86%
MuE	Millsite-Rock outcrop complex, steep	Slope, depth to bedrock, seepage (bottom layer)	Very Limited	17.27%
MwB	Muskellunge silty clay loam, 3 to 8 percent slopes	Depth to saturated zone, slow water movement, depth to saturated zone, slow water movement, depth to bedrock	Very Limited	0.70%
QeB	Quetico-Rock outcrop complex, 2 to 8 percent slopes	Depth to bedrock	Very Limited	22.26%
Ru	Ruse gravelly loam, rocky	Ponding, depth to bedrock, depth to saturated zone, seepage (bottom layer)	Very Limited	18.26%
WnB	Wilpoint silty clay loam, 3 to 8 percent slopes	Depth to saturated zone, slow water movement, depth to bedrock	Very Limited	2.23%

The suitability of soils for septic tank absorption fields are rated by the National Resources Conservation Service (NRCS). Properties of soils between depths of 24 and 60 inches are evaluated on how they affect absorption of the effluent, construction and maintenance of the system and the possible effects on public health. The ratings indicate how treatment potential is limited by these soil properties. According to the Homer et al. (2015) “Not limited” means there are features very favorable for use with the expectation of good performance and very low maintenance. “Somewhat limited” means that the features present are moderately favorable for septic tank absorption fields. These limitations may be overcome by planning or engineering, with fair performance and moderate maintenance. “Very limited” means there are one or more properties within the soil that are unfavorable for this use; they may not be overcome without great efforts and one can expect poor performance and high maintenance needs. The values provided along with the rating provide the severity of each limiting feature. Those soil features that have the most severe impact upon use receive a 1.00 and those where the soil feature is not a limitation receive a 0.00. All 14 soils in the Sixberry Lake watershed are rated by the NRCS as very limited for septic tank absorption fields (Table B.1, Appendix B). However, site-specific testing should be conducted to verify these limitations (Homer et al. 2015).

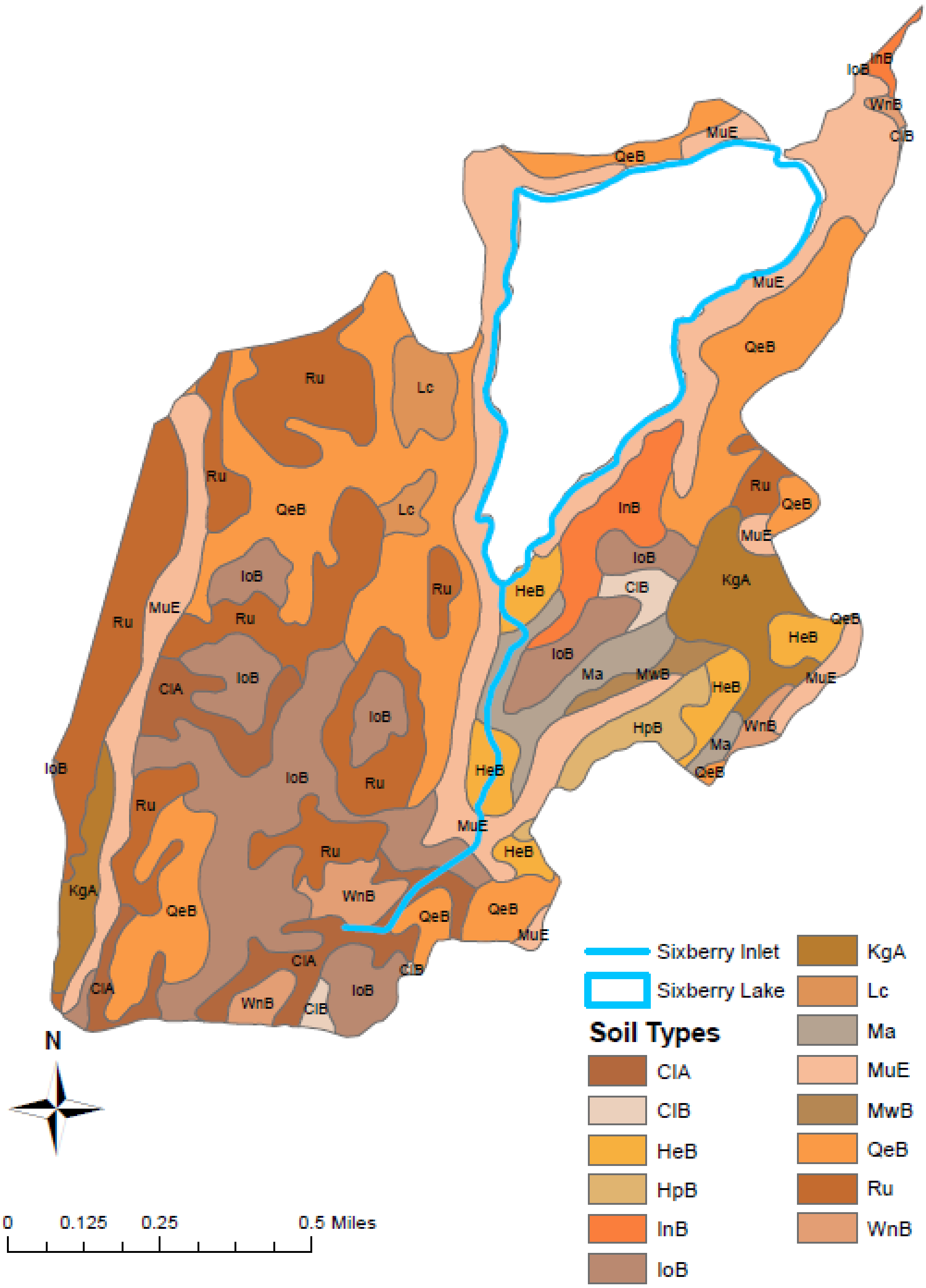

Figure 2.2 Soil types within the Sixberry Lake watershed (NRCS 2015).

2.3 Land Cover and Use

Based upon the most recent edition of the National Land Cover Database available (Homer et al. 2015), the most prevalent land cover type in the watershed is forest (~56%), followed by planted and/or cultivated land (~23%) (see Table 2.2, Figure 2.3). Most development is close to the lake and there is one paved road, English Settlement Road, which borders the lake to the south and east.

Table 2.2 Composition of land cover and use within the Sixberry Lake Watershed (Homer et al. 2015).

Category	Class		Area (ha)	Percent cover
Forested	Deciduous Forest		135.87	38.82
	Evergreen Forest		33.37	9.53
	Mixed Forest		26.54	7.58
		Total	195.78	55.93
Planted/Cultivated	Hay/Pasture		49.56	14.16
	Cultivated Crops		29.52	8.43
		Total	79.08	22.59
Developed	Developed, Low Intensity		0.01	2.45
	Developed, Medium Intensity		0.01	1.50
	Developed, High Intensity		<0.01	0.67
	Developed, Open Space		0.02	5.02
		Total	0.04	9.64
Herbaceous/Grassland	Herbaceous		<0.01	0.93
		Total	<0.01	0.93
Wetland	Woody Wetlands		0.02	6.39
	Emergent Herbaceous Wetlands		<0.01	1.02
		Total	0.03	7.41
Shrub/Scrub	Shrub/Scrub		0.12	3.19
		Total	0.12	3.19
Barren Land	Barren Land		<0.01	0.25
		Total	<0.01	0.25
Unclassified	Unclassified		<0.01	0.03
		Total	<0.01	0.03
		Grand Total	350.00	100.0

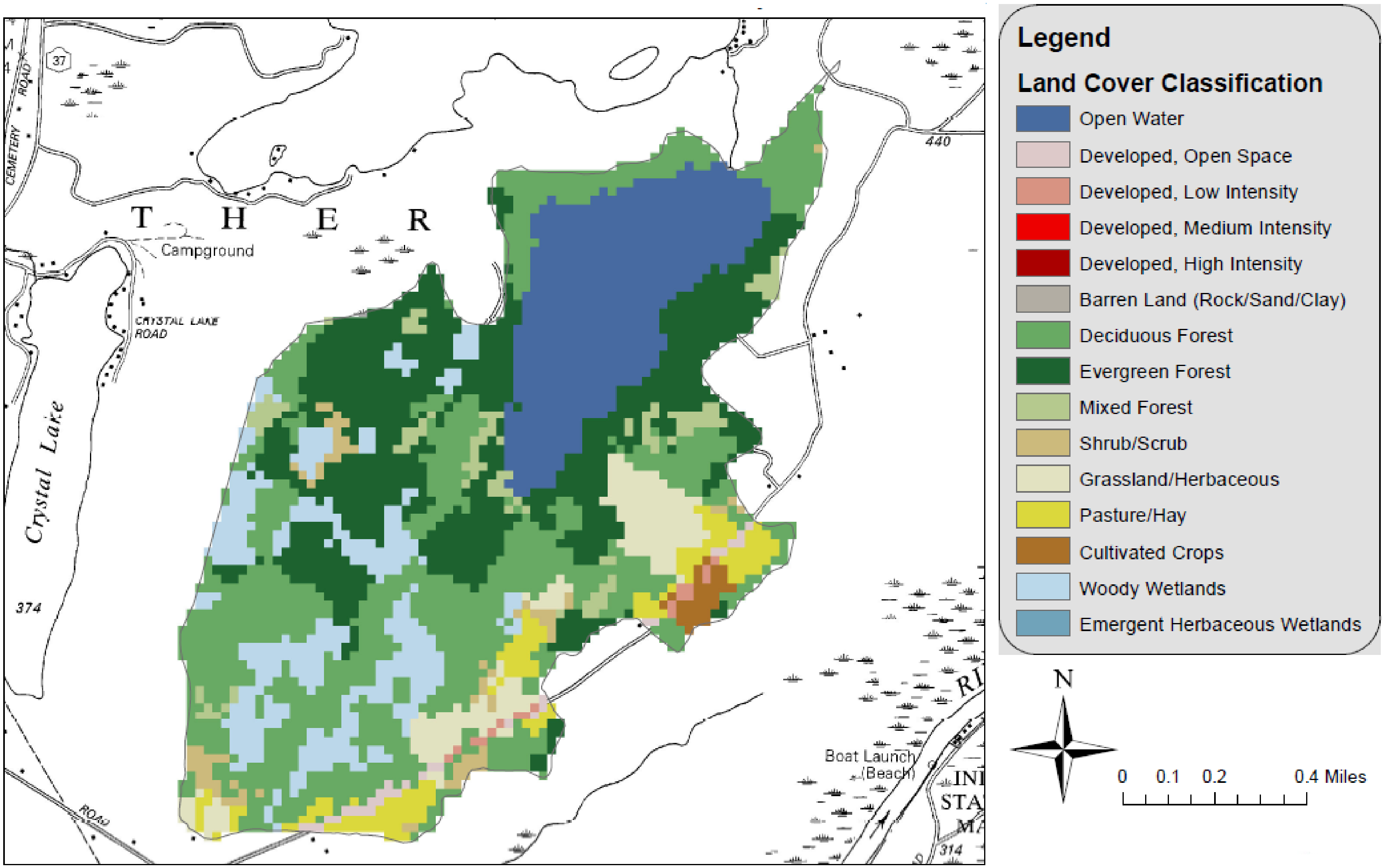

Figure 2.3 Land cover classifications with the Sixberry Lake Watershed (Homer et al. 2015)

2.4 Climate

The climate of the county containing Sixberry Lake is heavily influenced by Lake Ontario, due to its proximity and orientation relative to the prevailing winds. Jefferson County, particularly the southern portion, receives "lake effect" snow in the winters and the average total annual precipitation for the county is 96.52 centimeters (cm). The area is categorized as humid-continental, with long and cold winters, a cool and short spring, warm and moderate summers, and warm but short autumns (Jefferson County 2016). The winter of 2015 – 2016 was an atypical season because it was an El Niño year; one of the strongest on record. The National Oceanic and Atmospheric Administration (NOAA) predicted average precipitation and above-average temperatures in Jefferson County (NOAA 2015).

Chapter 3 PHYSICAL AND CHEMICAL LIMNOLOGY

Physical and chemical limnological parameters are used to understand the "health" or state of a lake, determine the trophic status, and identify suitable ecological and recreational uses. Limnological parameters of Sixberry Lake were previously monitored between 2001 and 2004 through participation in the Citizen Statewide Lake Assessment Program (CSLAP). During CSLAP participation total phosphorus (TP), Secchi depth (SD), and Chlorophyll a (Chl. a) were measured approximately every other week during the open water season (NYSFOLA and NYSDEC 2005). Data collected indicated that the water quality of Sixberry Lake was suitable for all designated uses (see Section 1 of Appendix A, the Sixberry Lake Watershed and Lake Management Plan for a discussion of designated uses). No consistent water quality monitoring was conducted between 2005 and fall 2014, though anecdotal observations suggest changes in the lake's character were noticed during this period of time. This data gap makes it more challenging to develop a long-term lake management.

This study was designed to (1) assess existing limnological parameters and (2) compare them to historical data in order to determine if limnological changes have occurred since the cessation of CSLAP participation in 2005. The information contained within will also be used to determine appropriate lake and watershed management strategies and practices, as discussed in Appendix A, the Sixberry Lake and Watershed Management Plan. Additional limnological data not discussed in the following sections are provided in Appendix C.

3.1 Methods

Water Quality Sampling and Analysis

Physical and chemical limnological parameters were measured in 2014 and 2015 on a bi-weekly interval during the open water season and at least once a month during periods of ice cover. All limnological data were collected at the deepest point of the lake basin. Depth was determined at each sampling event using a Speedtech ® Depthmate portable sounder. Physical water quality parameters (temperature, pH, dissolved oxygen [D.O.], and specific conductivity) were measured using a YSI® 650 MDS with a 6-Series multiparameter sonde, calibrated prior to each sampling trip following the manufacturer's instructions (YSI Incorporated 2009). Measurements occurred at 1 m intervals from the surface (depth = 0 m) to the lake bottom (depth = 26 m). Water transparency was measured using a Secchi disk, which was lowered along the shaded side of the boat. The Secchi disk was lowered until it disappeared and then raised until it reappeared, and the depths for both the disappearance and reappearance were recorded and averaged.

Water samples were collected using a Kemmerer water sampler at five depths during each sampling trip for in-lab analysis of nutrient concentrations (TP, total nitrogen (TN), and nitrate and nitrite combined [nitrate + nitrite]). Sample depths were adjusted at each sampling event to ensure that samples were collected in the following depth strata: surface, middle of the epilimnion, thermocline, middle of the hypolimnion, and at the lake bottom. On sampling trips when no thermocline was present, water samples were collected at equidistant depth intervals. Samples were kept in a refrigerator or in a cooler and out of the sun until they could be processed for storage at the field station. Sulfuric acid was added to all nutrient samples to acidify them to pH < 2 in order to stop adsorption to seston and biological activities (section 4500-P B, Way 2012). Acidified samples were stored at room temperature in acid-washed, translucent 125 mL polyethylene bottles for up to 2 months before analysis.

Samples for Chl. *a* were collected at varying depth intervals (see Table C.1 in Appendix C). Samples for Chl. *a* analysis were stored in brown, opaque 1 L polyethylene bottles to limit additional photosynthesis. Samples were kept in a refrigerator or in a cooler and out of the sun until they could be processed for storage. Chl. *a* samples were prepared by filtering 500 mL of lake water through a 47 mm Whatman® GF/A glass fiber filter using a low pressure vacuum pump. Filters were trimmed to remove unused edges of the filter, folded, patted dry, wrapped in aluminum foil, labeled, and stored at -20 °C.

Total phosphorus, TN, and nitrate + nitrite were measured with a Lachat QuickChem FIA 8000 series auto analyzer using the methods outlined in Table 3.1. Each Chl. *a* sample on a GF/A filter was cut into small pieces and added to a 15 milliliter (mL) grinding tube with approximately 4 mL of buffered acetone (90% C3H6O, 10% MgCO3). Each sample was then ground down to a homogenous slurry using a drill with a Teflon pestle drill bit. The slurry was then transferred to a 15 mL centrifuge tube and brought to a final volume of 10 mL with buffered acetone and stored in the dark prior to centrifugation in a Thermo Scientific Sorvall Legend XI centrifuge. During centrifugation, the samples were spun for 10 minutes at 10,000 × *g*. Upon completion, samples were transferred into a clean 12 mL cylindrical cuvette and analyzed using a Turner Design TD-700 fluorometer. Chlorophyll *a* concentrations were determined using the method of Arar and Collins (1997):

$$\text{Chl. } a\ (\mu g/l) = \text{concentrated Chl. } a \times \text{final volume/mL sample filtered}$$

Table 3.1 In-lab chemical analysis methods.

Parameter	Preservation	Method	Reference	Detection Limit
TP	H_2SO_4 to pH < 2	Persulfate digestion followed by single reagent ascorbic acid	Liao and Marten 2001	4 µg/l
TN	H_2SO_4 to pH < 2	Cadmium reduction method following peroxodisulfate digestion	Pritzlaff 2003; Ebina et al. 1983	0.04 mg/l
Nitrate+nitrite-N	H_2SO_4 to pH < 2	Cadmium reduction method	Pritzlaff 2003	0.02 mg/l

Isopleths

Isopleths used in the following sections were created using the 'akima' package (Akima et al. 2015) in R (R Core Team 2015). These isopleths provide a visual representation of limnological parameter values throughout the water column during the study period.

Trophic State

Carlson's trophic state index (TSI) for SD, Chl. *a*, and TP (Carlson 1977) was calculated for each sampling event during the open water season. These TSI values were also calculated for historical CSLAP data. TSI values less than 30 often indicate oligotrophy, TSI values between 50 and 70 often indicate eutrophy, and TSI values greater than 70 often indicate hypereutrophy (Wetzel 2001). The equations used to calculate each parameter are:

$$\text{TSI (SD)} = 60 - 14.41 \times \ln(\text{SD})$$

$$\text{TSI (Chl. } a) = 9.81 \times \ln(\text{Chl. } a) + 30.6$$

$$\text{TSI (TP)} = 14.42 \times \ln(\text{TP}) + 4.15$$

Statistical Analysis

Mean open water surface values of several parameters (SD, TP, Chl. *a*, pH, and TSI) were compared between historical data collected during CSLAP sampling with data collected from the first open water sampling event (October 2014) and during the 2015 open water season. To determine if there was a statistically significant difference in means for each parameter, a Wilcoxon rank sum test with continuity correction (Wilcoxon 1945) was performed with $\alpha = 0.05$. All CSLAP years were pooled and all statistical analyses were run in R (R Core Team 2015).

3.2 Results

A summary of sampling results is provided in Table 3.2 below as reference for the following discussion.

Table 3.2 Summarized water quality parameters measured in Sixberry Lake during the present study period (October 2014 to March 2016). All data shown represent the values closest to the surface. All parameters were measured on a bi-weekly basis during the open water period.

Parameter	Sample Size (number)	Range	Mean	Standard Deviation
Total Phosphorus (µg/L P)	19	3.0-18.0	7.1	3.9
Total Nitrogen (mg/L N)	18	0.06-0.27	0.16	0.07
Nitrate + Nitrite (mg/L)	19	0.02-0.07	0.03	0.02
Chlorophyll *a* (µg/L)	16	0.65-20.75	4.77	5.94
Transparency (m)	12	3.75-7.00	5.38	1.07
Specific Conductivity (µS/cm)	19	0.083-0.094	0.089	0.003
pH	19	7.10-8.48	7.76	0.38

m = meters
mg/L = milligrams per liter
N = nitrogen
P = phosphorus
µg/L = micrograms per liter
µS/cm = microSeimens per centimeter

Temperature

Sixberry Lake is dimictic with periods of summer and winter stratification, and spring and fall mixing events. Thermal stratification was present during the first sampling event in October 2014, under the ice between February and March of 2015, and between June and November of 2015 (Figure 3.1). During the open water season the thermocline was observed at 5 to 10 m. The maximum water temperature observed was 25.15 °C on August 20, 2015. For Figure 3.1 and other isopleths in this section, the top of the isopleth represents the surface of the lake, and the bottom of the isopleth represents the lake bed. When read from left to right, the isopleth show values for one parameter throughout the water column as a progression through time.

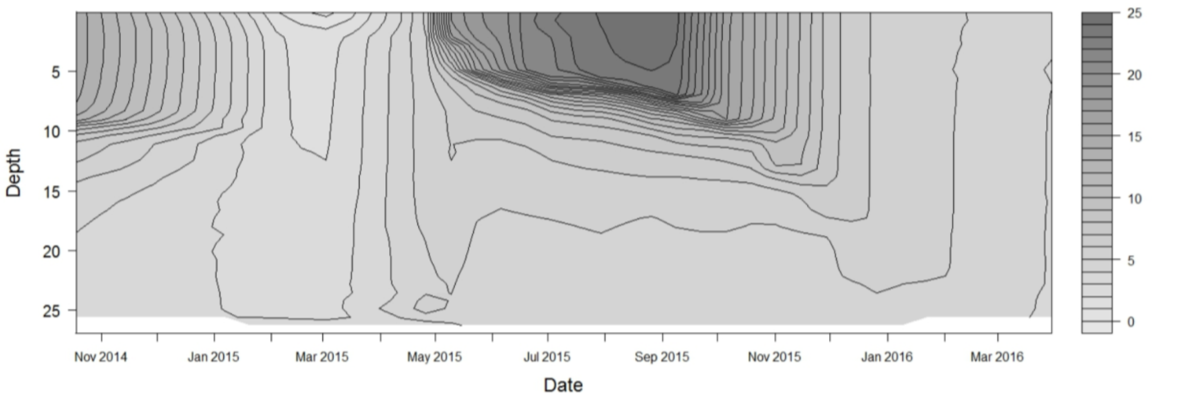

Figure 3.1 Temperature (ºC) isopleth for Sixberry Lake (October 2014 through March 2016).

Transparency

Mean SD during the open water season was 5.38 m, which is higher than the New York State threshold for oligotrophic lakes (> 5 m; NYSFOLA and NYSDEC 2005) and lower than neighboring oligotrophic lakes (Table 3.3). We failed to detect a significant difference in SD between the present study and historical CSLAP data (Wilcoxon rank sum test: W = 198.5, df = 1, p-value = 0.796).

Table 3.3 Mean SD depth, TP, pH, and Chl. *a* measured in other Indian River Lakes during the open water season (NYSFOLA and NYSDEC 2005, 20015, 2016b, 2016c, 2016d, 2016e, and 2016f).

Lake	Trophic State per CSLAP	Origin	CSLAP Years	SD (m)	TP (µg/L)	pH	Chl. *a* (µg/L)
Black	Eutrophic	Augmented by Dam	1998 - 2015	1.58	43.0	8.05	24.49
Butterfield	Mesoeutrophic	Natural	1986 - 2015	2.71	73.0	7.83	10.73
Grass	Mesotrophic	Natural	2004 - 2015	3.48	17.0	7.96	2.61
Hyde	Mesoeutrophic	Natural	1999 - 2001, 2003 - 2004, 2008 - 2012, 2014	2.46	28.0	7.84	12.56
Lake of the Woods	Oligotrophic	Natural	1994, 1997 - 2009, 2015	6.23	6.0	7.65	1.39
Millsite	Oligotrophic	Natural	1997 - 2015	6.67	8.0	7.74	1.78

Dissolved Oxygen

During periods of thermal stratification, D.O. was depleted in the hypolimnion, likely due to decomposition. Dissolved oxygen less than 5.0 mg/L, the threshold for salmonids (see Chapter 4 for further discussion), was observed in the bottom 1 to 9 m of the hypolimnion, and anoxic conditions (D.O. less than 1.0 mg/L) were recorded in the bottom 1 to 3 m, both beginning mid-summer and extending until fall turnover (Figure 3.2).

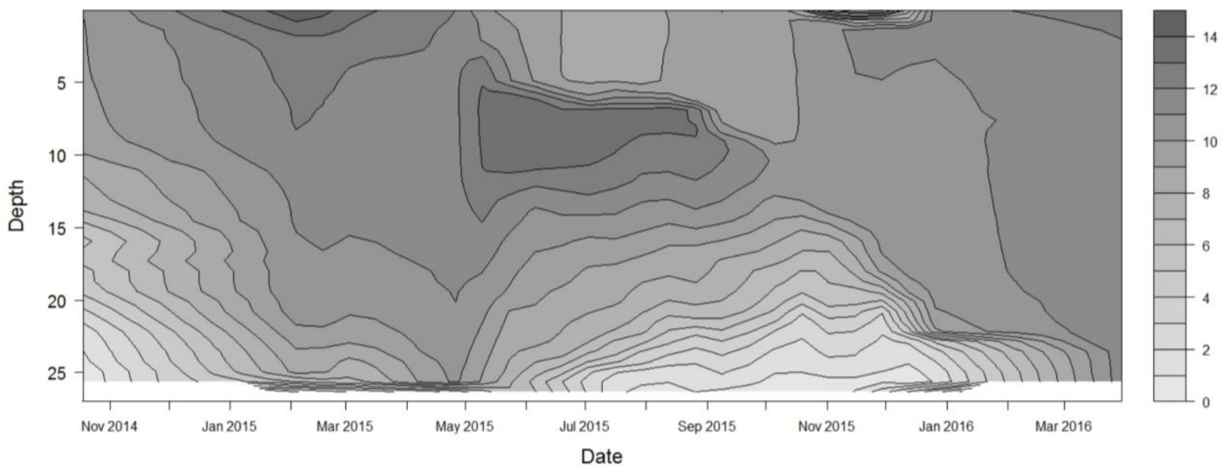

Figure 3.2 Dissolved oxygen (mg/L) isopleth for Sixberry Lake (October 2014 through March 2016).

Total Phosphorus

Mean TP in the present study was 7.1 micrograms per liter (µg/L), which is lower than the New York State threshold for oligotrophic lakes (< 10.0 µg/L; NYSFOLA and NYSDEC 2005). Elevated TP was observed in Sixberry Lake in the hypolimnion during the fall months, which coincided with periods of anoxia described above. Mean TP measured within 0 to 2 m of the surface during the open water study period was 6.5 µg/L, and was lower than neighboring oligotrophic lakes. We failed to detect a significant difference between the present study and historical CSLAP data (Wilcoxon rank sum test: $W = 184.5$, $df = 1$, p-value = 0.0872).

pH

Mean surface pH was 7.76, and was within the range for New York State standard (6.5 to 8.5; 6 NYCRR Part 703.3). Lake of the Woods was the only nearby lake with a lower surface pH than Sixberry Lake (Table 3.3).

Chlorophyll a

Mean Chl. *a* 2 m below the surface during the open water season was 4.77 µg/L, which is higher than the New York State threshold for oligotrophic lakes (< 2 µg/L; NYSFOLA and NYSDEC 2005), and was higher than surface Chl. *a* values of neighboring oligotrophic lakes (Table 3.3). We failed to detect a significant difference in Chl. *a* between the present study and surface samples from the historical CSLAP data (Wilcoxon rank sum test:, W = 148, df = 1, p-value = 0.1686) (Figure 3.3). For all boxplots in this section, the bold line in the center of each box represents the median value, the upper bound of the box represents the third quartile, the lower bound of the box represents the first quartile, and the whiskers show the largest and smallest values within the dataset. Dots represent outliers within a dataset.

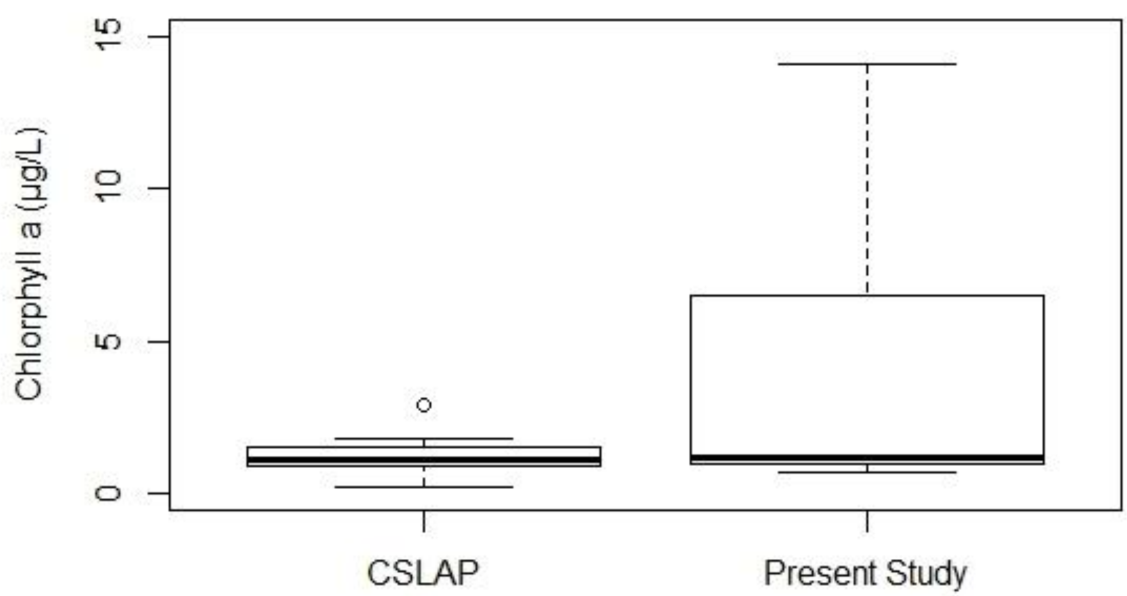

Figure 3.3 Comparison of Chl. *a* (µg/L) values in Sixberry Lake measured during past CSLAP studies (n=25, median = 1.1 µg/L, inner quartile range = 0.6 µg/L, 1st percentile = 0.3 µg/L, 99th percentile = 2.7 µg/L) and the present study (n=16, median = 1.1 µg/L, inner quartile range = 5.2 µg/L, 1st percentile = 0.7 µg/L, 99th percentile = 19.7 µg/L).

Trophic Status

Calculated TSI (SD) (Wilcoxon rank sum test: W = 178.5, df= 1, p-value = 0.796) TSI (Chl. *a*) (Wilcoxon rank sum test: W = 148, df= 1, p-value = 0.7312) and TSI (TP) (Wilcoxon rank sum test: W = 175, df= 1, p-value = 0.2281) values from the open water study period were not statistically different from CSLAP values. As depicted in Figure 3.4, mean values for TSI (SD) indicate that the lake is categorized as mesotrophic, mean values for TSI (Chl. *a*) indicate that the lake is categorized as slightly mesotrophic, and mean values for TSI (TP) indicate the lake is categorized as oligotrophic.

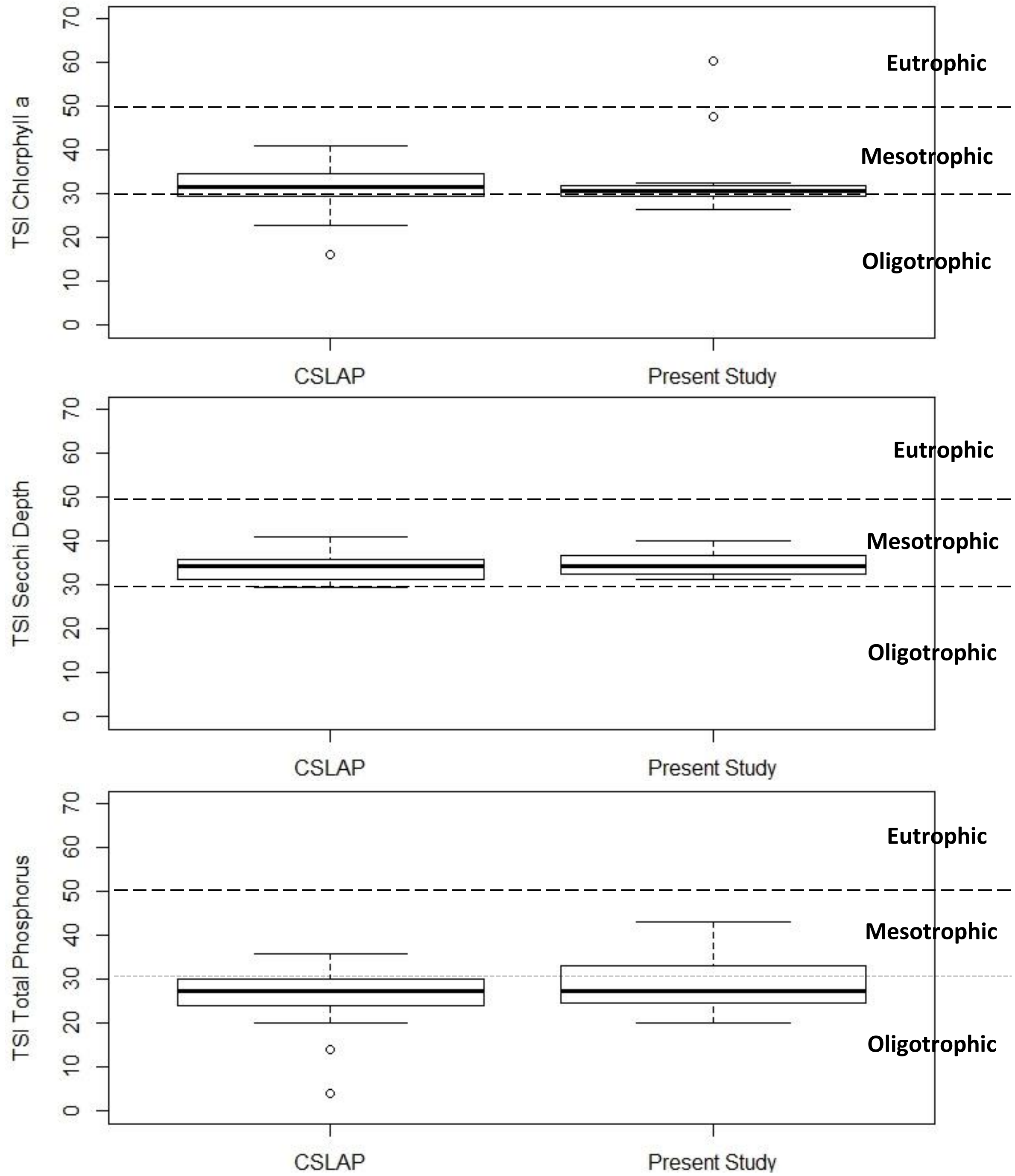

Figure 3.4 Comparison of TSI values for Chl. *a*, SD, and TP in Sixberry Lake measured calculated from data collected during past CSLAP studies and the present study). For Chl. *a* from CSLAP studies n= 25, median = , inner quartile range = , 1st percentile = , 99th percentile = . For Chl. *a* from present study n=11, median = , inner quartile range = , 1st percentile = , 99th percentile = . For SD from CSLAP studies n= 29, median = 34, inner quartile range = 4, 1st percentile = 30, 99th percentile = 41. For SD from present study n=13, median = 34, inner quartile range = 4, 1st percentile = 31, 99th percentile = 40. For TP from CSLAP studies n= 30, median = 27, inner quartile range = 6, 1st percentile = 7, 99th percentile = 35. For TP from present study n=15, median = 27, inner quartile range = 9, 1st percentile = 21, 99th percentile = 43.

Discussion

Through comparison of limnological data from historical CLSAP surveys and the present study, it appears that there has been no significant limnological change in Sixberry Lake in the past decade. All parameters measured in this study were well below New York State standards for eutrophic status (NYSFOLA and NYSDEC 2005), indicating that the lake is oligotrophic/mesotrophic based upon TSI values for SD, TP, and Chl. *a*. Anoxic conditions were present in the deeper part of the lake from mid-summer to fall turnover 2015. Internal phosphorus loading (high TP measured near the lake bottom) was observed corresponding with periods of anoxia, with some evidence of internal loading influencing TP measured in the epilimnion during fall turnover. Surface pH measured in Sixberry Lake during the historical CSLAP surveys and the present study was similar to surface pH of nearby lakes and was within New York State water quality standards.

Based on these limnological results, Sixberry Lake is suitable for its designated uses as a Class B waterbody and for expected ecological state as an unproductive lake. Therefore, the management plan provided in Appendix A includes management strategies aimed at limiting the influence of anthropogenic effects on the trophic state of the lake.

Chapter 4 EXISTING FISHERIES

The first recorded fisheries survey of Sixberry Lake was conducted in 1931, a part of the effort to catalogue the fishes of New York State (Greeley and Greene 1931). Surveys conducted in the 1970s specifically evaluated salmonid stocking methods and management (Klindt 2013). Since 1931, a total of 23 species have been collected from Sixberry Lake (Tables 4.1 and D.1, Appendix D). Smallmouth bass (*Micropterus dolomieu*), lake trout (*Salvelinus namaycush*), and walleye (*Sander vitreus*) have been consistently caught since the earliest surveys. Rock bass (*Ambloplites rupestris*), pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), and yellow perch (*Perca flavescens*) are warm-water fishes that have been consistently documented. Yellow bullhead (*Ameiurus natalis*), common shiner (*Luxilus cornutus*), blacknose dace (*Rhinichthys atratulus*), brook trout (*Salvelinus fontinalis*), and creek chub (*Semotilus atromaculatus*) were historically present in Sixberry Lake, but have not been observed since pre-1976 surveys (Table D.2, Appendix D). The reason for this is unknown, but it may be related to sampling design and execution related to study objectives in recent decades. Of note, cutlips minnows (*Exoglossum maxillingua*) were captured in several surveys, but were likely living in the inlet or the outlet as opposed to the lake itself.

Historically, Sixberry Lake was managed for cool- and cold-water fisheries. The waterbody has been stocked with lake trout, landlocked salmon (*Salmo salar*), brook trout, rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), walleye, and smallmouth bass (Klindt 2013). Only lake trout, rainbow trout, and landlocked salmon have been stocked by the New York State Department of Environmental Conservation (NYSDEC) since 2005 (Table D.2, Appendix D), and lake trout reproduce in the lake naturally (Klindt 2013).

Table 4.1 Fish species captured in NYSDEC Surveys in Sixberry Lake Between 1931 and 2013 (NYSDEC 2014).

Family	Scientific Name	Common Name
Coldwater		
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout
Salmonidae	*Salmo salar*	Atlantic salmon
Salmonidae	*Salmo trutta*	Brown trout
Salmonidae	*Salvelinus fontinalis*	Brook trout
Salmonidae	*Salvelinus namaycush*	Lake trout
Coolwater		
Centrarchidae	*Ambloplites rupestris*	Rock bass
Esociformes	*Esox lucius*	Northern pike
Percidae	*Perca flavescens*	Yellow perch
Percidae	*Sander vitreus*	Walleye
Warmwater		
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed
Centrarchidae	*Lepomis macrochirus*	Bluegill
Centrarchidae	*Micropterus dol*omieu	Smallmouth bass
Centrarchidae	*Micropterus salmoides*	*Largemouth bass*
Cottidae	*Cottus cognatus*	Slimy sculpin
Cyprinidae	*Cyprinella spiloptera*	Spotfin shiner
Cyprinidae	*Exoglossum maxillingua*	Cutlips minnow
Cyprinidae	*Luxilus cornutus*	Common shiner
Cyprinidae	*Pimephales notatus*	Bluntnose minnow
Cyprinidae	*Rhinichthys atratulus*	Blacknose dace
Cyprinidae	*Semotilus atromaculatus*	Creek chub
Fundulidae	*Fundulus diaphanus*	Banded killifish
Ictaluridae	*Ameiurus natalis*	Yellow bullhead
Ictaluridae	*Ameiurus nebulosus*	Brown bullhead

The purpose of this chapter is to review historical fisheries data from Sixberry Lake to assess how fisheries might be influenced by current limnological characteristics. This review of historical fisheries data will: (1) determine if current limnological conditions are suitable for a cool- and cold-water fishery; (2) describe the fishery of the lake; and (3) evaluate past fishery survey methods while making recommendations for future surveys where needed.

4.1 Methods

Historical fisheries information for Sixberry Lake was found in the NYSDEC State Historic Database, the New York State Museum, and the NYSDEC Statewide Fisheries Database. These included fisheries sampling data from surveys from 1992 through 2013, but do not include data from every year. Nine fisheries surveys were conducted by the NYSDEC Region 6 during this time frame, with a variety of gear types used (Table 4.2).

Table 4.2 Summary of Region 6 NYSDEC fisheries surveys for Sixberry Lake 1992–2013 including approximate survey date and gears used for fish collection (NYSDEC 2014).

Survey dates	Gear used	Gear specs
June 1992	100 × 2 ft monofilament Gillnet	2.5 in mesh
	100 × 2 ft monofilament Gillnet	2.5 in mesh
	100 × 2 ft monofilament Gillnet	2 in mesh
October 1992	150 × 6 ft 6-panel multifilament experimental gillnet	1—3.5 in mesh
November 1994	150 × 6 ft 6-panel multifilament experimental gillnet	1—3.5 in mesh
	150 × 5 ft Swedish experimental gillnet	1—3.5 in mesh
October 1996	Oneida style trap net	4 ft × 4 ft car
November 1998	Oneida style trap net	5 ft × 4 ft car
May 1999	150 × 6 ft 6-panel multifilament experimental gillnet	1—3.5 in mesh
October 1999	ALSC modified Alaska style trap net	.25 in mesh
June 2003	150 × 6 ft 6-panel multifilament experimental gillnet	1—3.5 in mesh
	Hoop net	n/a
	Oneida style trap net	4 ft × 4 ft car
July 2013	150 × 6 ft 6-panel multifilament experimental gillnet	1—4 in mesh
	200 × 8 ft 8-panel monofilament experimental gillnet	1.5—6 in mesh
	Hoop net	n/a
	60 × 5 ft bag seine	0.25 in mesh

To assess the fisheries of Sixberry Lake, two common metrics were used: proportional stock structure (PSD) and catch per unit effort (CPUE). To acknowledge the limitations that resulted from the use of various sampling gears in different sampling seasons, the fishery was described by comparing years in which the same gear type was used.

Proportional Size Distribution, PSD (Guy et al. 2006), is an index of the relative size structure within fish communities. PSD is a conglomerate index that takes into account biological processes such as recruitment, growth, and mortality of fish species. The index is based on the number of fish in one length category that are also in a larger length category. Traditionally, five length categories have been used: stock, quality, preferred, memorable, and trophy. These size categories are based on angler opinions about the length of a fish from a given species that constitutes a catchable (stock), quality, preferred, memorable, or trophy fish (Table 4.3; Gabelhouse, Jr. 1984; Willis et al. 1993). One common use of PSD is the calculation of the number of fish of stock size that are also of quality size (PSD_Q):

$$PSD_Q = \frac{\text{Number of fish} \geq \text{quality length}}{\text{Number of fish} \geq \text{stock length}} \times 100$$

To calculate predator PSD_Q the average PSD_Q of walleye, lake trout, largemouth and smallmouth bass was calculated. To calculate prey PSD_Q the average PSD_Q of yellow perch, rock bass, and pumpkinseed was calculated. Average PSD_Q was calculated for fish captured in gill nets, for those caught in hoop nets, and then the combination of predator and prey fish captured. For instances where a species was not captured in one gear type, the PSD_Q for that species was designated "non-applicable" and not included in the average PSD_Q. To attempt to minimize sampling bias and provide an overall summary of fish captured, PSD_Q was also calculated for fish captured in all gear types.

Table 4.3 Accepted length categories for common fish species in Sixberry Lake. Length category definitions and values obtained from Willis et al. 1993.

Length Categories		Species						
Category	Description	Largemouth bass	Lake trout	Pumpkin-seed	Rock bass	Smallmouth bass	Walleye	Yellow perch
Stock	"approximate length at maturity, minimum length effectively sampled by traditional fisheries gear, and the minimum length of fish that provide recreational value"	200	300	80	100	180	250	130
Quality	"size of fish most anglers like to catch"	300	500	150	180	280	380	200
Preferred	anglers may like to catch a fish of quality length but would prefer to catch a larger fish	380	650	200	230	350	510	250
Memorable	"size of fish most anglers remember catching"	510	800	250	280	430	630	300
Trophy	"size considered worthy of acknowledgment"	630	1000	300	330	510	760	380

Seven different gill nets were used between June 1992 and July 2013, with variable mesh sizes and filament types (Table 4.2). Consistency in gill net design is important because mesh size effects size selectivity and mesh material can effect net efficiency (Hubert 1996), and comparisons of CPUE and PSD_Q are compared with this caveat. Similarly, the variability in styles of trap and hoop nets makes it difficult to compare CPUE and PSD values between survey years (Hubert 1996). CPUE values were calculated for species collected in gill, hoop, and trap net catches from surveys listed in Table 4.1, and CPUE values of fish captured in seines was calculated for the 2013 survey effort.

PSDQ values were calculated for all individual fish species captured in hoop, trap, and/or gill nets for all surveys, and the average predator PSDQ and prey PSDQ values were calculated for all individual fish species captured in hoop, trap, and/or gill nets for all surveys. The PSDQ values for fish captured in hoop and trap nets in June 2003 could not be calculated as lengths were not collected during the survey. Fish captured and recorded as "bulk fish" were also not included in these calculations, as the length ranges for these fish were not broken out by the size categories listed above.

4.2 Results

The most abundant species by CPUE on average between June 1992 and July 2013 for fish captured in gill nets was rock bass (5.6 fish/night), followed by smallmouth bass (2.7 fish/night), and yellow perch (2.1 fish/night) and lake trout (2.1 fish/night) (Figure 4.1). The most abundant species by CPUE on average between June 1992 and July 2013 for fish captured in hoop and trap nets was rock bass (8.9 fish/night), followed by yellow perch (4.2 fish/night), and pumpkinseed (3.5 fish/night) (Figure 4.2). The most abundant species by CPUE in July 2013 for fish captured in seine nets was pumpkinseed (77.7 fish/haul), followed by unidentified sunfish species (29.7 fish/haul), and bluntnose minnows (25.7 fish/haul) (Figure 4.3).

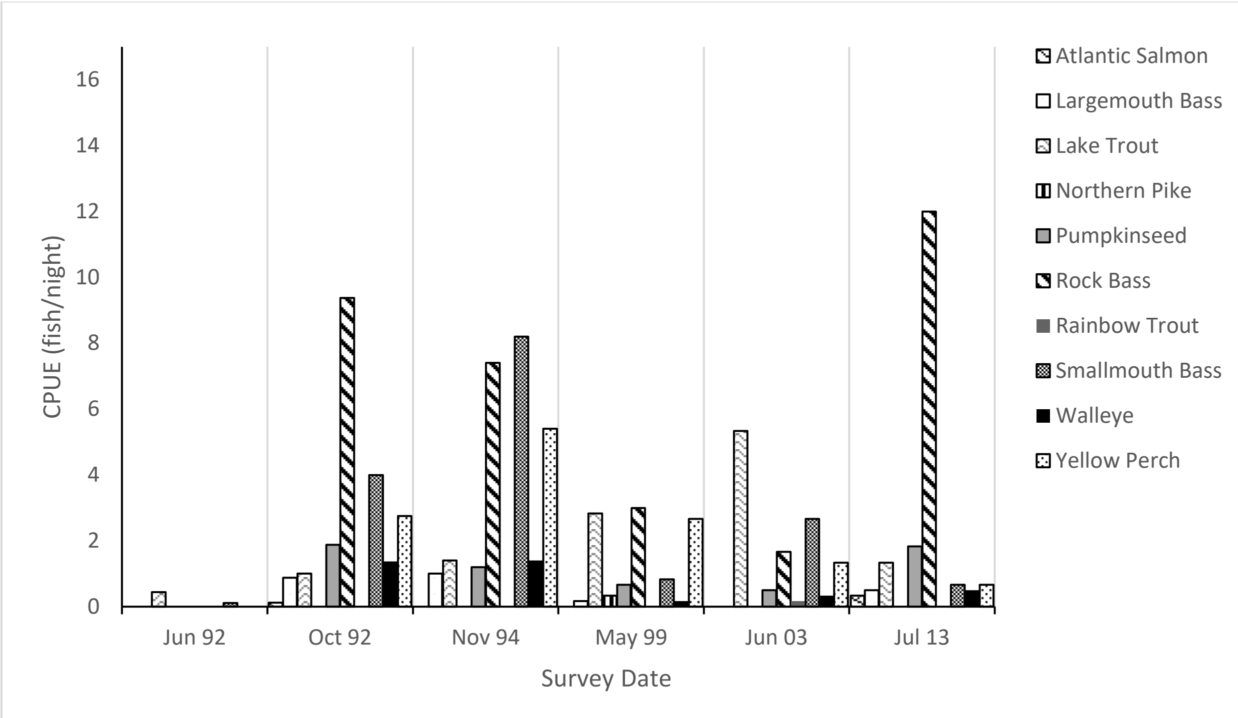

Figure 4.1 CPUE (fish/night) of fish species caught in gill nets in Sixberry Lake.

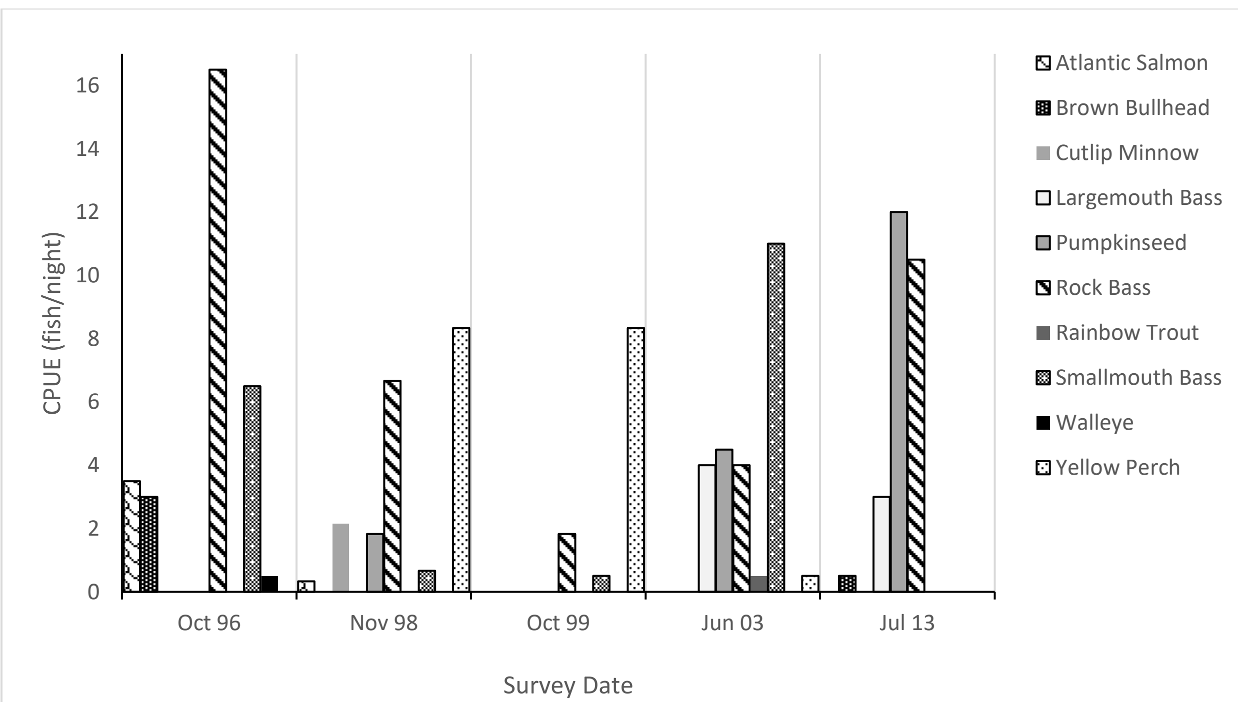

Figure 4.2 CPUE (fish/night) of fish species caught in hoop or trap nets in Sixberry Lake.

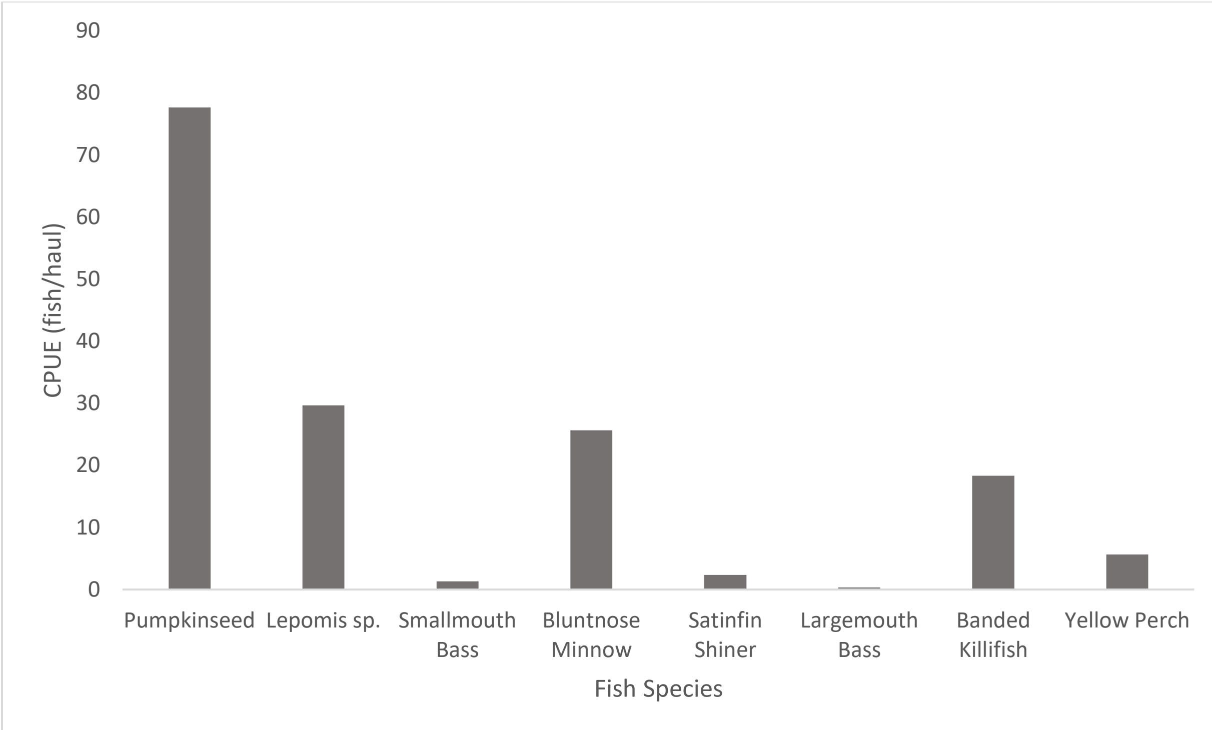

Figure 4.3 CPUE (fish/haul) of fish species caught in seine nets in Sixberry Lake in 2013.

The PSD_Q of largemouth bass, lake trout, pumpkinseed, rock bass, smallmouth bass, walleye, and yellow perch varied between years and between gear types (Table 4.4). There were only 8 instances across all surveys where the minimum required sample size of quality and stock fish need to calculate PSD_Q where captured (Green 1989). When examining across all surveys by gear type, there was sufficient sample size to calculate PSD_Q for five of the seven species captured in gill net surveys and one of the seven species captured in trap and hoop nets. When all surveys and all gear nets were combined, there was sufficient sample size to calculated PSD_Q for six species. There was insufficient sample size to properly calculated PSD_Q for walleye captured.

The predator PSD_Q (the average PSD_Q of walleye, lake trout, largemouth and smallmouth bass) was graphed against the prey PSD_Q (the average PSD_Q of yellow perch, rock bass, and pumpkinseed) for fish captured in gill nets, for those caught in hoop nets, and then the combination of fish captured in both gear types (Figure 4.4). Based on the results, the fishery is considered balanced between large and small fish, indicating that the system is at a "steady state", with consistent recruitment, growth, and mortality (Willis et al. 1993). The system appears unbalanced when considering fish captured in hoop nets only, which indicates that there may be a combination of high density, high recruitment, slow growth, and high mortality for predator species (Willis et al. 1993).

Table 4.4 Proportional Stock Densities (PSD_Q) of Common Fish Species in Sixberry Lake by survey date and gear type. "NA" denotes a species that was not captured in a survey. Values in bold indicate the minimum required sample size of quality and stock size fish were captured.

Survey	Gear Used	Species						
		Largemouth bass	Lake trout	Pumpkin - seed	Rock bass	Smallmouth bass	Walleye	Yellow perch
June 1992	Gill net	NA	100	NA	NA	100	NA	NA
October 1992	Gill net	50	100	71	**42**	87	45	**15**
November 1994	Gill net	75	100	0	**36**	95	83	0
October 1996	Trap net	NA	NA	NA	**32**	85	100	NA
November 1998	Trap net	NA	NA	100	NA	50	NA	NA
May 1999	Gill net	0	53	NA	44	60	100	NA
June 2003	Gill net	NA	96	67	64	93	100	0
July 2013	Gill and hoop nets	14	50	**51**	**47**	75	33	25
July 2013	Gill net	0	50	0	**53**	75	33.	25
July 2013	Hoop net	20	NA	75	**29**	NA	NA	NA
1992-2013	Gill net	46	**81**	**36**	**46**	**90**	61	**14**
1996-2013	Trap and Hoop net	20	NA	76	**31**	76	100	NA
1992-2013	Gill, Trap, and Hoop net	**39**	**81**	**53**	**43**	**88**	63	**14**

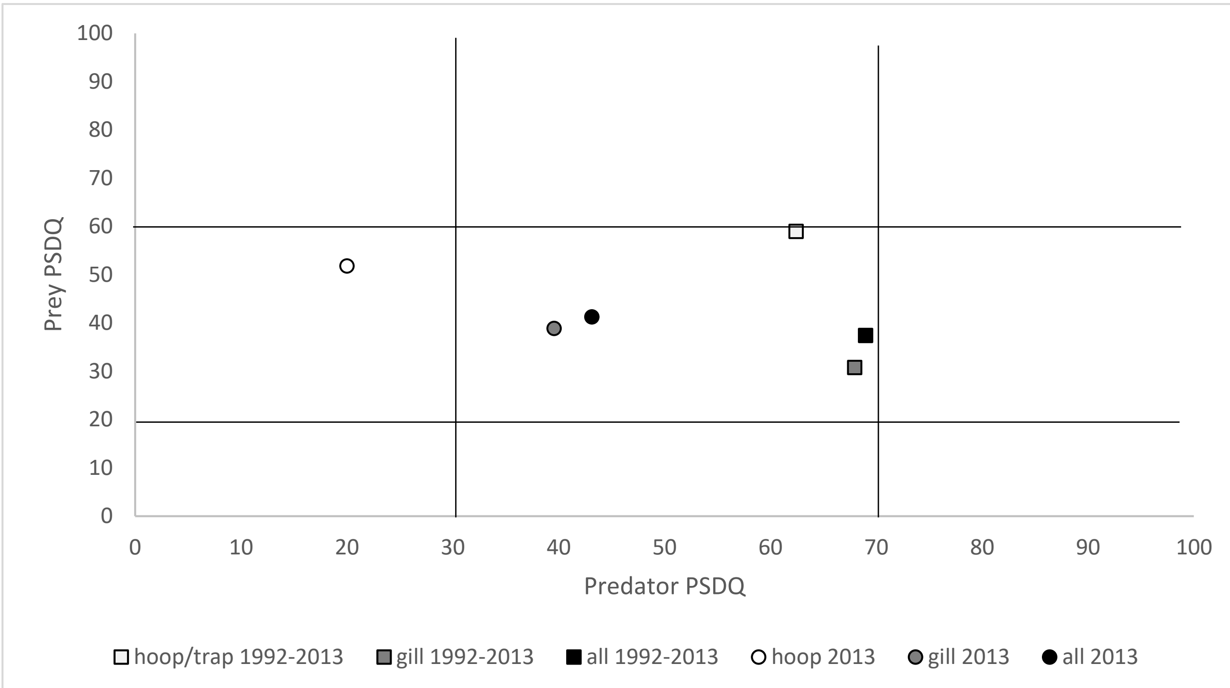

Figure 4.4 Predator PSD_Q as a function of Prey PSD_Q by gear type for fish captured between 1992 and 2013 and only in 2013.

4.3 Discussion

The surveys conducted between June 1992 and July 2013 occurred in different seasons (Table 4.2), making it challenging to draw comparisons between years due to seasonal effects on fish behavior and physiology (Hubert 1996; Pope and Willis 1996). Additionally, multiple gear types were used across these nine surveys (Table 4.2), and the gear selectivity and species catchability need to be taken into consideration when comparing survey results. For instance: all three styles of nets used select for fish species that move within a waterbody, but trap and hoop nets often select for fish species that swim along the shoreline over species that swim out in the middle of a lake. Additionally, the size of mesh used in nets effects the size of individual fish captured- larger mesh allows smaller fish to swim through without being caught. Thus, the variety of net styles used in surveys complicates the comparison of the fishery over time (Hubert 1996).

Trap and/or hoop nets, which are designed to select for littoral species (i.e. pumpkinseed and largemouth bass), captured more littoral fish species than gill nets (Figures 4.5 and 4.6). For the same surveys gillnets, which are set at depth, caught a wide variety of cool-water fishes such as walleye and smallmouth bass in addition to littoral species collected in hoop and/or trap nets (Figures 4.5 and 4.6). Both gear types collected a large number rock bass, which may be related to the abundance of rock bass in the lake. Each gear type provides a different perspective regarding species presence and abundance in the lake.

The combined CPUE for both gear types used in Sixberry Lake in 2013 (Figure 4.7) provides a similar overall picture for the individual CPUE values calculated for fish species captured in gill or trap nets in 2013 (Figure 4.6). However, notable differences between the CPUE values provided in the two figures may be attributed to the different levels of effort used between gear types.

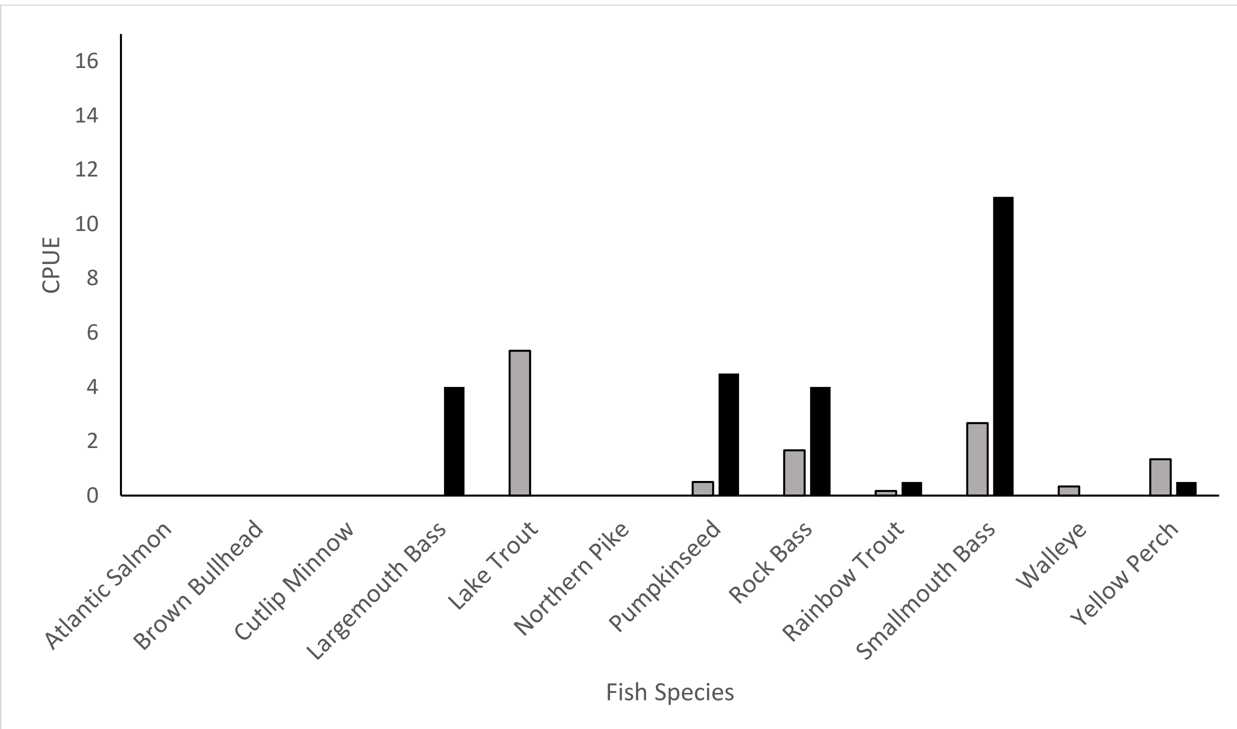

Figure 4.5 CPUE for fish species caught in gill (gray) and hoop or trap nets (black) in Sixberry Lake, June 2003.

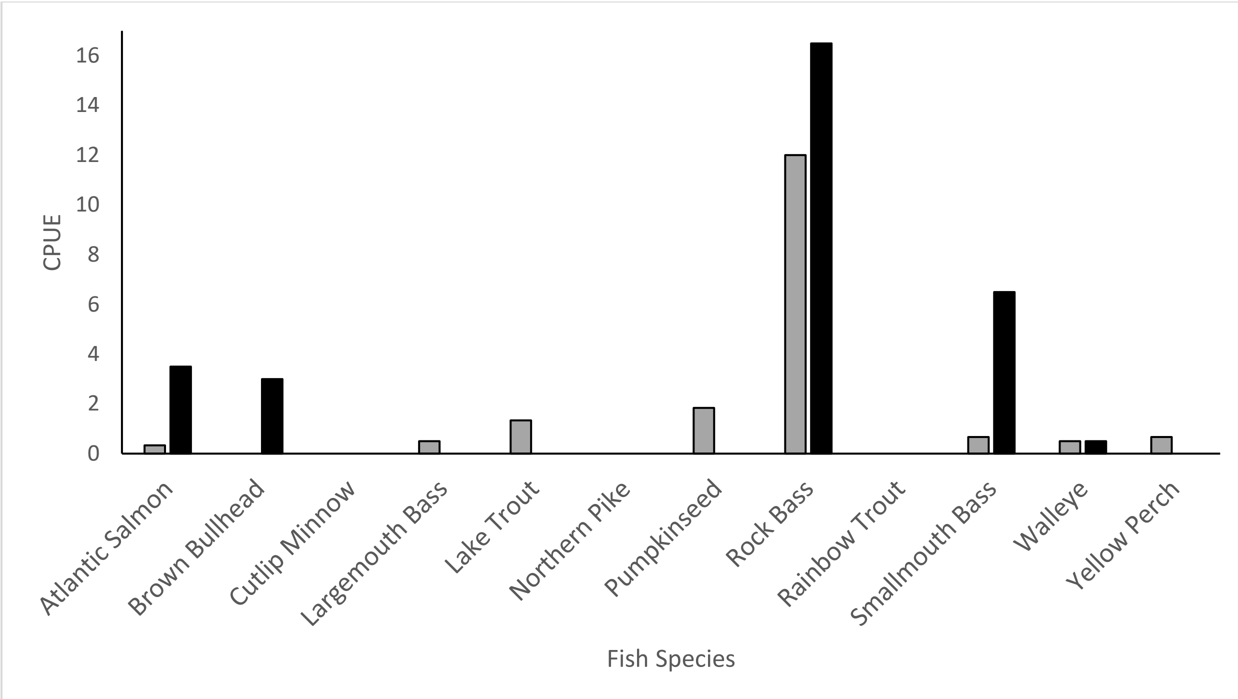

Figure 4.6 CPUE for fish species caught in gill (gray) and hoop nets (black) in Sixberry Lake, July 2013.

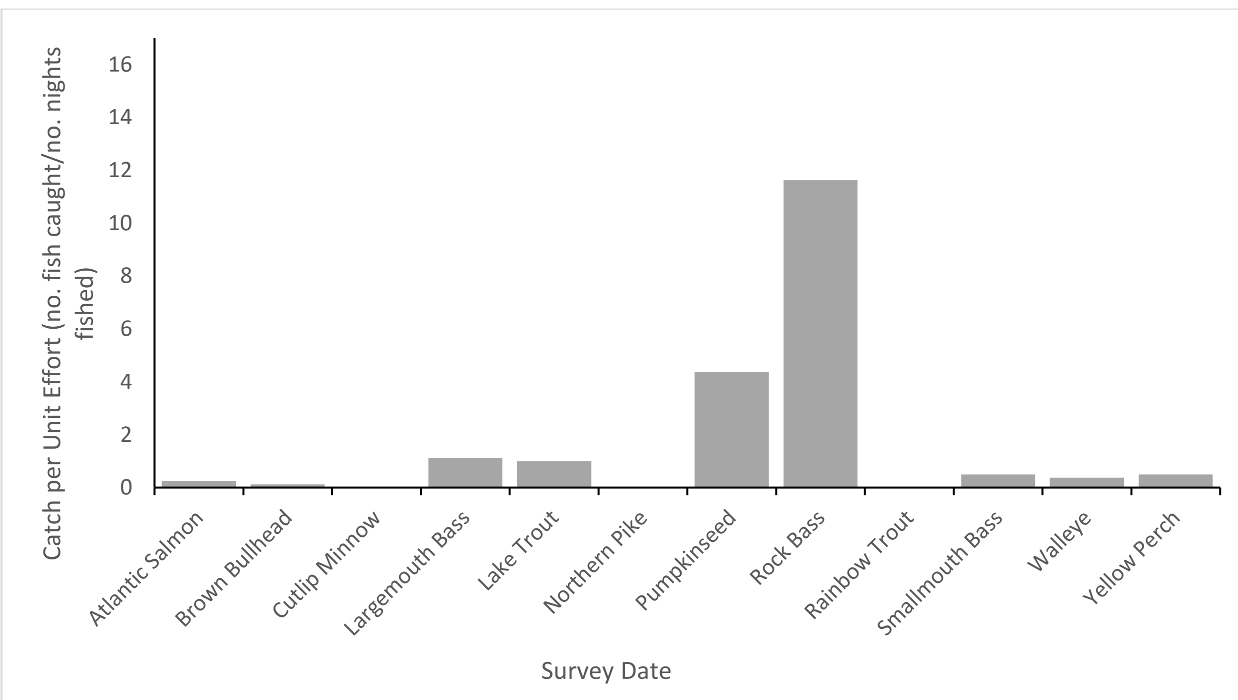

Figure 4.7 The combined CPUE for fish species caught in gill and hoop nets in Sixberry Lake, July 2013.

Sampling plans should be designed to account for seasonal and temporal patterns of salmonids. Previous studies have found that in general, CPUE of stock-length fishes caught in gill or trap nets can peak during the spring and fall. For example, walleye, a coolwater species, caught in sinking or experimental gill nets were found to have spring and fall peaks in mean CPUE (Pope and Willis 1996). For purposes of catching and managing walleye in the lake, it would be best to design a sampling plan for the spring or fall.

There is little information available on seasonal fluxes in CPUE of coldwater species (like lake trout)- one study found that Atlantic salmon had a peak in CPUE in fyke nets during the spring (Ryan 1984). In order to make up for a lack of scientific study, life history information can be used to design sampling plans. Lake trout prefer colder water temperatures and will move into surface and the shallower waters for spawning when water temperatures are below 15.56°C. This typically occurs between mid-October and mid-November (Johnson 2001). Sampling during the spawning season would be the most efficient method to capture adults of this species (Portt et al. 2006) as they move out of deeper waters into shore. Eggs typically hatch in April (Johnson 2001), so sampling with specialized emergent fry traps in April would provide some information on the recruitment of lake trout. Based on the literature on Atlantic salmon and the life history of lake trout (the only stocked salmonid that appears to naturally reproduce in Sixberry Lake) sampling in the spring or fall would most likely be most representative of salmonid species.

Furthermore, there is evidence of a general movement of fish species into deeper waters during the summer months (Hall et al. 1977). A study on a power plant cooling reservoir in South Carolina hypothesized that fish moved into deeper water in the summer, remaining there during late summer sampling because there was adequate D.O. and a thermal refuge (Barwick 1984). Sixberry Lake has similar limnological conditions. Lake trout prefer temperatures below 15.56°C and levels of D.O. above 6 mg/L (Johnson 2001). At the height of the summer in 2015: the top 7 m of lake exceeded 15.56°C, and only the bottom 6 m of the lake contained less than 6 mg/L of D.O. It is therefore likely that when water temperatures are nearer to the preferred temperature of lake trout, sampling in nearshore and near-surface waters will produce higher CPUE of salmonids.

As described above, the predator PSD_Q (the average PSD_Q of walleye, lake trout, largemouth and smallmouth bass) was graphed against the prey PSD_Q (the average PSD_Q of yellow perch, rock bass, and pumpkinseed) for fish captured in gill nets, for those caught in hoop nets, and then the combination of fish captured in both gear types. PSD_Q is the relative proportion of catchable fish that anglers would also consider of a 'quality' size, and is a method used to assess the status of a fishery based on a single species or a community of fishes with respect to values that have specific ecological interpretations. In a balanced fishery predator PSD_Q should be 30-70 and prey PSD_Q should be 20-60 (Willis et al. 1993). Based on the results, the fishery is considered balanced between large and small fish, indicating that the system is at a "steady state", with consistent recruitment, growth, and mortality (Willis et al. 1993). The system appears imbalanced when considering fish captured in hoop nets only, which indicates that there may be a combination of high density, high recruitment, slow growth, and high mortality for predator species (Willis et al. 1993). This may reflect the selectivity of hoop nets towards all three species included in PSD_Q calculations (Willis et al. 1993). Alternatively, this may simply indicate that hoop nets are not as efficient at capturing prey species as the gill net.

Future fish surveys should utilize multiple gear types in order to continue to describe the entire fish community of Sixberry Lake as a whole, since the use of multiple gear types helps overcome biases of individual passive gear types (Colombo et al. 2008) (see comparison of PSD_Q calculations incorporating multiple gear types in Table 4.4). For instance, past studies have found trap nets select for larger rock bass, walleye, yellow perch, and pumpkinseed (Laarman and Ryckman 1982), and depending upon the mesh size of gill nets used they can select against small fish (Hamley 1975). Additionally, the value of using a multi-geared approach is observed while looking at previous Sixberry Lake fishery surveys; gillnets appear to provide a more representative community sample than hoop nets, while hoop nets tend to target the littoral fish community and can provide hints at changes in assemblages over time. Finally, adding minnow traps to future surveys would improve the assessment by increasing capture of small, littoral fish species and young of year game species (Jackson and Harvey 1997) while adding little effort to the overall survey.

Chapter 5 Macrophytes and Algae

As discussed in the attached management plan (Appendix A) two surveys were distributed to determine lake related concerns of watershed property owners; one in 2014 and one in 2016. One of the major lake management concerns expressed by watershed property owners and addressed in the attached management plan is aquatic invasive species (AIS) (specifically the aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*) (EWM)). To date, the only AIS found in Sixberry Lake is EWM. Property owners surveyed expressed the views that both the undesirable introductions of plants and animals to Sixberry Lake were environmental problems and that EWM in the lake was a great concern. Most felt the established population of this plant (already in the lake) was a greater problem than introductions of new AIS or of new strains of EWM. Survey participants also considered macrophyte growth to be an environmental problem.

Between June and September 2015 a rake toss survey was conducted with the main purpose of cataloging floating leaved and submerged macrophyte species, and the location of EWM and/or any other AIS plant species. No aquatic macrophyte survey had been previously conducted in Sixberry Lake. A secondary purpose of the survey was to determine relative composition of the plant community observed and how this changed through the summer.

Lake-side residents also indicated in the 2014 survey that there had been an increase in algae over time and that they considered algae to be an environmental problem. When asked, lakeshore residents remembered seeing “clouds” of algae growing from the bottom up towards the surface near their docks. Algae that matched these residents’ memories was visible in the summer of 2015.

5.1 Methods

Macrophytes

Sites were chosen using the method recommended by Dr. Lamb and the CSLAP Monitoring Program (Lamb 2000, NYSFOLA and NYSDEC n.d.). A 100 m x 100 m dotted grid, where each dot in the grid represented a potential sample site, was imposed over a bathymetric map of the lake to result in an even distribution of sample sites (see Figure 5.1 for reference). This resulted in 29 potential sites in water shallower than twice the average SD (an estimate of the euphotic zone) on the bathymetric map (Figure 5.1, Table 5.1). If any of the sites chosen by the unbiased grid overlay were located on the shore next to the water or too deep due to the steepness of the shoreline, they were adjusted slightly so that sections of the shoreline would not be ignored.

Before plants were sampled, each site was visually assessed for aquatic vegetation density, presence of emergent, submergent, or floating-leaved macrophytes, and lake bottom (substrate) composition. Then, following the CSLAP aquatic plant sampling protocol, a double-sided rake on a 30-foot line was tossed three times from the site forming a y-shaped arrangement. The plants collected from all three tosses were grouped and then separated by species for identification.

Identification was made to species, whenever possible. Once identified, an estimate of percent composition of each plant type collected at each sample site was made. This method was repeated at each of the 29 preselected sites. Ten of these sites proved to be too deep to support plants.

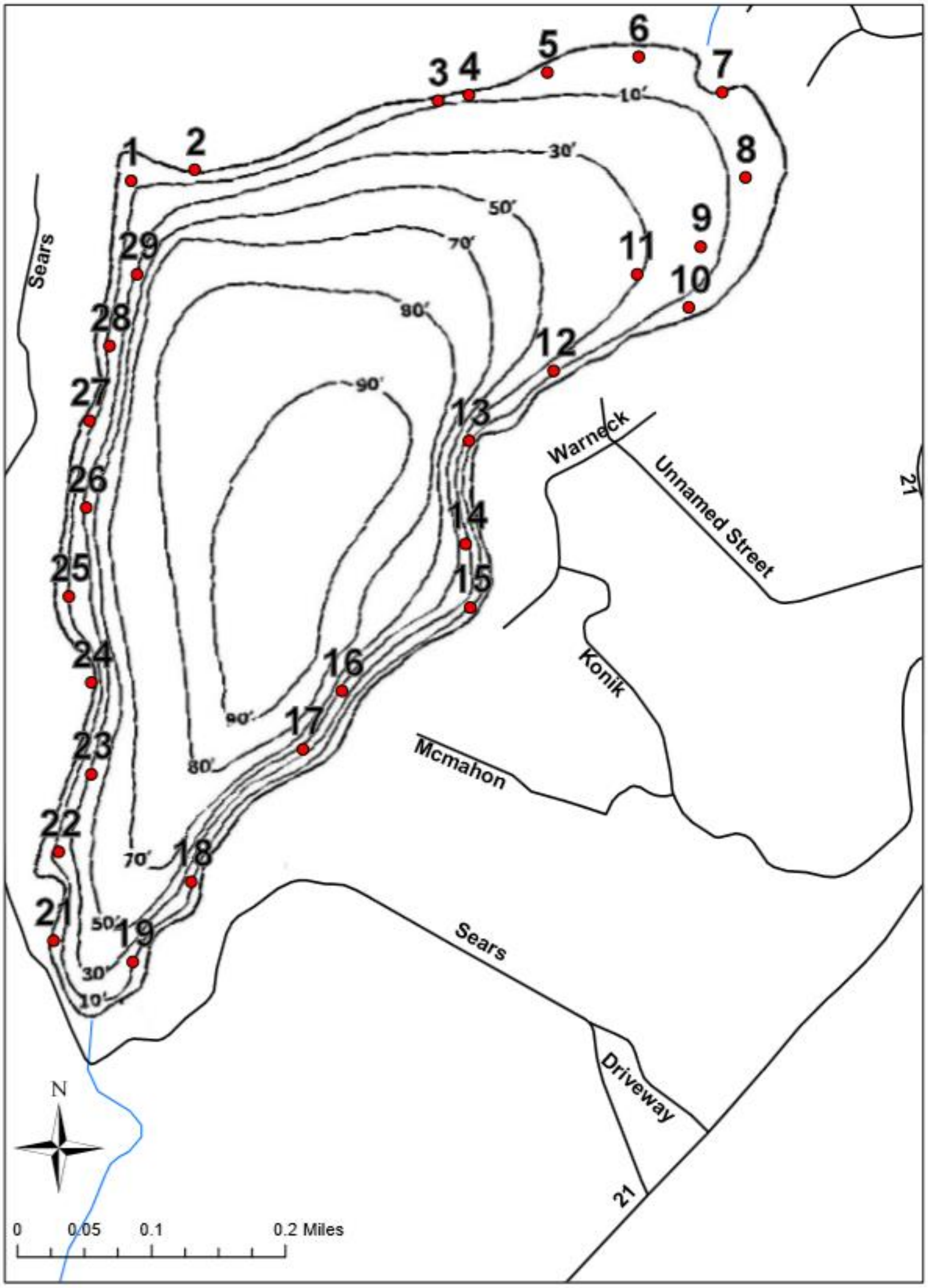

Figure 5.1 Map of the 29 sample sites potentially within the euphotic zone, determined by an overlay of 100 m x 100 m dotted grid (Lamb 2000, NYSDEC n.d., NYSFOLA and NYSDEC n.d.).

Table 5.1 Macrophyte Sample Site Coordinates.

Site No.	Coordinates (New York State Plane) Eastings	Northings	Water Depth at Site (m)
1	437904	4903546	4.2
2	437980	4903559	4.4
3	438272	4903642	3.0
4	438309	4903649	2.0
5	438403	4903676	5.5
6	438513	4903695	3.2
7	438613	4903652	1.2
8	438641	4903556	3.0
10	438573	4903394	4.1
12	438411	4903318	5.2
13	438305	4903234	4.6
14	438305	4903110	3.7
17	438110	4902864	2.1
18	437976	4902705	3.2
19	437906	4902609	1.5
22	437817	4902741	5.2
25	437829	4903047	4.6
27	437854	4903258	4.0
28	437878	4903348	4.6

Algae

In September 2014 a shoreline resident documented a planktonic algae “cloud” in the cove in front of their dock that lasted for approximately two days. The resident took photographs of the bloom and took water samples of the algae for identification; these samples were provided.

“Clouds” of algae were observed growing from the bottom up towards the surface near their docks in the summer of 2015. Two samples from a single site were taken, one was submitted taken and submitted to CSLAP on August 2, 2015 and one sample was collected on August 8, 2015 and brought back to the Biological Field Station for examination.

5.2 Results

Macrophytes

A total of 25 different species were observed and/or collected (Table 5.2), including the invasive EWM. Typha sp. was observed outside of the survey, but was not identified to species. The most frequent macrophyte collected in June was EWM, in August Najas flexilis and in September Nitella sp. (Table 5.3). EWM was present in all sampled locations and the percent relative abundance of plants observed changed throughout the season (Table 5.4) and the relative percent abundance of EWM decreased during the 2015 growing season compared to the combined relative abundance of all native aquatic plants species observed (Figure 5.2).

Table 5.4 Analysis of deviance table for the general linear model used to test for differences in relative abundance between dates and species

	LR Chisq	DF	PR(>Chisq)
Species	12.0163	1	0.0005274 ***
Date	0.0000	2	1.0000000
Species : Date	7.2403	2	0.0267792 *

Significance codes: 0 ‘***’, 0.01 ‘*’

Figure 5.2 Rake Toss Survey Results. Three rake toss surveys were conducted over the course of the summer 2015. Sixteen sites were surveyed in June and 19 sites were surveyed in August and September. For each survey site, the relative percent abundance of Eurasian watermilfoil and native plant species observed in the rake toss was calculated.

Table 5.2 Macrophytes observed and/or collected during the three rake toss surveys in 2015. Borman et al. 1997 was used for taxonomic identification.

Macrophytes		Survey Date		
Order	Genus and Species	6/25/2015	8/7/2015	9/11/2015
Charlaes	*Chara* sp.	N	Y	Y
	Nitella sp.	Y	Y	Y
Isoetales	*Isoetes* sp.	Y	Y	Y
Nymphaeales	*Nuphar advena*	O	N	N
Alismatales	*Elodea Canadensis*	Y	N	Y
	Najas flexilis	N	Y	Y
	Potamogeton amplifolius	Y	Y	N

Table 5.2 Macrophytes observed and/or collected during the three rake toss surveys in 2015. Borman et al. 1997 was used for taxonomic identification.

Macrophytes		Survey Date		
Order	Genus and Species	6/25/2015	8/7/2015	9/11/2015
	Potamogeton diversifolius	Y	N	N
	Potamogeton foliosus	N	Y	N
	Potamogeton gramineus	N	Y	Y
	Potamogeton illinoensis	N	Y	Y
	Potamogeton pusillus	N	Y	Y
	Potamogeton robbinsii	Y	Y	Y
	Potamogeton zosteriformis	N	Y	N
	Sagittaria graminea	Y	N	N
	Sagittaria latifolia	O	O	O
	Vallisneria Americana	Y	Y	Y
Ceratophyllales	*Ceratophyllum demersum*	Y	Y	Y
Commelinales	*Pontederia cordata*	O	O	O
Lamiales	*Utricularia* sp.*	N	Y	Y
Poales	*Eriocaulon* sp.	N	O	O
	Juncus effuses	O	O	O
	Typha sp.	O	O	O
Ranunculales	*Ranunculus aquatilis*	Y	Y	Y
Saxifragales	*Myriophyllum spicatum*	Y	Y	Y
	Total number of macrophyte types observed or collected	17	23	21

*The *Utricularia* sp. observed was not identified to species, but was identified as not being the known invasive species, *Utricularia inflata*.

KEY

Y = Collected and observed

N = Neither collected nor observed

O = Only observed, not collected

Table 5.3 Aquatic vegetation of Sixberry Lake for 2015.

	Survey Date					
	6/25/2015		8/7/2015		9/11/2015	
Macrophytes	Frequency (%)	Relative Frequency (%)	Frequency (%)	Relative Frequency (%)	Frequency (%)	Relative Frequency (%)
Chara sp.	0	0	36.8	7.4	15.8	2.8
C. demersum	15.8	5	5.3	1	5.3	0.9
E. canadensis	26.3	8.3	21	4.2	26.3	4.7
Isoetes sp.	10.5	3.3	15.8	3.2	10.5	1.9
M. spicatum	73.7	23.3	68.4	13.7	89.5	16
N. flexilis.	0	0	78.9	15.8	73.7	13.2
Nitella sp.	42.1	13.3	68.4	13.7	94.7	17
P. amplifolius	15.8	5	10.5	2.1	0	0
P. diversifolius	31.6	10	0	0	0	0
P. foliosus	0	0	21	4.2	0	0
P. gramineus	0	0	15.8	3.2	47.4	8.5
P. illinoensis	0	0	10.5	2.1	36.8	6.6
P. pusillus	0	0	26.3	5.3	31.6	5.7
P. robbinsii	42.1	13.3	42.1	8.4	42.1	7.5
P. zosteriformis	0	0	5.3	1.1	0	0
R. aquatilis	10.5	3.3	5.3	1.1	5.3	0.9
S. graminea	10.5	3.3	0	0	0	0
Utricularia sp.*	0	0	47.4	9.5	42.1	7.5
V. americana	36.8	11.7	21	4.2	26.3	4.7
Z. dubia	0	0	0	0	10.5	1.9

*The *Utricularia* sp. observed was not identified to species, but was identified as not being the known invasive species, *Utricularia inflata*.

Table 5.4 Analysis of deviance table for the general linear model used to test for differences in relative abundance between dates and species

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Species	12.0163	1	0.0005274 ***
Date	0.0000	2	1.0000000
Species : Date	7.2403	2	0.0267792 *

Significance codes: 0 '***', 0.01 '*'

Algae

The sample from the nearshore algae "cloud" document by a resident in September 2014 confirmed that the algae observed had been a cyanobacteria consisting of *Mycrocystis* sp. and *Dolichospermum* sp.

The sample collected from the "clouds" of algae in 2015 and sent to CSLAP contained *Microcystis* sp., *Aphanizomenon* sp., filamentous green algae, and sparse *Lyngbya* sp. with blue green Chl. *a* levels of 51 µg/l (above the NYSDEC criteria of 25-30 µg/l blue green Chl. *a*), indicating an algal bloom (Kishbaugh 2015, NYSFLOA and NYSDEC 2016a). The sample of the same algae brought back to the Biological Field Station contained *Mougeotia* sp (likely the same filamentous green mentioned above), *Gleotrichia* sp., *Lyngbya* sp., and *Dolichospermum* sp. Fluroprobe data for open water samples collected in 2015 as part of the CSLAP program indicated low levels of total algae and low blue green algae (NYSFLOA and NYSDEC 2016a).

5.3 Discussion

Macrophytes

Macrophytes provide important ecological services in a lake environment in that they serve as habitat and refuge for fish, macroinvertebrates, and zooplankton, and stabilize sediments in the nearshore environment (Holdren et al. 2001). As discussed in the attached management plan (Appendix A), the establishment of invasive aquatic plant species, specifically EWM, has been found to negatively impact navigation, swimming, and fishing; reduce property values; degrade water quality; alter food web interactions; increase decomposing material within lakes; and change the chemistry of sediments (Madsen 2014a). The Council for Agricultural Science and Technology (CAST) also found that EWM invasions may also have more than just biological consequences, and EWM invasions of waterbodies have resulted in a 20 to 40% average decrease in lakefront house values (CAST 2014).

While there were established beds of EWM present in the 2015 survey of Sixberry Lake, there were also a lot of native aquatic plant species, which informed the development of the attached management plan (Appendix A). Management strategies that were incorporated in the plan are ones that can be applied on a smaller scale (i.e. not necessarily lake-wide), in order to target EWM and avoid native plant species.

Algae

As with macrophytes, algae serve important ecological roles in lakes and are a source of food for fish, macroinvertebrates, and zooplankton. Algae become a management concern when it is present in overabundance, reducing water clarity, producing (harmful) algal blooms, depleting dissolved oxygen, as well as leading to other water quality concerns (Holdren et al. 2001).

The water sample from the bloom in September 2014 contained two species of cyanobacteria, making it the first documented cyanobacteria algae bloom in Sixberry Lake. Both *Mycrocystis* sp. And *Dolichospermum* sp. have the potential to produce cyanotoxins, which are harmful to people and animals (Rosen and St. Amand 2015).

As discussed further in the attached management plan (Appendix A), increased algal growth is a common sign of increased nutrients and is associated with declining water quality. Other factors such as a change in the zooplankton community and increased annual water temperature also contribute to increased algal growth, however these parameters were not investigated as part of this study. A small increase in available nutrients coupled with higher summer temperatures can give a competitive advantage to cyanobacteria and can result in apparent changes in algal growth (Indiana University 2019; University of Florida 2018). At Sixberry Lake it is likely that external nutrient sources are non-point source nutrient pollution from eroding shorelines, lawn care practices, and on-site septic systems (NYSDEC 2005). Non-point source watershed management strategies identified to reduce nutrients entering the lake are described in the management plan (Appendix A).

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APPENDIX A

SIXBERRY LAKE WATERSHED AND LAKE MANAGEMENT PLAN

SIXBERRY LAKE WATERSHED AND LAKE MANAGEMENT PLAN

Town of Theresa, Jefferson County, New York

Sixberry Lake Association

Indian River Lakes Conservancy

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Suggested Attachments

1.0 Introduction

Sixberry Lake is a public lake located in Jefferson County, NY, approximately 8.1 miles (mi.) (13 kilometers [km.]) away from the St. Lawrence River. The lake is part of the Indian River Lakes region, a network of 18 natural lakes and the Indian River; 17 of these lakes are within the Saint Lawrence River Watershed. This dimictic, oligotrophic lake has a maximum depth of about 107 ft. (32.6 m.) with much of the incoming water believed to be from ground water sources (as opposed to precipitation and upstream waterbodies). It has a mean depth of 63.81 ft. (19.5 m.) and a surface area of 128.29 ac. (51.9 ha.), and one main basin (see Figure 1). The lake is classified by the New York State Department of Environmental Conservation (NYSDEC) as a Class B waterbody. Designated uses of Class B waterbodies are contact recreation activities, fishing, and fish and wildlife propagation and survival (CRR-NY 701.7). A summary of these characteristics is provided in Table 1.

Historically Sixberry Lake was managed for cool- and cold-water fisheries. The waterbody has been stocked with lake trout (*Salvelinus namaycush*), landlocked salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), walleye (*Sander vitreus*), and smallmouth bass (*Micropterus dolomieu*) (Klindt 2013). Lake trout, rainbow trout, and landlocked salmon have been stocked by the NYSDEC since 2005. Lake trout also reproduce in the lake naturally (Klindt 2013). Dissolved oxygen concentrations and temperatures in the lake support this cold water fishery year-round.

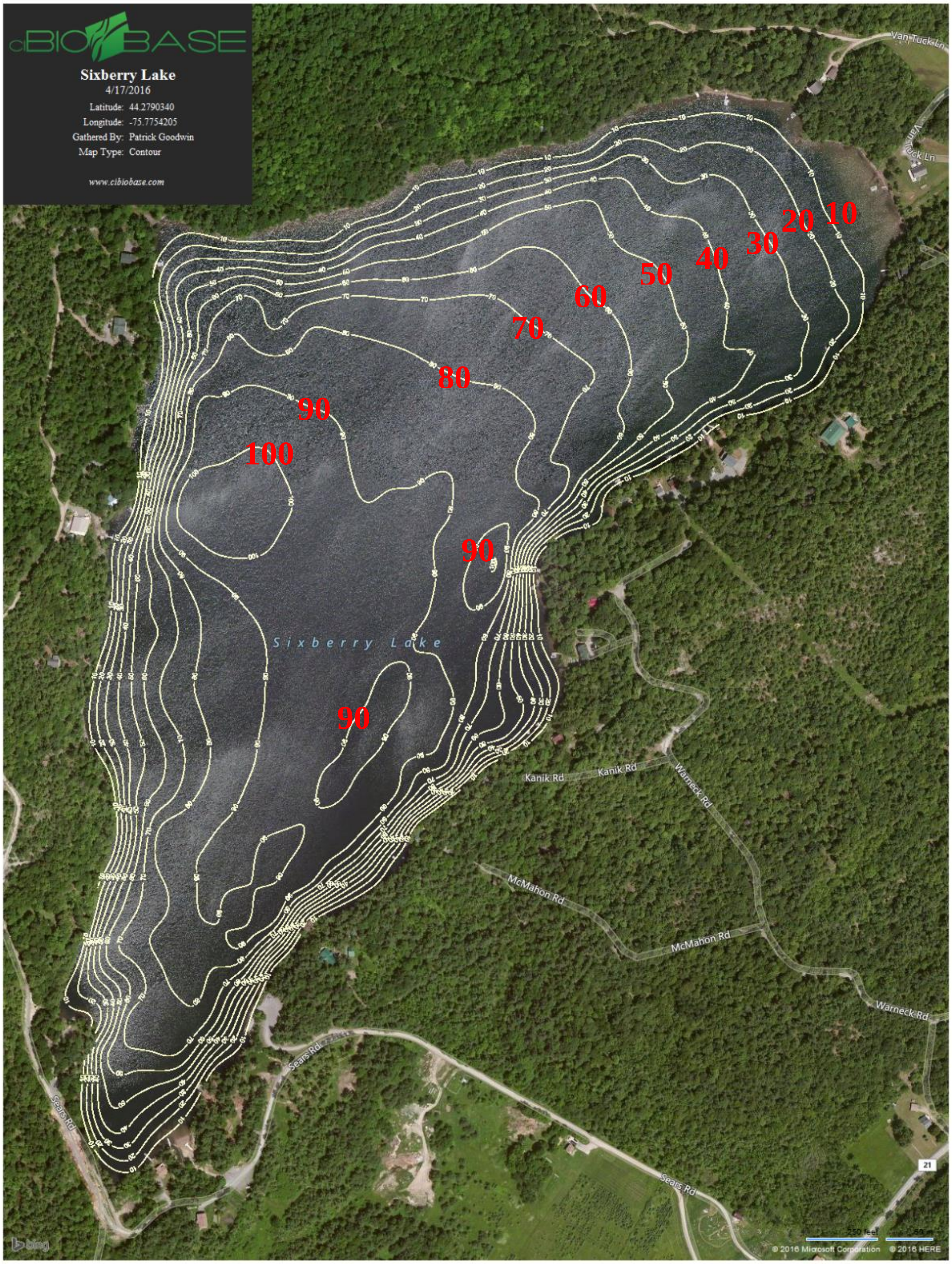

Figure 1. Updated Bathymetric Map of Sixberry Lake.

Table 1 Characteristics of Sixberry Lake used in management decisions.

Characteristic	Units (standard)	Units (metric)
Elevation (above sea level)	344.5 feet (ft.)	105 meters (m)
Surface Area	128.3 acres (ac.)	51.9 hectares (ha)
Max Depth	107.1 ft.	32.6 m
Mean Depth	63.8 ft.	19.5 m
Volume	7,765.10 ac. ft.	9,578,095.6 cubic meters (cu. m.)
Shoreline Length	2.2 miles (mi)	3.6 kilometers (km)
Watershed Area	864.87 ac.	350 ha
Watershed to Lake Ratio	350 : 52	
Retention Time	4.5 years	
Water Quality Classification (NYSFOLA 2005)	B	
Trophic State Index (Carlson 1977) (mean of annual means from 2001-2004 & 2014-2015)[1]	34.2 classified as an oligotrophic lake with clear water and periods of low hypolimnetic dissolved oxygen[2]	

Prior to the start of this study, the most recent water quality documentation was undertaken in the summer of 2004 as part of the Citizen Statewide Lake Assessment Program (CSLAP). Although about 1/3 of the 864.87 ac. (350 ha) watershed is used in residential development or agriculture (see Table 2, Figure 2), the lake had not undergone obvious anthropogenic eutrophication[3] by 2004 (NYSDEC 2005). According to the personal observations reported in a survey of watershed property owners, there has been an increase in algae, and the first noted occurrence of a blue green algal bloom was in September 2014. Such reports from residents raise the question of whether or not the lake may be transitioning from an oligotrophic into a mesotrophic state. To investigate this possibility, between October 2014 and March 2016, watershed characteristics were studied and Chlorophyll *a* (Chl. *a*), total phosphorus, nitrogen, and water transparency data were collected for the lake (except for Chl. *a*, which was first collected in April 2016).

[1] See State of Lake Report Section 3.2 for calculation of Trophic State Index value
[2] Hypolimnetic dissolved oxygen: the amount of dissolved oxygen in the layer of water at the bottom of the lake (hypolimnion)
[3] Anthropogenic eutrophication: the process of physical, chemical, and biological changes in a waterbody resulting from the addition of nutrients from human activities (Holdren et al. 2001)

Table 2 Composition of land cover and use within the Sixberry Lake Watershed (Homer et al. 2015).

Land Cover and Use				Combined
Category	Class	Acres	Percent Cover (%)	Category Totals (%)
Forested	Deciduous Forest	335.7	38.82	55.94
	Evergreen Forest	82.4	9.53	
	Mixed Forest	65.6	7.58	
Agriculture	Hay/Pasture	122.5	14.16	22.59
	Cultivated Crops	72.9	8.43	
Developed	Developed, Low Intensity	21.2	2.45	9.64
	Developed, Medium Intensity	13.0	1.50	
	Developed, High Intensity	5.82	0.67	
	Developed, Open Space	43.4	5.02	
Herbaceous/Grassland	Herbaceous	8.1	0.93	0.93
Wetland	Woody Wetlands	55.3	6.39	7.42
	Emergent Herbaceous Wetlands	8.9	1.02	
Shrub/Scrub	Shrub/Scrub	27.6	3.19	3.19
Barren Land	Barren Land	2.2	0.25	0.25
Unclassified	Unclassified	0.3	0.03	0.03

Two citizen groups were involved with the development of this management plan: The Sixberry Lake Association (SLA), a citizens group with voluntary membership for lakeside property owners, and The Indian River Lakes Conservancy (IRLC), a non-profit land trust. Although both groups are concerned about in-lake problems at Sixberry Lake, the IRLC has a broader mission that encompasses many waterbodies throughout the Indian River Lakes Region of upstate New York while the SLA is focused only on Sixberry Lake. Thus, this final management plan is designed to balance needs of both organizations and to provide effective, long-term guidance for all stakeholders vested in the management of Sixberry Lake.

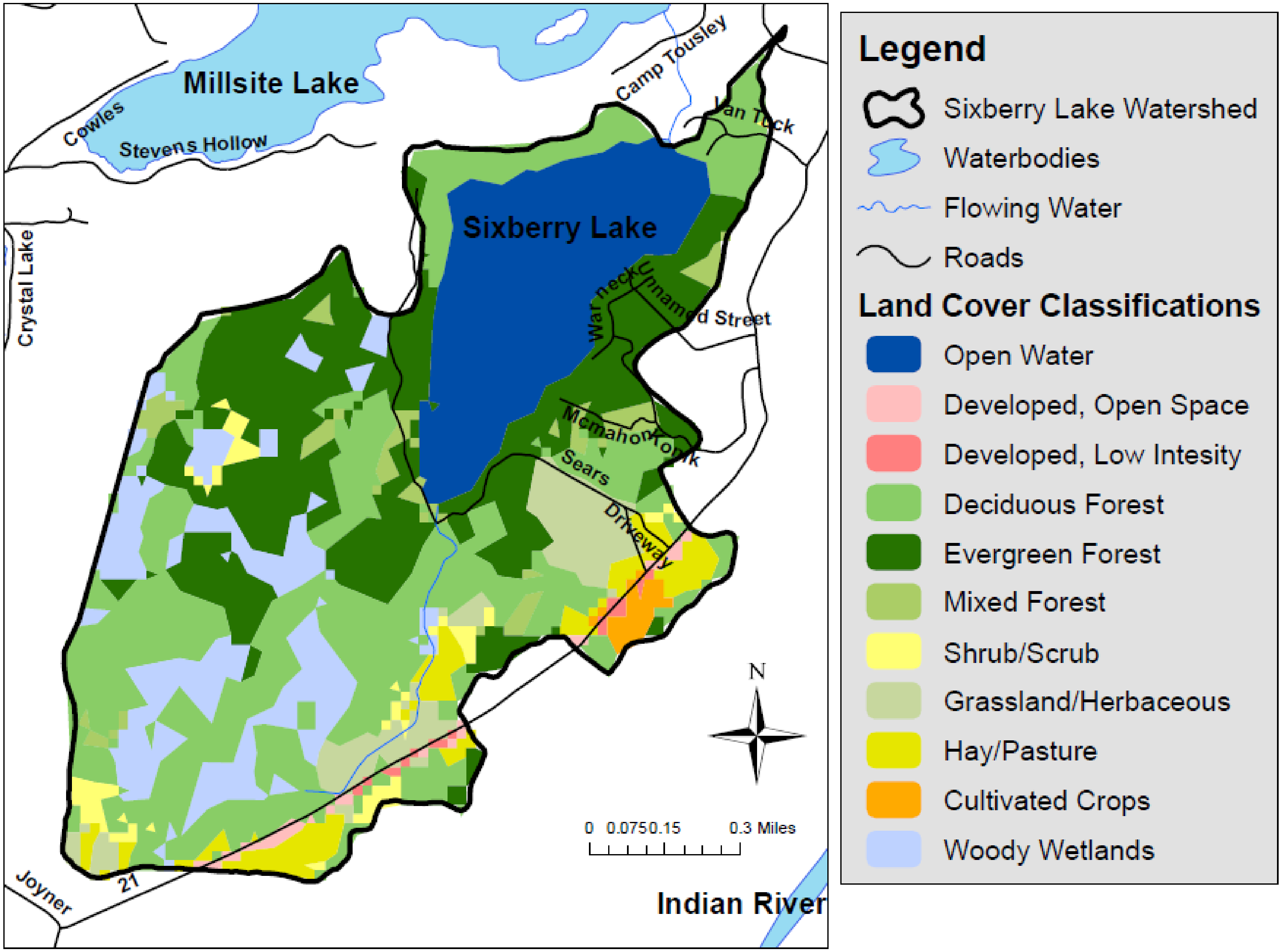

Figure 2. Land cover and use in the Sixberry Lake watershed, based on the 2011 National Land Cover Database (Homer et al. 2015)

2.0 Concerns of Stakeholders, Lake Management Goals and Objectives

To determine lake related concerns of watershed property owners, two surveys were distributed; one in 2014 and one in 2016. The 2014 survey was mailed to 42 homes with addresses collected using tax records, and thirty households responded. The 2016 survey was accessible on SurveyMonkey.com and distributed via email by the Sixberry Lake Association; it was completed by 15 property owners.

Concerns expressed by survey participants were often symptoms of underlying "lake-health" problems. Using information gathered from watershed maps and in-lake sampling, the likely causes of these symptoms were determined. Through consultation with the SLA, wishes of property owners, review of available limnological records, and the limnological qualities documented as part of the development of this management plan, specific management techniques were identified that can be used to address these underlying problems.

The major lake management concerns addressed in this plan are aquatic invasive species (specifically Eurasian watermilfoil (*Myriophyllum spicatum*) (EWM)), preservation of existing water quality, and control of water levels. These broad topics encompass other stakeholder concerns including increased algal growth and shoreline erosion. For each management concern, management Objectives and Goals have been outlined in the following sections. Each objective has a specific goal, which can be measured to determine success. Table 3 provides quantitative thresholds (goals) for specific lake management objectives and concerns and how they relate to NYS regulations.

Table 3. Sixberry Lake management objectives and goals.

Parameter	6 CRR-NY 703 Water Quality Standards for Class B fresh surface waters	Trophic Status Indicators: Oligotrophic* Lake	Current Condition	Management Concern, Objective	Management Goal
Dissolved Oxygen (D.O.)	The D.O. cannot be less than 4.0 mg/ L and the minimum daily average cannot be less than 5.0 mg/L	None.	On days sampled, the minimum daily average for the entire water column was greater than 5.0 mg/L. In October, the hypolimnetic D.O. dropped below 4.0 mg/L at depths greater than 20 meters.	<u>Concern:</u> Preserving Water Quality <u>Objective:</u> Encourage Best Management Practices (BMPs) to reduce non-point source pollution	D.O. throughout the water column should exceed 5.0 mg/L to provide year-round fish habitat and limit nutrient introductions into the water column from the lake bottom. Achieved through control of nutrients entering the lake from the watershed.
Total Phosphorus	No amount that will result in the growth of algae, weeds and slimes, which will impair the waterbody for its best usages. Additionally, NYSDEC uses a statewide maximum of 0.02 mg/L for total phosphorus.	Surface total phosphorus is less than 0.01 mg/L.	On days sampled, surface total phosphorus exceeded 0.01 mg/L during periods associated with spring snow melt. Anecdotal evidence suggests there has been an increase in algae and plant growth. Total phosphorus measured in bottom waters with low D.O. may be indicative of internal loading. All samples taken from the inlet exceeded 0.02 mg/L.	<u>Concern:</u> Preserving Water Quality <u>Objective:</u> Encourage BMPs to reduce non-point source pollution	Surface total phosphorus should not exceed 0.01 mg/L; total phosphorus measured in bottom waters during periods of low D.O. shall not continue to increase between years; total phosphorus measured in the inlet shall not exceed 0.02 mg/L.

Table 3. Sixberry Lake management objectives and goals.

Parameter	6 CRR-NY 703 Water Quality Standards for Class B fresh surface waters	Trophic Status Indicators: Oligotrophic* Lake	Current Condition	Management Concern, Objective	Management Goal
Aquatic Invasive Species	None.	None.	Eurasian watermilfoil represented 25 % of plants sampled from June to Sept.	<u>Concern:</u> The Threat of Aquatic Invasive Species <u>Objective:</u> Control of in-lake population of Eurasian watermilfoil	Eurasian watermilfoil should not exceed 25 % of plants sampled each year between June and Sept. No new introductions of aquatic invasive species.
				<u>Concern:</u> The Threat of Aquatic Invasive Species <u>Objective:</u> Prevention of further AIS introduction	No new successful introductions of EWM or other AIS
Algal growth (planktonic), measured as chlorophyll *a*	None.	Surface chlorophyll *a* does not exceed 2 µg/l.	Chlorophyll *a* measured at 2 m depth exceeded 2 µg/L in the spring, late fall, and early winter prior to ice on.	<u>Concern:</u> Preserving Water Quality <u>Objective:</u> Encourage BMPs to reduce non-point pollution	Chlorophyll *a* measured at 2 m and/or at the surface should not exceed 2 µg/l.

Table 3. Sixberry Lake management objectives and goals.

Parameter	6 CRR-NY 703 Water Quality Standards for Class B fresh surface waters	Trophic Status Indicators: Oligotrophic* Lake	Current Condition	Management Concern, Objective	Management Goal
Fishery	None.	None.	The lake currently supports a cold- and coolwater fishery.	Concern: Preserving Water Quality Objective: Encourage BMPs to reduce non-point pollution	Habitat for cool- and coldwater fishes will be protected through management activities aimed at total phosphorus, total nitrogen, D.O., and planktonic algae.
KEY * = an oligotrophic lake has low productivity due to low availability of nutrients, which leads to low chlorophyll *a*					

2.1 <u>Management Concern:</u> The threat of Aquatic Invasive Species

For this management plan, an aquatic invasive species (AIS) is defined as any plant, algae, animal, fungus, bacteria, or virus that is not native to Sixberry Lake and can harm humans or degrade the environment. Aquatic Invasive Species threaten diversity and abundance of native species and can be harmful to human health and potentially cause economic and environmental harm (Aquatic Nuisance Species Task Force 2016, NYSFOLA 2009). Within lakes, they are also known to negatively impact navigation, swimming, and fishing; reduce property values; degrade water quality; alter food web interactions; increase decomposing material within lakes; and change the chemistry of sediments (Madsen 2014a). To date, the only AIS found in Sixberry Lake is the aquatic plant EWM. Property owners surveyed expressed the views that both the undesirable introductions of plants and animals to Sixberry Lake were environmental problems and that EWM in the lake was a great concern. Most felt the established population of this plant (already in the lake) was a greater problem than introductions of new AIS or of new strains of EWM.

Eurasian watermilfoil is an aquatic plant originally from Eurasia and was most likely introduced to North America in a number of locations through a combination of discharged ship ballast and use as an ornamental plant in aquaria and water gardens (Madsen 2014b; Pfingsten et al. 2016). Eurasian watermilfoil was first documented in the United States in 1881 in the Potomac River, Virginia. Since then, the plant has been recorded in 48 States (excluding Hawaii and Wyoming), Washington, D.C., and the Canadian Provinces of British Columbia, Ontario, and Quebec (Pfingsten et al. 2016).

This invasive aquatic plant roots in the sediment and grows up to the water's surface where it can form dense mats. The leaves are featherlike in appearance and whorled around the stem, usually in sets of 4 leaves per whorl, see Figure 3. (Aquatic Nuisance Species Task Force 2016).

Eurasian watermilfoil grows earlier in the year and faster than many native aquatic plants, enabling the plant to reach the water's surface quickly and block sunlight from reaching native plants below. After flowering in mid-June and late-July, the plant produces roots along its stem and then breaks off into pieces, each of which can take root and colonize a new area. Fragments of EWM are commonly spread between waterbodies attached to boats, trailers, and other water craft equipment (Pfingsten et al. 2016), which presents a substantial management challenge.

Figure 3. Photos of Eurasian watermilfoil. A bed of EWM found in Sixberry Lake (left) and a close up of an individual plant (right).

In other lakes invaded by EWM, the plant has grown to such abundance that it interferes with swimming, fishing, and boating. Infestations of EWM may cause periods of low dissolved oxygen in the water, influence the water pH, reduce the natural currents within a lake, and increase turbidity of the water (Madsen 2014b).

Eurasian watermilfoil invasions also have negative impacts on fish and wildlife. As native aquatic plants disappear, waterfowl that rely on aquatic plants for food are forced to eat EWM, which is a lesser quality food source than preferred native plants. Dense beds of EWM support lower abundance and diversity of aquatic invertebrates, a source of food for many fish species. Predatory fish are less effective at finding their food in dense areas of the invasive plant (Pfingsten et al. 2016).

Eurasian watermilfoil invasions may have more than just biological consequences; through a literature review, the Council for Agricultural Science and Technology (CAST) found EWM invasions of waterbodies resulted in a 20 to 40% average decrease in lakefront house values (CAST 2014).

Based on plant surveys conducted in June, August, and September 2015, EWM was present in all sampled locations (Figure 4) and the relative percent abundance of EWM decreased during the 2015 growing season compared to the combined relative abundance of all native aquatic plants species observed (Figure 5). To preserve and protect the water quality, fishery, aesthetics, and recreational usage of Sixberry Lake, several management options have been identified for the control of this exotic. No method is perfect and each has some associated risks (NYSFOLA 2009).

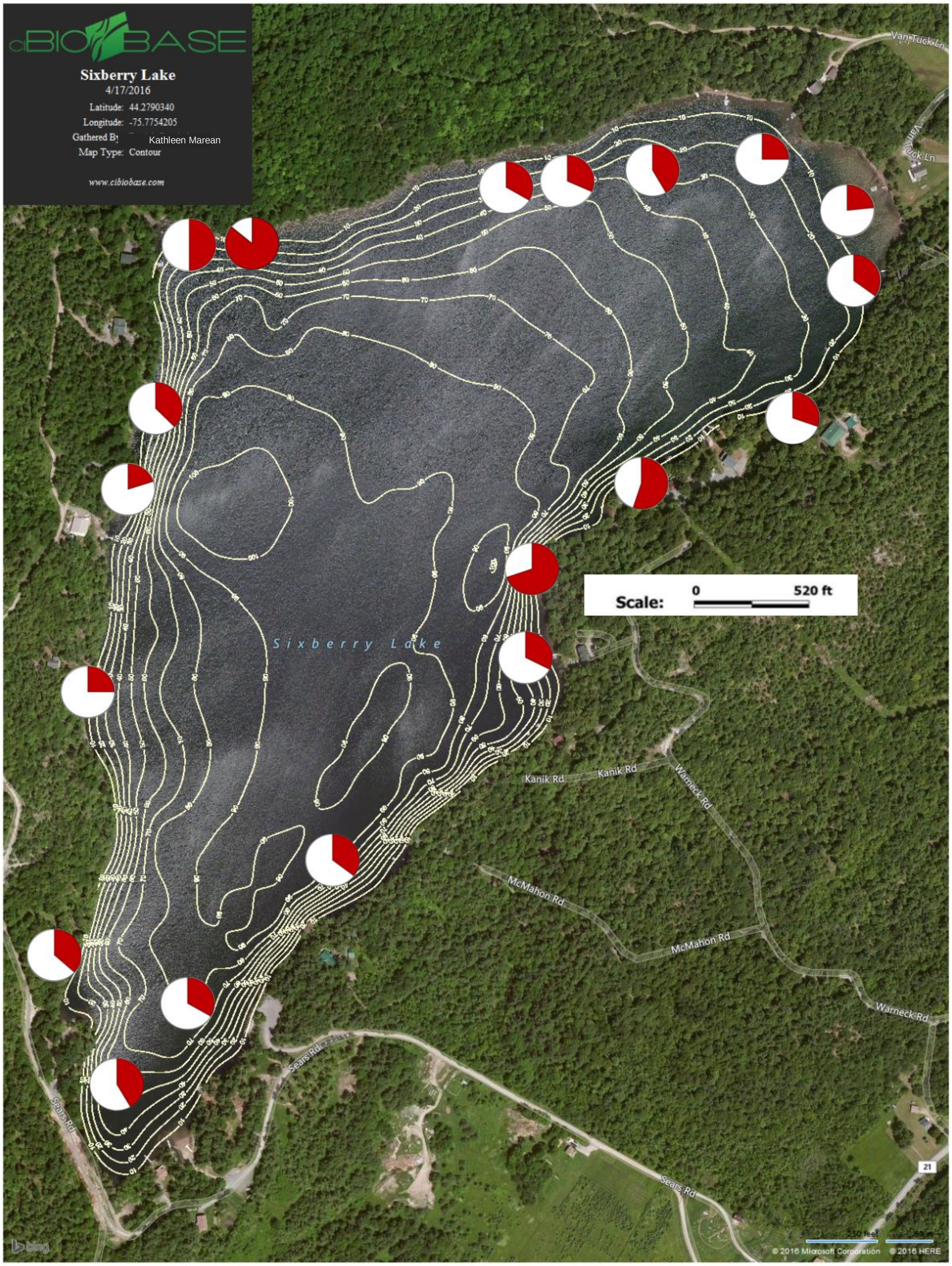

Figure 4. Map of Rake Toss Survey Results. Three rake toss surveys were conducted over the course of the summer 2015. For each survey site, the percent of each species observed in the rake toss was calculated. The pie charts at each sample site on the map represent the average percent of the invasive EWM (red) versus all other native plant species (white) observed across all three surveys.

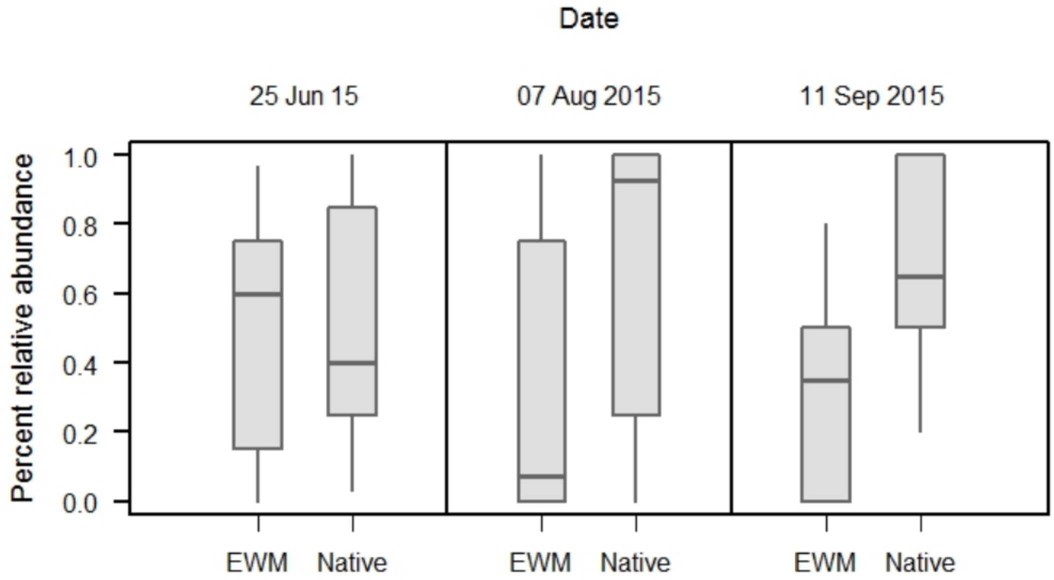

Figure 5. Rake Toss Survey Results. Three rake toss surveys were conducted over the course of the summer 2015. Sixteen sites were surveyed in June and 19 sites were surveyed in August and September. For each survey site, the relative percent abundance of Eurasian watermilfoil and native plant species observed in the rake toss was calculated.

2.1.1 <u>Objective:</u> Control of in-lake population of Eurasian watermilfoil

2.1.1.1 Goal: Maintain Eurasian watermilfoil such that it does not exceed 25% of plants sampled each year between June and September

2.1.1.1.1 Method 1: Hand (and suction) harvesting by SCUBA divers

Hand harvesting entails the use of volunteer or hired SCUBA divers to remove the plant by the roots. Most professional divers use a suction hose to remove harvested plants and fragments from the water in this type of operation. This technique requires consistent effort over years to manage EWM.

Hand harvesting also results in less fragmentation than mechanical harvesting operations, and native plant beds remain undisturbed. As long as divers work carefully to limit disturbance of as sediment, increases in turbidity can be minimized. This technique is suited for localized plant control and may not be practical as a whole-lake control option.

Hand harvesting requires more labor over a longer period of time than many other management options. This is a labor-intensive method as divers are limited in the number of plants they can harvest per hour. Hand harvesting by a team of professional SCUBA divers was estimated to cost between $400 and $1,000 per acre in 2009 for typical aquatic plant densities. Suction harvesting, which requires specialized equipment and personnel, increased the 2009 estimated cost by $500 to $1,000 per acre per day (NYSFOLA 2009).

In New York, a Joint Application and a General Permit (GP) 0-15-005 is required for suction harvesting in Sixberry Lake since it is a navigable waterway (see Suggested Attachment 1 for permit application).

2.1.1.1.2 Method 2: Hand harvesting and cutting around docks

Stakeholders reported in the surveys that they selectively hand harvested EWM growing around private docks and beaches. The majority of the Sixberry Lake shorelines are steep, and lakeside homeowners harvest EWM from their docks, which is likely to result in incomplete removal of the roots and regrowth of the plant. While this technique can improve swimming, aesthetics, and fishing locally, it does not contribute to lake-wide EWM management. All fragments of the harvested EWM must be removed from the harvested area to prevent further spread of this AIS within the lake. Cutting (trimming the growing tips) does not reduce localized infestations as the roots of the plant remain in the sediment. It is a “mowing the lawn” solution instead of a “weeding the garden”.

Local hand harvesting or cutting of EWM around docks does provide short-term relief for boaters, swimmers, and some anglers. It is also inexpensive depending if it is pulled or cut by hand. This EWM management technique requires effort both to maintain plants at the desired height and to prevent the spread of EWM fragments generated by cutting and/or pulling. Harvesting by SCUBA divers and the use of herbicide are more effective methods.

2.1.1.1.3 Method 3: Benthic Mats

Benthic mats[4] are typically made of plastics, nylon, fiberglass, burlap, or other non-toxic materials, which are placed on top of plants on the lake bottom. They limit rooted plant growth by physically blocking sunlight from reaching treated plant beds, but plants may still attach on top of the mat and grow there. In most instances, they are professionally installed, but in shallower areas they can be installed by a layperson and without the use of SCUBA divers. Benthic mats are typically considered “fill” within navigable waterbodies, and as such are subject to permitting by the U.S. Army Corp of Engineers (USACE) and/or the NYSDEC. In New York, and as of the writing of this Plan, a Joint Application and GP-0-15-005 is required for installation of benthic barriers in Sixberry Lake since it is a navigable waterway (see Suggested Attachment 1 for permit application).

In most instances, mats must be removed annually and require maintenance while in the lake. There are cases of mats drifting away or floating up to the water surface because of gasses trapped underneath. There are negative biological effects associated with benthic mat installation:

[4] Also known as benthic barriers

organisms living on the lake bottom (including native plant species) may be smothered or displaced; and fish spawning may be negatively impacted. Finally, the long term effects of benthic barriers on benthic habitat are not well known.

If installed correctly, benthic mats can provide immediate localized relief from aquatic plant growth to stakeholders using shallow areas. While this technique does require maintenance and permitting, benthic mats are non-toxic and, as a result, have less of a stigma with the general public than herbicides. They can easily cover and prevent seasonal plant growth in known dense patches of EWM. Benthic mats can cost from about $10,000 to $20,000 per acre depending upon the material used (NYSFOLA 2009). Each type of benthic mat has its own advantages and disadvantages (Holdren et al 2001). Costs are less when installed by a layperson, but most installations require SCUBA divers. A guide for citizens to create and install their own benthic mats is available in "Diet for a Small Lake" (NYSFOLA 2009).

2.1.1.1.4 Method 4: Herbicide (NYSFOLA 2009)

Based upon the input of surveyed property owners and the SLA (Figure 6), a majority of residents surveyed were not in favor of using aquatic herbicides to control EWM, therefore this management plan does not address the use of aquatic herbicides in depth.

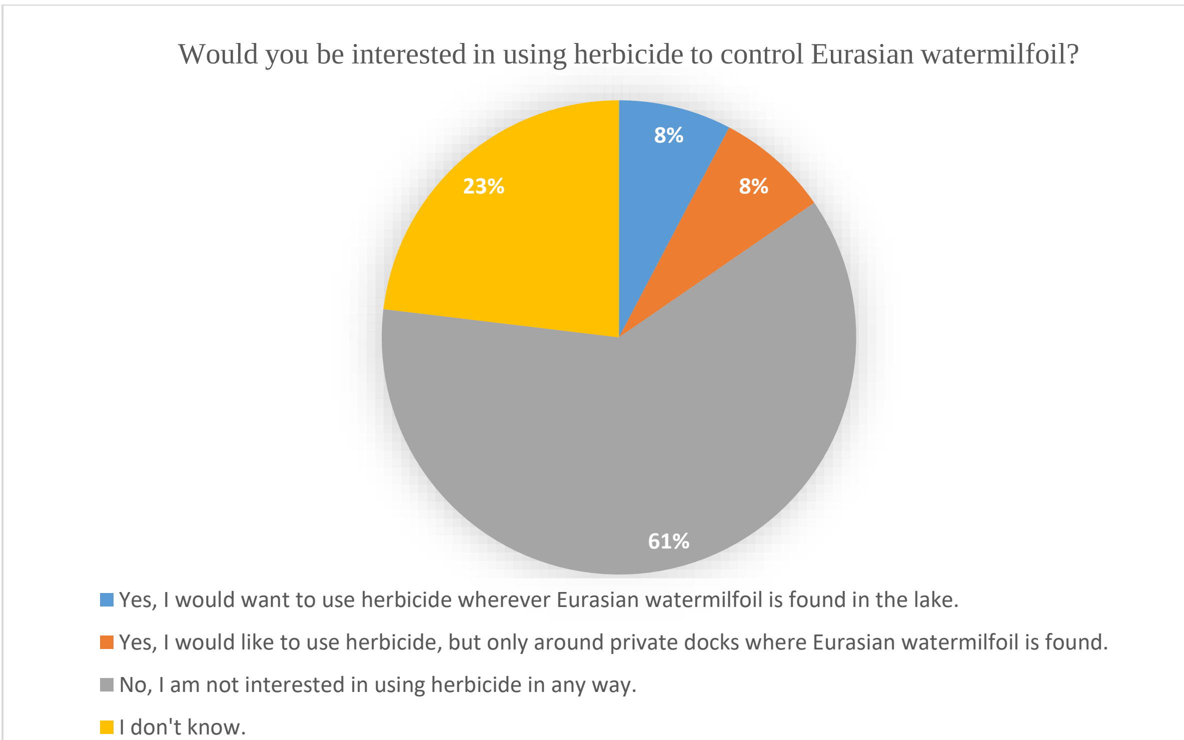

Figure 6. Responses of Surveyed Landowners to Question on Use Herbicide in Sixberry Lake, from February 2016 (N=15).

Title 3 of Article 15 of the Environmental Conservation Law requires a permit from the NYSDEC to apply pesticides (which include herbicides) to water bodies in NYS. In the event that a lake contains a regulated wetland, then an additional wetland permit is required. In New York, any pesticide labeled for direct application to water is classified as "restricted use" and can only be purchased and used by certified pesticide applicators or NYSDEC special permit holders (Cornell Cooperative Extension Pesticide Management Education Program 2004).

Formulations for use in aquatic environments include liquids, emulsifiable concentrates (active ingredient dissolved in petroleum-based solvent), granules (clay particles/porous materials impregnated with active material), and slow release pellets. Aquatic herbicides can be applied as a volume treatment, bottom treatment, surface treatment, granular/pellet treatment, or flowing water treatment. Depending upon the treatment plan, treatments may occur on a regular basis (Cornell Cooperative Extension Pesticide Management Education Program 2004).

In New York there are several aquatic herbicides formulations registered for the control of EWM. These are: amine salts of endothall (e.g. Hydrothol 191®), dipotassium salts of endothall (e.g. Aquathol K®), diquat dibromide (e.g. Reward®), copper compounds (e.g. Komeen ®), amine formulations of 2,4-D granules (e.g. Navigate®, Aquakleen®, and Aquacide®), fluriodone (e.g. Sonar® and Avast!®), and liquid triclopyr (e.g. Renovate 3® and Renovate ® OTF) (New York State Invasive Species Information 2019). If used at the permitted dosage rates aquatic herbicides should only impact target species (i.e. species identified on the herbicide label), however these may include other native plant species in the area (Cornell Cooperative Extension Pesticide Management Education Program 2004). A summary of aquatic plants controlled by the active ingredients of the above mentioned formulations is provided below in Table 4.

Table 4. Susceptibility of herbicides on select macrophytes found in Sixberry Lake. Adapted from Holdren et al. 2001 and NYSFOLA 2009.

Macrophytes	Diquat	Endothall	Glyphosate	Fluridone	Triclopyr	2,4-D
Emergent Plants						
Arrowhead (*Sagittaria* sp.)	No	No	Yes	Somewhat	Somewhat	Yes
Cattail (*Typha* sp.)	Yes	No	Yes	Yes	No	Yes
Pickerelweed (*Pontederia cordata*)	No	No	Somewhat	No	Yes	Somewhat
Floating Leaf Plants						
Yellow water lily (*Nuphar* sp.)	No	Yes	Yes	Yes	Somewhat	Yes
Submergent Plants						
Bladderwort (*Utricularia* sp.)	Yes	No	No	Somewhat	No	Somewhat
Bushy pondweed (*Najas flexilis*)	Yes	Yes	No	Yes	No	Somewhat
Buttercup (*Ranunculus* sp.)	Yes	--	--	--	--	Yes
Common waterweed (*Elodea canadensis*)	Yes	No	No	Yes	No	Somewhat
Coontail (*Ceratophyllum demersum*)	Yes	Yes	No	Yes	No	Yes
Eelgrass (*Vallisneria americana*)	No	Somewhat	No	Somewhat	No	No
Eurasian watermilfoil (*Myriophyllum spicatum*)	Yes	Yes	No	Yes	Yes	Yes
Illinois pondweed (*Potamogeton illinoensis*)	--	--	--	Yes	--	--
Large-leaf pondweed (*Potamogeton amplifolius*)	No	Yes	No	Yes	No	No
Muskgrass (*Chara* sp.)	No	No	No	No	No	No
Robbins pondweed (*Potamogeton robbinsii*)	No	Somewhat	No	Yes	No	No
Waterthread pondweed (*Potamogeton diversifolius*)	No	Yes	No	Yes	No	No

KEY
-- = uncertain

Aquatic herbicides are generally cheaper than other management methods and costs range from $200 to $1500 per-acre, depending upon brand, form, dosage concentration/rate, and frequency (NYSFOLA 2009).

In the event that residents elect to use herbicides to manage EWM in Sixberry Lake, a lake management company and/or licensed aquatic herbicide applicator must be consulted to determine the appropriate course of action and appropriate herbicides to use.

2.1.2 Objective: Prevention of further AIS introduction

2.1.2.1 Goal: No new introductions of EWM or other AIS

2.1.2.1.1 Method 1: Education and Outreach

Not all lake users may be aware of AIS or how people accidentally transport AIS between waterbodies. It is important that users of the lake know the importance of and remember to properly disinfect fishing gear, boats, bathing suits, or other recreational items when moving these items between waterbodies. Many AIS can survive out of water and are transported unknowingly by people on items like fishing tackle, in boat carpeting or bilges between waterbodies. For directions on how to properly disinfect these items, see Suggested Attachment 2.

2.1.2.1.2 Method 2: Continuation of rake toss survey

A rake toss survey was conducted to catalogue aquatic plants in Sixberry Lake in 2015. This survey should be repeated at least annually (during the growing season) to monitor abundance of EWM. Conducting plant rake toss surveys on a seasonal and annual basis will also help stakeholders monitor for new invasive species. Invasive plant species identified at an early stage of population establishment may be completely eradicated if promptly addressed, in comparison with populations identified in a more established state (Seneca County Cornell Cooperative Extension 2017). Instructions for a rake toss survey are found in Suggested Attachment 3.

2.1.2.1.3 Method 3: Boat Launch Steward Program

One of the ways that AIS are introduced to waterbodies is on boats and trailers transported between waterbodies, and the amount of aquatic plants accidentally transported on a trailered boat is greatly reduced by visual inspection and hand removal (Rothlisberger et al 2010). Through a voluntary boat launch steward inspection program run by volunteers, SLA members and property owners can teach and share effective ways to inspect and clean boats and equipment, and to help prevent the spread of AIS into Sixberry Lake. During boat inspections, stewards can educate lake users on AIS and ways they can help prevent the spread of AIS (Penney 2014). If stewards are volunteers, shifts should be organized so that stewards are present at the boat launch at peak use hours. A guide for how to start a boat launch steward program is attached in Suggested Attachment 4.

2.2 <u>Management Concern:</u> Preserving water quality

Declining water quality in Sixberry Lake is likely a result of excess total nitrogen and total phosphorus (nutrients essential for plant and algae growth) entering the lake. At Sixberry Lake it is likely that these nutrients enter the lake due to non-point source nutrient pollution[5] from eroding shorelines, lawn care practices, and on-site septic systems (NYSDEC 2005).

Two concerns expressed by stakeholders were directly related to preserving water quality; they were preserving the fishery and perceived increases in algae. For instance, preserving the quality of the cool- and cold-water fishery is reliant on maintaining a sufficiently oxygenated hypolimnion throughout the year. Increased biological activity in the hypolimnion[6] uses up oxygen and reduces habitat for these fish that are restricted to the hypolimnion during summer months. Stakeholders were also concerned with increased algal growth, which is a common sign of increased nutrients and declining water quality.

2.2.1 <u>Objective:</u> Increase resident and SLA involvement with outside stakeholders

2.2.1.1 Goal: Utilize tools and funding available, while increasing citizen participation and advocating for Sixberry Lake

2.2.1.1.1 Stakeholder 1: Indian River Lakes Conservancy (Huffman 2019)

At this time the IRLC has two paid staff, an executive director and a program coordinator, and relies mainly on volunteers in the community to advance goals for the good of the Indian River Lakes (IRLC n.d., IRLC 2019). Property owners and members of the SLA can become involved with this organization in a number of different ways (if they are not already). The following are three examples of IRLC programs where the public can become involved:

- Water Quality Conference and Development of the Indian River Watershed Management Plan;
- Protectors of Water and Habitat on the Indian River Lakes (Project WHIRL); and
- Real Time Hydrologic Stations (RTHS).
-

The IRLC hosts an annual water quality conference that offers residents an opportunity to learn more about the Indian River lakes watershed and watershed management strategies. In past years, attendees have included residents, lake association leaders, elected officials, town planning board members, soil and water conservation district representatives, conservation organization

[5] Non-point source pollution: pollution not originating from a specific, singular location
[6] An increase in nutrients entering the lake leads to an increase in plant and algae growth. If there are more plants and algae growing in the lake, there are also more plants and algae dying and decomposing. The process of decomposition uses up oxygen in the hypolimnion, creating an anoxic (deoxygenated) zone where fish may not be able to survive, and also leads to internal loading from the deep water sediments.

representatives, and university faculty. This conference is part of the IRLC's plan to develop and implement a comprehensive watershed management plan for the Indian River. Data collected by volunteers through the CSLAP program, through the RTHS (discussed below), and from State University of New York College at Oneonta management plans will be used to help inform the Indian River management plan. The IRLC has also partnered with the St. Lawrence River Watershed Project, led by the Franklin County Soil and Water Conservation District, which is working to develop a St. Lawrence River watershed revitalization plan and will be used to help inform the Indian River management plan.

Project WHIRL is geared towards local high school students interested in improving environmental conditions in an around the Indian River Lakes. In the summer of 2019 these high school students will participate in an extracurricular program consisting of three stewardship tracts (Aquatic Resource Education Stewards, Invasive Species Management Stewards, and Watershed Management Stewards). Each tract will be affiliated with a different set of regional partners including the Central New York Chapter of the Izaak Walton League, the New York State Office of Parks, Recreation, and Historic Preservation, the Saint Lawrence- Eastern Lake Ontario Partnership for Regional Invasive Species Management, and Paul Smith's College. High school students will also be mentored by university student interns majoring in related fields.

For the RTHS program, the IRLC has partnered with the Beacon Institute for Rivers and Estuaries and Clarkson University and is in the process of installing RTHSs (sensors) at inlets and outlets of multiple Indian River lakes. These RTHS currently have the capability to monitor water parameters including temperature, meteorological data, turbidity, and salinity. Within a year, the RTHS will be upgraded and will also begin collecting data on nitrogen and phosphorus levels. The IRLC anticipates that the data generated by these RTHS will help identify and isolate specific limnological conditions that lead to in-lake harmful algal blooms. Real Time Hydrologic Stations are planned for install in the early spring of 2019 at the Butterfield Lake boat launch inlet and the Red Lake boat launch outlet. The IRLC is currently looking for other lakeside residents who own properties near inlets and outlets of other Indian River lakes that are interested in hosting a RTHS.

Volunteering is a way to help achieve the goal of the IRLC to engage and connect with the community members. A stronger presence within the IRLC community provides property owners of Sixberry Lake and members of the SLA with a greater voice.

The IRLC can also specifically help landowners protect and preserve their property (and ultimately Sixberry Lake) in perpetuity through conservation easements. Property owners can form a conservation easement with the IRLC, which is a non-profit land trust. Conservation easements are permanent, legal agreements used to limit or eliminate future development and/or undesirable land uses on a private property. Landowners may sell or donate the easement to the IRLC and receive tax credits with New York State in return. More detailed information on conservation easements can be found at www.dec.ny.gov/lands/41156.html and www.conservationeasement.us.

2.2.1.1.2 Stakeholder 2: Jefferson County Soil and Water Conservation District (SWCD)

Members of the SLA can reach out to the Jefferson County SWCD, which offers conservation related services and programs with the goal of protecting the County's natural resources. Working with the Jefferson County SWCD has many potential benefits for the SLA and land owners in the watershed (Jefferson County SWC District n.d.). The Jefferson County Water Quality Coordinating Committee holds monthly meetings at the SWCD offices and aims to assist and coordinate both citizen organizations and public agencies with the goal of protecting and improving surface and groundwater quality. They are primarily focused on improving water quality through the reduction of non-point source pollution. The SWCD will work with agricultural landowners in the watershed to prepare grant proposals for non-point source pollution reduction projects. With the available water quality information (summarized in Table 3), SWCD staff can work with landowners to design appropriate agricultural best management practices (BMPs) to protect the lake. If awarded a grant, NYS Department of Agriculture and Markets funds part of the project, reducing the cost of the project for the landowner. To encourage and promote watershed stewardship, the SLA can choose to assist the landowners by raising money to reduce their out of pocket expenses.

2.2.1.1.3 Stakeholder 3: Town of Theresa and Jefferson County

The IRLC encourages property owners and residents to become involved with local governments. The New York State Constitution, Article IX, states that local governments have the power to adopt their own local laws. This means that citizens can partner with local officials (including members of the Town Planning Board) to pass, update, and/or enforce land use regulations that address the unique, local conditions. The IRLC particularly encourages property owners to read and understand the current regulations pertaining to residential onsite septic systems (NYS Rules and Regulations Title 10 Appendix 75-A; Department of Health Chapter II, Part 75) and engage with the local officials to determine ways in which these septic systems can be improved. (IRLC 2015)

Potential land use regulations that Sixberry Lake property owners could petition for in the Town of Theresa include:

- Expand minimum setbacks from waterbodies to increase the distance of future homes and onsite septic systems from the water;
- Mandate waterfront property owners to maintain buffer zones[7] to protect their property from shoreline erosion and to reduce runoff into the waterbody;
- Create no-wake-zones around inlets to promote native aquatic plant growth and nutrient removal by them. A dense bed of native aquatic plants located where the inlet meets

[7]Buffer zones are strips of vegetation along the shoreline and extending into the water.

the lake will slow the movement of water, allowing suspended sediments, which may contain excess nutrients, to settle out before reaching the rest of the lake. The plants will also take up some of the nutrients, which reduces nutrient availability to algae and ultimately lowers the potential for algal blooms.

New York State Law also authorizes local governments to establish Conservation Advisory Councils (CACs) to advise development, management, and protection of the local natural resources (New York State Association of Conservation Commissions 2016). Conservation Advisory Councils consist of 3 to 9 appointed citizens, and are responsible for developing an open area inventory (open space index) of the Town. Once an open area inventory has been produced and accepted by the Town legislative body, the CAC may be re-designated as a Conservation Board (CB). While a CB is still an advisory group within the Town, it holds a formal role in environmental reviews of proposed developments listed in the open space index. By serving on CACs and CBs Sixberry Lake property owners can become directly involved in local government to conserve and protect the Sixberry Lake watershed. More detailed information on CACs and CBs is found in Suggested Attachment 5.

2.2.2 Objective: Encourage BMPS to reduce non-point source pollution

2.2.2.1 Goal: All shoreline landowners implement land management and use BMPs

2.2.2.1.1 Method 1: Buffer zones around inlet and shorelines

Buffer zones mimic natural shoreline conditions in the absence of development and can be composed of a mix of native wildflowers, grasses, sedges, rushes, shrubs, or trees. The roots of these plants tend to be deeper than typical lawn grass and serve to stabilize shorelines, reduce shoreline erosion, and slow the movement of stormwater runoff and groundwater. These vegetated areas also provide habitat for a variety of fish, birds, and other wildlife (Minnesota Department of Natural Resources 1998).

Vegetated buffer zones help to mitigate numerous stakeholder concerns and have the potential to be especially effective around the inlet of Sixberry Lake. Water samples taken from the inlet exceeded the thresholds for total nitrogen and total phosphorus set by the NYSDEC (Table 3). Creating and maintaining buffer zones along the inlet would help mitigate nutrient inputs from properties bordering the inlet.

Many lakeside homes around Sixberry Lake already have existing buffer zones, but there are portions of the inlet that do not. Homeowners can improve and expand on existing buffer zones or create new ones. Limiting the removal of fallen trees or plants in the water is an easy and important first step for creating fish habitat and stabilizing the shoreline. Stabilizing the shoreline helps to reduce shoreline erosion. For specific recommendations on how to create buffer zones and what plants to use, see Suggested Attachment 6.

2.2.2.1.2 Method 2: Septic System Best Management Practices

There is no centralized sewer system around Sixberry Lake, and each home is on an independent wastewater treatment system. A majority of property owners who responded to the second survey reported using an onsite septic system, the ages of which varied from new to over 20 years old (see Figure 7-A and Figure 7-B). Septic systems are a known source of excess nutrients to waterbodies, especially for lakes with geology similar to Sixberry Lake (i.e. shallow soil depth to bedrock)(Soil Science Division Staff 2017). The soils surrounding the lake are all rated unsuitable for septic systems because they are too permeable, too shallow, and the seasonal high water table is too close to the ground surface (Figure 8)(NRCS 2015).

Based on survey responses, most property owners considered septic systems to be an environmental problem (Figure 9), but most were opposed to upgrading or replacing their current systems (Figure 7-C and Figure 7-D). This is understandable as these management techniques come at great personal expense, with estimated costs ranging from $5,000 to $15,000 or more (Meyer et al. 2013). The following management options have been identified that best fit the cost concerns of stakeholders.

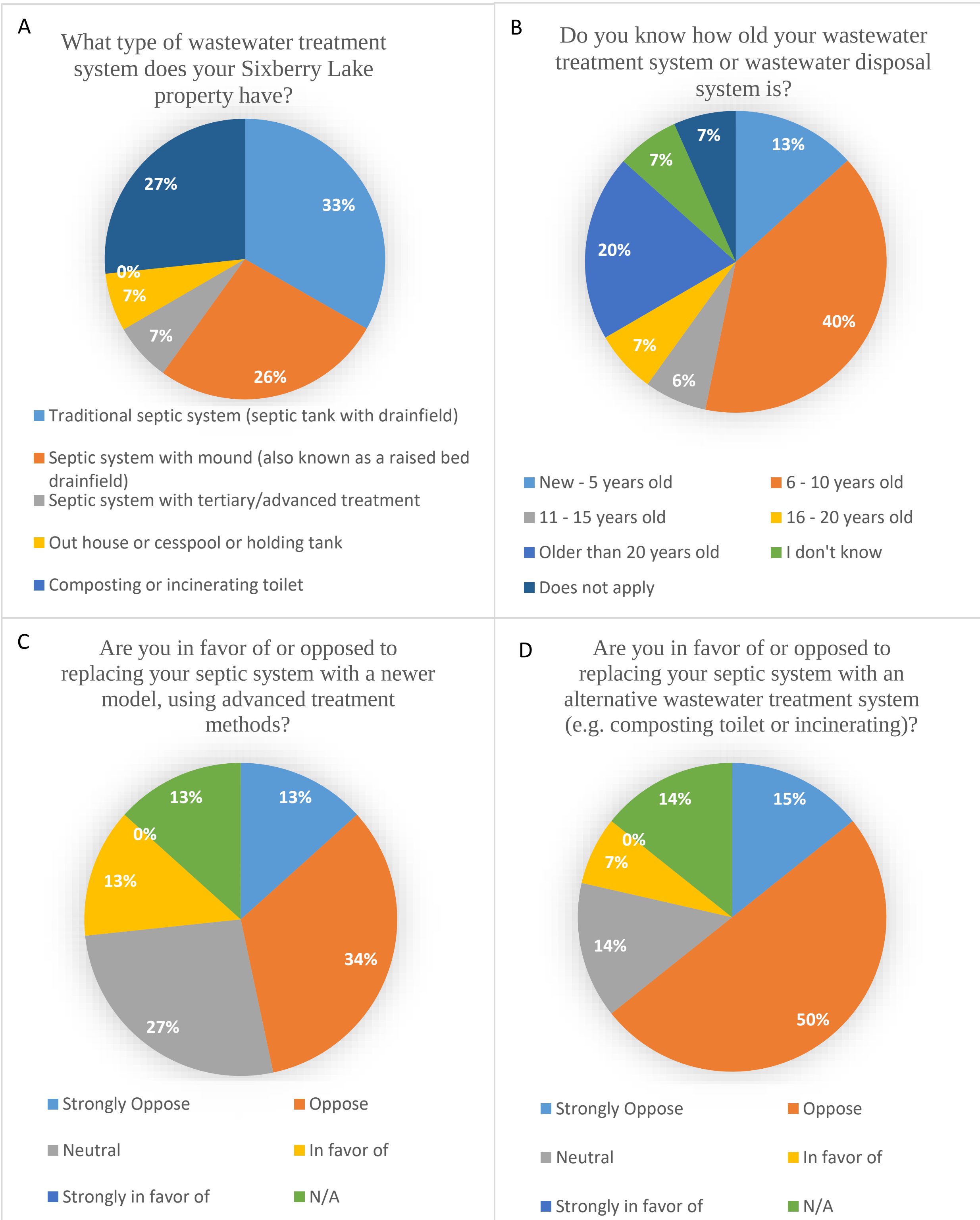

Figure 7. Responses of Surveyed Landowners to Questions on Onsite Wastewater Treatment from February 2016 (N=15).

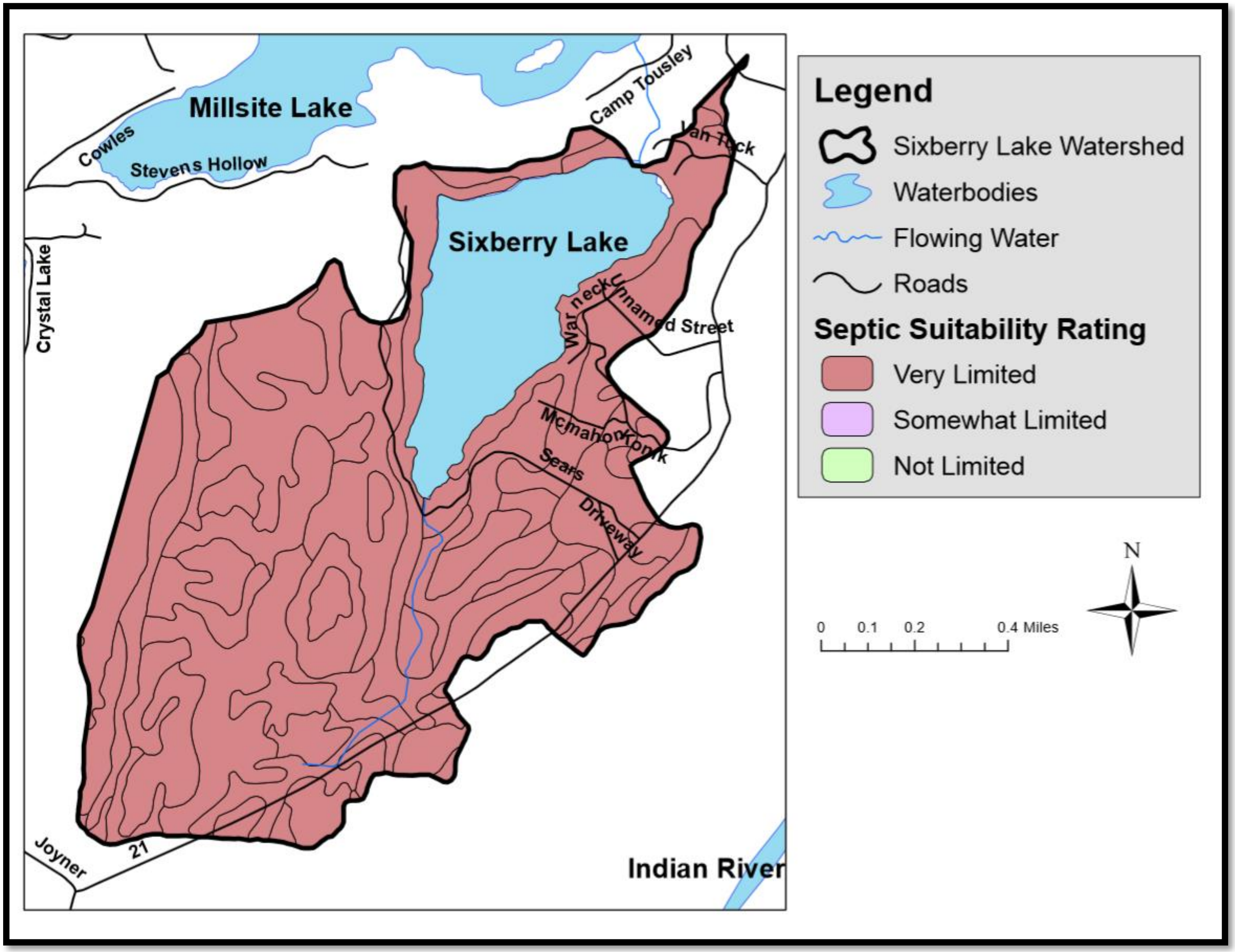

Figure 8. Septic System Suitability within the Sixberry Lake Watershed. Soil type suitability for septic systems is determined by evaluating a number of criteria. These include: depth to bedrock; how fast water travels down through the soil; depth to water table (NRCS 1995).

In conventional household septic systems, partially treated household wastewater is released into the soil and moves towards the lake with groundwater. Vegetated buffer zones (Section 2.2.2.1.1) have the ability to slow the movement of groundwater, providing additional time for nutrients in the wastewater to be utilized by plants and other organisms in the soil. For recommendations on how to create a buffer zone, see Suggested Attachment 6.

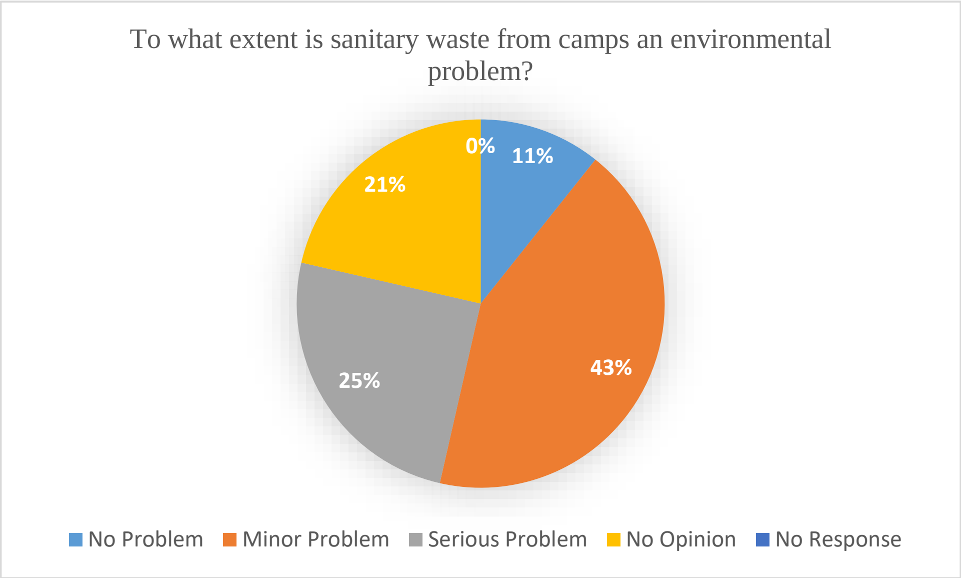

Figure 9. Responses of Surveyed Landowners to Question on Onsite Wastewater Treatment as an Environmental Concern, from Fall/Winter 2014 (N=30).

Onsite septic systems rely of an array of living organisms for proper function. A variety of bacteria inhabit septic tanks and drainfields. If inappropriate or hazardous materials are disposed of through a septic system (see further discussion in the following paragraph) these beneficial organisms work inefficiently or even die, ultimately leading to untreated wastewater being released into the soils outside residences. This is harmful to both human health and the lake.

Certain materials should never be disposed of through a wastewater treatment system and should be disposed of through solid waste facilities (i.e., paint thinners, medications, or food scraps). Flushing these materials will either kill the helpful bacteria living in the septic system or physically harm the septic system components. Using low-flow water appliances (i.e. toilets, faucets) or waterless toilets are other ways to improve performance in systems that may be undersized or located in unsuitable soils. For specifics on how to properly care for a septic system, see Suggested Attachment 7.

As with any home utility, septic systems require routine maintenance to keep systems in working order and should be pumped every 3 to 5 years to remove accumulated solids (sludge).

If not routinely pumped, this sludge can interfere with the functioning of the system and may lead to a hydraulic failure of the drainfield. Components should also be inspected at least every 3 years to ensure that all parts are structurally sound and operating properly, and that no leaks are present in the home (Environmental Protection Agency (EPA) n.d.). The SLA can also organize lakeshore-wide pump out and inspection events can be used to bring awareness to this maintenance need, may provide a group discount, and without stigmatizing individuals. Group discounts may be offered by service providers, which may provide financial incentive for property owners to participate.

As stated above, inspection and pumping are both integral in keeping a septic system properly functioning. A majority of the property owners surveyed in 2016 were in favor of mandatory inspection and pumping. Property owners and members of the SLA can promote legislation within the Town of Theresa and Jefferson County to require pumping and inspection by law either when a property is transferred or at specific time intervals (i.e., every 3 to 5 years).

Replacing onsite septic systems with alternative wastewater treatment options was not a popular option with survey responder, but was favored by the IRLC because of the anticipated effectiveness. Alternative wastewater treatment options approved for use in New York State include septic systems with the addition of: a mound, raised-bed, intermittent sand-filter, or non-waterborne systems. Non-waterborne systems are components added into homes and utilized in areas where there is a need or desire to conserve water, and include: chemical toilets, incinerator toilets, and greywater systems. (New York State Public Health Law, 201(1)(1) Appendix 75-A).

More information on the variety of technical aspects of alternative wastewater treatment systems can be found on the National Environmental Services Center website, located here: http://www.nesc.wvu.edu/eti.cfm.

2.2.2.1.3 Method 3: Construction Stormwater Practices

Any future development around the lake should properly utilize erosion control measures, which can be incorporated into local ordinances (Section 2.2.1.1) to expand upon any existing state and/or county regulations. Loose soil entering the lake in runoff increases turbidity and adds excess nutrients. The most commonly used erosion control device during construction is the silt fence, which holds back loose soil carried in runoff from construction sites and prevents the soil from entering the lake. Post-construction practices such as re-seeding or re-planting disturbed areas also provide erosion control. Required methods of stormwater management during and after construction may be specified in the project's construction permit. More examples of and information on construction stormwater BMPs can be found in Suggested Attachment 8.

2.2.2.1.4 Method 4: Agricultural BMPs

There is a mapped area of small scale family-owned agriculture (approximately 120 acres), consisting of abandoned agricultural land, and hay and pasture surrounding the inlet (Homer et al. 2015). Known impacts from agriculture include increased runoff containing sediment, nutrients from fertilizers and livestock waste, and eroding shorelines from livestock entering waterways. To protect the lake from these potential effects, vegetated riparian buffers (Section 2.2.2.1.1) should be maintained around the inlet. Well planned buffer zones with added fencing discourage livestock from accessing waterways and reduces subsequent soil erosion and nutrient runoff (Gumbery et al. 2009).

2.2.2.1.5 Method 5: Forestry BMPs

About 56% of the Sixberry Lake watershed is forested. Forestry BMPs aim to reduce soil erosion, a common side effect of tree removal. When forested areas are disturbed or cleared (temporarily or permanently) for timber harvest or building construction, erosion control methods such as waterbars and diversion ditches should be employed; stream crossings should protect the integrity of stream banks. These slow the movement of water and allow the water to pool so that it does not erode and transport soil. Work in wetland areas, riparian zones, and on steep slopes should be done with consideration for the sensitive nature of the soils and potential for erosion, compaction and disturbance of surface drainage patterns.

Landowners can discuss their property and goal before any forest harvesting begins. Landowners should be encouraged to take an active role in the planning process by communicating up front with their forester and/or logger the importance of minimizing soil disturbance, protecting water features, and maintaining the skid roads and landings in ways that minimize erosion and runoff. Landowners can request specific best management practices such as buffers in sensitive areas (such as wetlands) and that wet areas are only accessed during periods of frozen ground. For more information about forestry BMPs, see Suggested Attachment 9.

2.3 <u>Management Concern:</u> Maintaining water levels

2.3.1 <u>Objective:</u> Maintain water levels such that low-lying houses are not flooded

2.3.1.1 Goal: Control beaver dam construction on the outlet

Sixberry Lake is a natural lake, and the water level is controlled by beavers. If the beaver dam in the outlet of the lake is not dismantled on a routine basis, the water level rises high enough to threaten homes along the eastern shore.

2.3.1.1.1 Method 1: Beaver Dam Removal

Currently, the resident who owns the property surrounding the inlet has granted permission to select property owners to remove the beaver dam as needed. These individuals must provide notice to the landowner prior to removing the dam. To preserve the threatened homes, the current management method should be continued as long as beaver dams are constructed on the outlet.

2.3.1.1.2 Method 2: Protect Trees

Protecting trees and shrubs with wire barriers will discourage and prevent beavers from felling trees. This management technique will make it more difficult for beavers to find materials to make dams with. Additionally, limiting the impact of beavers on the vegetation surrounding the lake reduces potential erosion caused by tree removal.

2.3.1.1.3 Method 3: Control Beaver Population

Currently, one landowner maintains a trapping permit with the intent of trapping beavers on Sixberry Lake to mitigate damage to trees. In order to continue to protect trees in the nearshore area, this management practice should be maintained.

3.0 <u>Management Concern:</u> Growing the landowner and resident participation in Sixberry Lake Management

3.1 <u>Objective:</u> Outreach and Engagement

3.1.1 Goal: Increase membership and participation in the SLA among landowners and property owners

3.1.1.1 Method:

The SLA and IRLC can provide education and outreach opportunities to get neighbors and watershed property owners (i.e. individuals who do not live directly on Sixberry Lake but can affect its water quality) involved with management and planning. Techniques recommended include: sponsoring environmental education events on weekends when seasonal residents are at the lake; holding workshops on planting lakeside vegetation; and mailing educational materials to the homes of residents.

The SLA should continue to increase its membership and encourage participation in the SLA meetings by all property owners and other stakeholders. The success of the strategies outlined above relies on participation by and cooperation among homeowners. The SLA should continue mailing out newsletters to residents and consider including brief educational materials in each mailing. It also should continue to hold their annual lake appreciation event and possibly invite a guest speaker to give a brief talk on a lake related topic and interact with residents. SLA should develop a list of BMPs applicable to land use around Sixberry Lake (described in previous sections) and maintain them in an easy to distribute format so that they are readily accessible to the current and future residents and property owners.

4.0 Ongoing Monitoring

Continued lake monitoring in the form of CSLAP participation and plant surveys (Section 2.1.2.1.2) is vital to proper evaluation of progress towards achievement of management goals and objectives. Participation in CSLAP provides data and a level of analysis otherwise inaccessible to residents and the Lake Association, which is important to understanding the lake. Continuing the plant rake toss survey yearly at the intervals described in Section 2.1.2.1.2 provides concrete data for decisions to be made in the EWM management program; for example, a decision to switch techniques if desired results are not attained or to quickly identify new invasion by an AIS. The costs associate with continued monitoring of AIS through the rake toss survey, discussed in Section 2.1.2.1.2, are limited to the initial purchase of materials (as described in Suggested Attachment 3) and the use of a small motorized boat. If EWM or any other AIS reach more than 25% of the plants collected then objectives and management strategies should be revaluated to include more dramatic measures (herbicide).

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SUGGESTED ATTACHMENTS

Suggested Attachment 1. General Permit 0-15-005 Application

New York State Department of Environmental Conservation (NYSDEC) General Permit GP-015-005 application for Management of Invasive Species

Joint Application Form to apply for permits from NYSDEC, the New York State Office of General Services, New York State Department of State, and the U.S. Army Corps of Engineers for activities affecting streams, waterways, waterbodies, wetlands, coastal areas, sources of water, and endangered and threatened species.

Suggested Attachment 2. "A New York Boaters Guide to Cleaning, Drying and Disinfecting Boating Equipment"

"A New York Boaters Guide to Cleaning, Drying and Disinfecting Boating Equipment- Procedures to Prevent the Spread of Aquatic Invasive Species While Boating" by the NYSDEC, 6 pages

Suggested Attachment 3. Aquatic Plant Sampling Protocol

"CSLAP Aquatic Plant Sampling Protocol" by the New York State Federation of Lake Associations and the NYSDEC, 16 pages

Suggested Attachment 4. "New York State Watercraft Inspection Steward Program Handbook"

"New York State Watercraft Inspection Steward Program Handbook- A Guide for Starting New Watercraft Inspection Programs, Includes Watercraft Inspection Steward Training & Field Guide" developed by Mary Penney, New York Sea Grant for the Cornell University Statewide Invasive Species Outreach Program. Publication ID: NYSGI-H-14-001. Copyright September 10, 2014. 81 pages.

Suggested Attachment 5. Citizens, Local Government, and Land Use

"Beginner's Guide to Land Use Law" Pace Law School Land Use Law Center, 53 pages

"Conservation Advisory Councils and Boards- Building Capacity for Local Conservation in New York" NYSDEC Hudson River Estuary Program, Region 3, 2 pages

"Local Conservation Strategies for Hudson Valley Communities: How a Conservation Advisory Council Becomes a Board" NYSDEC Hudson River Estuary Program, Region 3, 3 pages

Suggested Attachment 6. Creating a Buffer Zone

"Planning Primer 15: Water Body Protection" Compiled by the Jefferson County Planning Office, October 2012, 2 pages

"Stream Buffer Planting Guide" Tompkins County Stream Buffer Management, 22 pages

Suggested Attachment 7. Septic System Care

"Your Septic System: Buying or Selling a House with a Septic System" Cornell University, 10 pages

"Water Treatment Notes- Household Chemicals and your septic system" John J. Schwartz, Ann T. Lemlev, Kalpana Pratap, Cornell Cooperative Extension, College of Human Ecology. Fact Sheet 16. December 2004. 5 pages

Suggested Attachment 8. Construction Best Management Practices

"New York State Standards and Specification for Erosion and Sediment Control, Section 3 Erosion Control- Part 1 Runoff Control" Section prepared by Donald W. Lake Jr., PE, CPESC, CPSWQ, Assistant Professor State University of New York, College of Environmental Science and Forestry. November 2016. 55 pages

"New York State Standards and Specification for Erosion and Sediment Control, Section 4 Erosion Control- Part 2 Soil Stabilization" Section prepared by Donald W. Lake Jr., PE, CPESC, CPSWQ, Assistant Professor State University of New York, College of Environmental Science and Forestry. November 2016. 82 pages

Suggested Attachment 9. New York State Forestry Best Management Practices for Water Quality

"New York State Forestry Best Management Practices for Water Quality - BMP Field Guide" NYSDEC Division of Lands and Forests. 2011 Edition. 83 pages

APPENDIX B

Table B.1 Soils Within the Sixberry Lake Watershed (NRCS 2015).

			Septic Tank Absorption Fields				
Soil Symbol	Map Unit Name	Component Name (percent)	Limiting Features	Value	Rating	Hectares in Watershed	Percent of Watershed
CIA	Chaumont silty clay, 0 to 3 percent slopes	Chaumont (75%)	Depth to saturated zone	1	Very Limited	15.30	5.27%
			Slow water movement	1			
			Depth to bedrock	1			
CIB	Chaumont silty clay, 3 to 8 percent slopes	Chaumont (80%)	Depth to saturated zone	1	Very Limited	2.79	0.96%
			Slow water movement	1			
			Depth to bedrock	1			
HeB	Heuvelton silty clay loam, 3 to 8 percent slopes	Heuvelton (85%)	Depth to saturated zone	1	Very Limited	10.93	3.76%
		Muskellunge (5%)	Slow water movement				
		Adjidaumo, poorly drained (5%)		1			
		Elmwood (3%)					
		Hogansburg (2%)					
HpB	Hollis-Galoo, acid variant, complex, rocky, 0 to 8 percent slopes	Hollis (45%)	Depth to bedrock	1	Very Limited	4.61	1.59%
			Seepage, bottom layer	1			
		Galoo, acid variant (45%)	Depth to bedrock	1			
InB	Insula-Rock outcrop complex, 0 to 8 percent slopes	Insula (45%)	Depth to bedrock	1	Very Limited	7.77	2.67%
			Seepage, bottom layer	1			
		Quetico (45%)	Depth to bedrock	1			
IoB	Insula-Rock outcrop complex, 0 to 8 percent slopes	Insula (60%)	Depth to bedrock	1	Very Limited	44.96	15.48%
			Seepage, bottom layer	1			

Table B.1 Soils Within the Sixberry Lake Watershed (NRCS 2015).

Soil Symbol	Map Unit Name	Component Name (percent)	Septic Tank Absorption Fields: Limiting Features	Value	Rating	Hectares in Watershed	Percent of Watershed
KgA	Kingsbury silty clay, 0 to 2 percent slopes	Kingsbury (80%)	Depth to saturated zone	1	Very Limited	14.16	4.88%
			Slow water movement	1			
Lc	Livingston mucky silty clay	Livingston (75%)	Depth to saturated zone	1	Very Limited	5.30	1.82%
			Slow water movement	1			
Ma	Madalin silt loam, 0 to 3 percent slopes	Madalin (85%)	Depth to saturated zone	1	Very Limited	8.30	2.86%
		Rhinebeck (5%)	Slow water movement	1			
		Canandaigua (4%)					
		Cosad (2%)					
		Fonda (4%)	Depth to saturated zone	1			
			Slow water movement	1			
			Ponding	1			
MuE	Millsite-Rock outcrop complex, steep	Rock outcrop (45%)	Slope	1	Very Limited	50.18	17.27%
		Insula (5%)	Depth to bedrock	1			
		Unnamed soils, stones and boulders on surface (5%)	Seepage, bottom layer	1			
MwB	Muskellunge silty clay loam, 3 to 8 percent slopes	Muskellunge (85%)	Depth to saturated zone	1	Very Limited	2.02	0.70%
		Adjidaumo, poorly drained (5%)	Slow water movement	1			
		Heuvelton (4%)					
		Swanton (3%)					
		Matoon (3%)	Depth to saturated zone	1			
			Slow water movement	1			
			Depth to bedrock	1			

Table B.1 Soils Within the Sixberry Lake Watershed (NRCS 2015).

Soil Symbol	Map Unit Name	Component Name (percent)	Septic Tank Absorption Fields Limiting Features	Value	Rating	Hectares in Watershed	Percent of Watershed
QeB	Quetico-Rock outcrop complex, 2 to 8 percent slopes	Quetico (55%)	Depth to bedrock	1	Very Limited	64.67	22.26%
Ru	Ruse gravelly loam, rocky	Ruse (75%)	Ponding	1	Very Limited	53.06	18.26%
			Depth to bedrock	1			
			Depth to saturated zone	1			
			Seepage, bottom layer	1			
WnB	Wilpoint silty clay loam, 3 to 8 percent slopes	Wilpoint (85%)	Depth to saturated zone	1	Very Limited	6.48	2.23%
			Slow water movement	1			
			Depth to bedrock	1			

APPENDIX C

Table C.1 Water Quality Sample Depths

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
10/18/2014					
General*	0.5	7.5	13.5	20.0	24.5
Chlorophyll *a*	-	-	-	-	-
2/8/2015					
General*	2.0	12.0	24.0	-	-
Chlorophyll *a*	-	-	-	-	-
3/7/2015					
General*	3.0	13.0	25.0	-	-
Chlorophyll *a*	-	-	-	-	-
4/25/2015					
General*	2.0	14.0	24.0	-	-
Chlorophyll *a*	2.0	14.0	-	-	-
5/12/2015					
General*	0.0	3.5	-	-	-
Chlorophyll *a*	2.0	-	-	-	-
5/27/2015					
General*	0.0	4.0	6.0	14.0	25.0
Chlorophyll *a*	2.0	14.0	-	-	-
6/12/2015					
General*	2.0	4.0	5.5	12.0	25.0
Chlorophyll *a*	2.0	14.0	-	-	-
6/25/2015					
General*	2.0	6.0	8.0	18.0	24.0
Chlorophyll *a*	2.0	14.0	-	-	-
7/15/2015					
General*	2.0	5.0	7.0	13.0	26.0
Chlorophyll *a*	2.0	14.0	-	-	-
7/22/2015					
General*	2.0	6.0	12.0	18.0	25.0
Chlorophyll *a*	2.0	12.0	-	-	-
8/7/2015					
General*	0.0	2.0	6.5	14.0	25.5
Chlorophyll *a*	2.0	14.0	-	-	-
8/20/2015					
General*	0.0	2.0	6.5	14.0	25.0
Chlorophyll *a*	2.0	5.0	8.0	11.0	14.0
9/11/2015					
General*	0.0	2.0	6.5	14.0	25.0
Chlorophyll *a*	2.0	6.5	8.0	11.0	14.0
10/04/2015					
General*	0.0	2.0	6.5	14.0	25.0
Chlorophyll *a*	2.0	5.0	8.0	11.0	14.0
10/14/2015					
General*	0.0	2.0	6.5	14.0	25.0
Chlorophyll *a*	2.0	5.0	8.0	11.0	-
11/07/2015					
General*	0.0	2.0	6.5	16.0	25.0
Chlorophyll *a*	2.0	4.0	-	-	-
12/04/2015					
General*	0.0	2.0	6.5	14.0	25.5

Table C.1 Water Quality Sample Depths

		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
	Chlorophyll *a*	2.0	6.5	-	-	-
12/21/2015						
	General*	0.0	2.0	6.5	14.0	25.5
	Chlorophyll *a*	2.0	6.5	-	-	-
3/30/2016						
	General*	0.0	2.0	6.5	14.0	25.5
	Chlorophyll *a*	2.0	6.5	-	-	-

* "General" water samples collected were analyzed for water quality parameters outlined in Chapter 4, Table 4.1.

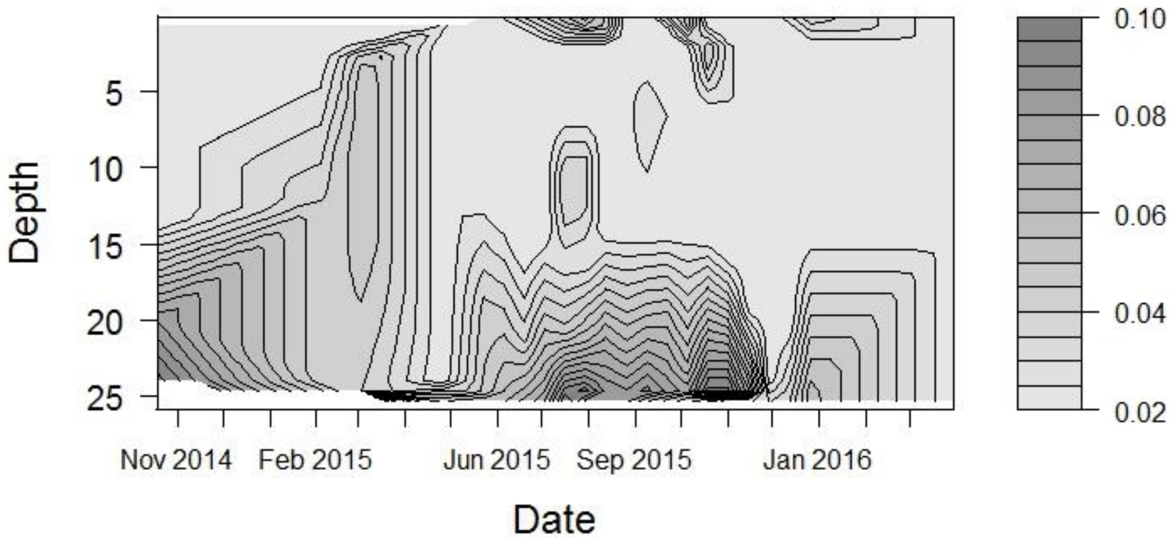

Figure C.1 Nitrates and nitrites (mg/L) in Sixberry Lake (October 2014 through March 2016).

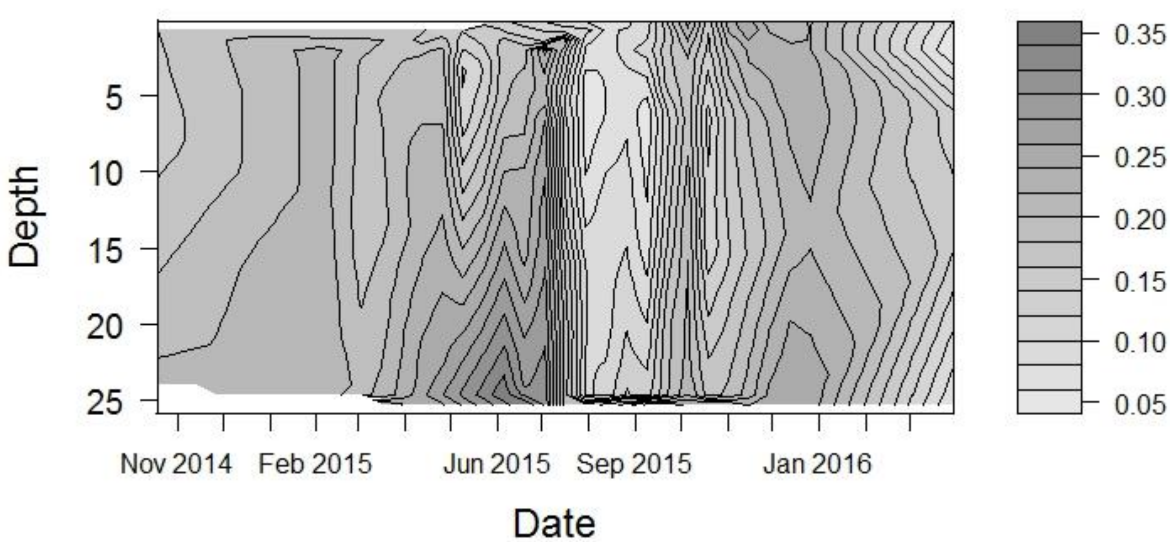

Figure C.2 Total nitrogen (mg/L) in Sixberry Lake (October 2014 through March 2016).

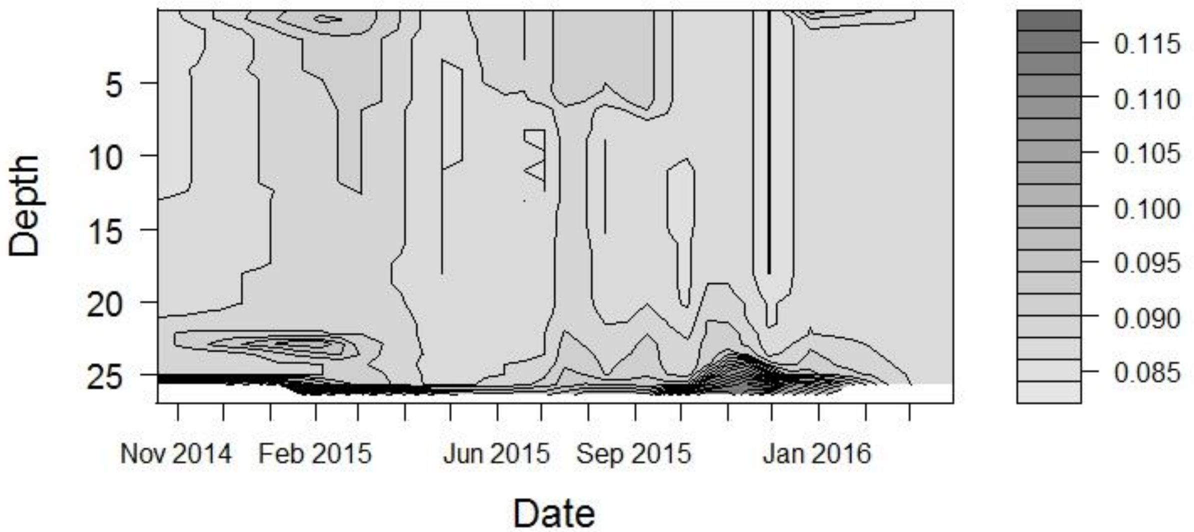

Figure C.32 Specific conductivity (micro-Siemen/cm) in Sixberry Lake (October 2014 through March 2016).

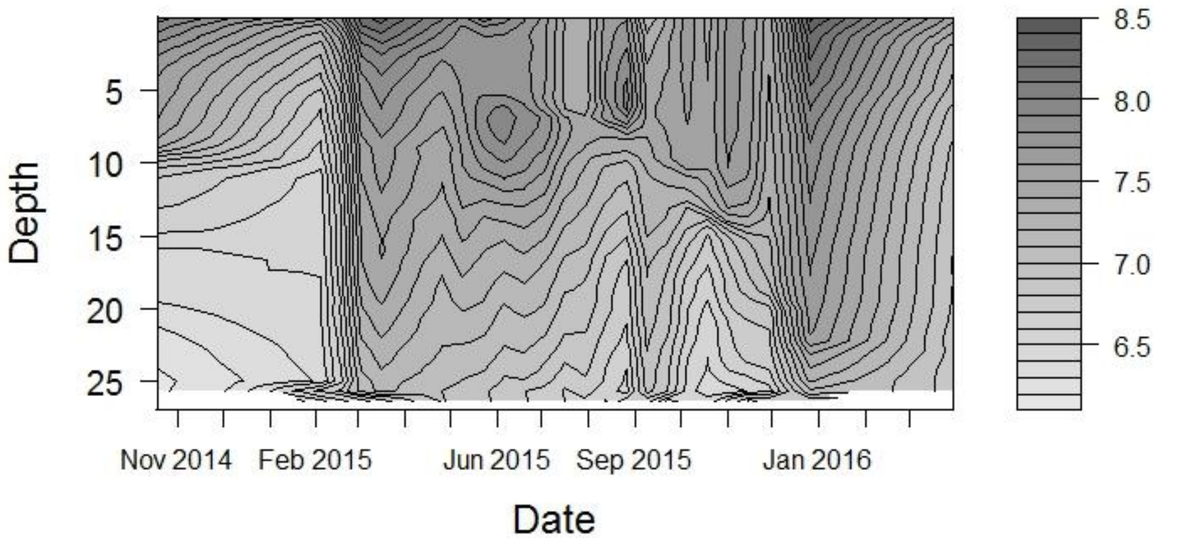

Figure C.4 pH in Sixberry Lake (October 2014 through March 2016).

APPENDIX D

Table D.1 Summary of Fish Species Captured in Sixberry Lake (NYSDEC 2014).

Family	Scientific Name	Common Name	Survey Date(s) Captured
Coldwater			
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout	8/6/1959, 6/18-19/2003
Salmonidae	*Salmo salar*	Atlantic salmon	10/6-7/1992, 10/21/1996, 11/10/1998, 7/8-10/2013
Salmonidae	*Salmo trutta*	Brown trout	7/2/1931 5/24-25/1978
Salmonidae	*Salvelinus fontinalis*	Brook trout	8/6/1959, 10/22-23/1974
Salmonidae	*Salvelinus namaycush*	Lake trout	7/8/1955, 7/7/1970, 10/24-26/1973, 10/22-23/1974, 11/4-5/1976, 9/20-21/1977, 5/24-25/1978, 10/21-22/1981, 6/11/1992, 10/6-7/1992, 11/8/1994, 5/17-18/1999, 6/18-19/2003, 7/8-10/2013
Coolwater			
Centrarchidae	*Ambloplites rupestris*	Rock bass	7/2/1931, 9/9/1931, 7/8/1955, 8/6/1959, 7/7/1970, 10/24-26/1973, 10/22-23/1974, 11/4-5/1976, 9/20-21/1977, 5/24-25/1978, 10/21-22/1981, 10/6-7/1992, 11/8/1994, 10/21/1996, 11/10/1998, 5/17-18/1999, 10/19/1999, 6/18-19/2003, 7/8-10/2013
Esociformes	*Esox lucius*	Northern pike	7/2/1931 5/17-18/1999
Percidae	*Perca flavescens*	Yellow perch	7/2/1931, 9/9/1931, 8/6/1959, 7/7/1970, 10/24-26/1973, 10/22-23/1974, 11/4-5/1976, 9/20-21/1977, 10/21-22/1981, 10/6-7/1992, 11/8/1994, 11/10/1998, 5/17-18/1999, 10/19/1999, 6/18-19/2003, 7/8-10/2013
Percidae	*Sander vitreus*	Walleye	7/2/1931, 7/8/1955, 7/7/1970, 10/24-26/1973, 10/22-23/1974, 11/4-5/1976, 9/20-21/1977, 5/24-25/1978, 10/21-22/1981, 10/6-7/1992, 11/8/1994, 10/21/1996, 5/17-18/1999, 6/18-19/2003, 7/8-10/2013
Warmwater			
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	7/2/1931, 9/9/1931, 8/6/1959, 7/7/1970, 10/24-26/1973, 10/22-23/1974, 11/4-5/1976, 9/20-21/1977, 5/24-25/1978, 10/21-22/1981, 10/6-7/1992, 11/8/1994, 11/10/1998, 5/17-18/1999, 6/18-19/2003, 7/8-10/2013
Centrarchidae	*Lepomis macrochirus*	Bluegill	7/2/1931 10/22-23/1974
Centrarchidae	*Micropterus dol*omieu	Smallmouth bass	7/2/1931, 7/8/1955, 7/7/1970, 10/24-26/1973, 10/22-23/1974, 9/20-21/1977, 5/24-25/1978, 10/21-22/1981, 6/11/1992, 10/6-7/1992, 11/8/1994, 10/21/1996, 11/10/1998, 5/17-18/1999, 10/19/1999, 6/18-19/2003, 7/8-10/2013

Table D.1 Summary of Fish Species Captured in Sixberry Lake (NYSDEC 2014).

Family	Scientific Name	Common Name	Survey Date(s) Captured
Centrarchidae	*Micropterus salmoides*	Largemouth bass	7/2/1931, 7/7/1970, 10/22-23/1974, 5/24-25/1978, 10/6-7/1992, 11/8/1994, 5/17-18/1999, 6/18-19/2003, 7/8-10/2013
Cottidae	*Cottus cognatus*	Slimy sculpin	10/24-26/1973
Cyprinidae	*Cyprinella spiloptera*	Spotfin shiner	7/8-10/2013
Cyprinidae	*Exoglossum maxillingua*	Cutlips minnow	11/10/1998
Cyprinidae	*Luxilus cornutus*	Common shiner	8/6/1959
Cyprinidae	*Pimephales notatus*	Bluntnose minnow	9/9/1931, 7/8-10/2013
Cyprinidae	*Rhinichthys atratulus*	Blacknose dace	8/6/1959
Cyprinidae	*Semotilus atromaculatus*	Creek chub	8/6/1959
Fundulidae	*Fundulus diaphanus*	Banded killifish	9/9/1931, 7/8-10/2013
Ictaluridae	*Ameiurus natalis*	Yellow bullhead	10/24-26/1973
Ictaluridae	*Ameiurus nebulosus*	Brown bullhead	8/6/1959, 5/24-25/1978, 10/21/1996, 7/8-10/2013

Table D.2 Salmonid stocking record for Sixberry Lake. Stocking records obtained from the NYS DEC Region 6 Fisheries Office (Klindt 2015).

Date	Species	No. Stocked	Length (cm)	Date	Species	No. Stocked	Length (cm)
5/2/1990	lake trout	700	17.78	5/15/2001	rainbow trout	350	20.32
5/17/1990	Atlantic salmon	340	17.78	5/20/2002	rainbow trout	500	22.86
11/16/1990	brook trout	1200	15.24	5/20/2002	lake trout	650	15.24
5/1/1991	Atlantic salmon	500	17.78	5/27/2003	lake trout	500	20.32
5/23/1991	lake trout	700	20.32	5/27/2003	lake trout	460	15.24
11/7/1991	brook trout	2500	12.7	6/19/2003	lake trout	680	20.32
5/1/1992	rainbow trout	95	58.42	5/11/2004	rainbow trout	480	20.32
5/29/1992	Atlantic salmon	500	17.78	5/11/2004	lake trout	650	15.24
6/10/1992	lake trout	700	17.78	5/25/2005	lake trout	780	17.78
5/3/1993	Atlantic salmon	500	17.78	5/12/2006	Atlantic salmon	480	17.78
5/25/1993	rainbow trout	100	60.96	6/1/2006	lake trout	720	17.78
5/25/1993	lake trout	810	17.78	5/14/2007	Atlantic salmon	520	16.51
6/28/1993	brook trout	10000	10.16	6/4/2007	lake trout	710	24.13
5/26/1994	Atlantic salmon	500	15.24	5/27/2008	lake trout	650	17.78
5/26/1994	brook trout	1300	22.86	6/4/2007	Atlantic salmon	520	17.78
7/7/1994	rainbow trout	1000	12.7	5/8/2009	lake trout	330	17.78
4/20/1995	Atlantic salmon	500	15.24	5/26/2009	Atlantic salmon	500	1.27
5/25/1995	lake trout	650	20.32	4/27/2010	lake trout	460	17.78
5/9/1996	Atlantic salmon	500	15.24	5/24/2010	Atlantic salmon	500	1.27
6/4/1996	lake trout	650	22.86	4/20/2011	lake trout	310	15.24
6/4/1997	lake trout	650	20.32	5/19/2011	Atlantic salmon	500	1.27
6/11/1997	Atlantic salmon	500	17.78	5/9/2012	Atlantic salmon	500	16.51
7/2/1997	Atlantic salmon	20	55.88	4/25/2013	lake trout	470	17.78
5/15/1998	Atlantic salmon	480	15.24	5/2/2013	Atlantic salmon	500	16.51
6/2/1998	lake trout	700	20.32	5/2/2014	Atlantic salmon	1437	5.08
4/23/1999	Atlantic salmon	250	17.78	5/2/2014	Atlantic salmon	500	17.78
6/7/1999	lake trout	650	17.78	5/28/2014	lake trout	650	17.78
5/22/2000	Atlantic salmon	500	15.24				
5/22/2000	lake trout	650	20.32				
5/15/2001	lake trout	650	17.78				

APPENDIX E

Table E.1 Sites descriptions for the 2015 rake toss macrophyte survey in Sixberry Lake.

							6/25/2015					8/7/2015					9/11/2015				
Site No.	Bottom Composition						Type			Density		Type			Density		Type			Density	
	Sand	Mud	Gravel	Silt	Muck	Rock	E	F	S	D	M	E	F	S	D	M	E	F	S	D	M
1	-	-	Y	-	Y	Y	-	-	Y	-	-	Y	-	Y	-	Y	-	-	Y	-	Y
2	-	-	Y	-	-	Y	-	-	Y	-	-	Y	Y	Y	Y	-	-	-	Y	Y	-
3	Y	-	-	-	Y	-	Y	-	Y	-	Y	Y	Y	Y	-	Y	-	-	Y	-	Y
4	Y	Y	-	-	Y	-	Y	-	-	-	-	-	-	Y	-	Y	-	-	Y	Y	-
5	-	Y	-	-	Y	-	Y	-	Y	-	-	Y	-	Y	Y	-	-	-	Y	-	Y
6	-	Y	-	-	Y	-	-	-	Y	-	-	Y	-	-	-	Y	Y	-	Y	Y	-
7	-	Y	-	-	Y	Y	Y	-	Y	Y	-	-	-	Y	-	Y	-	Y	Y	Y	-
8	-	-	-	-	Y	-	Y	-	Y	-	-	-	-	Y	Y	-	-	-	Y	-	-
10	-	-	-	-	Y	-	-	-	Y	Y	-	-	-	Y	-	Y	-	-	Y	-	Y
12	-	-	-	-	-	Y	-	-	Y	-	-	-	-	Y	-	Y	-	-	Y	-	Y
13	-	-	-	-	-	Y	-	-	Y	-	-	Y	-	-	-	Y	-	-	Y	-	-
14	-	-	-	-	-	Y	Y	-	-	-	-	-	-	Y	-	-	-	-	Y	Y	-
17	-	-	-	-	Y	Y	-	Y	Y	-	-	-	-	Y	-	Y	Y	Y	Y	Y	-
18	-	Y	-	-	Y	-	-	-	Y	Y	-	Y	-	-	Y	-	-	-	Y	Y	-
19	Y	-	-	-	Y	-	Y	-	Y	Y	-	Y	Y	Y	Y	-	-	-	Y	-	Y
22	-	-	-	-	-	Y	-	-	-	-	-	Y	Y	Y	Y	-	Y	Y	Y	Y	-
25	-	-	-	-	Y	Y	-	-	Y	-	-	-	Y	Y	Y	-	-	Y	Y	-	Y
27	-	-	-	-	-	Y	-	Y	-	-	-	-	Y	Y	-	Y	-	-	Y	-	Y
28	-	-	-	-	-	-	-	-	Y	-	-	-	-	Y	-	Y	-	-	Y	Y	-

KEY
E = emergent
F = floating leaved
S = submergent
D = dense
M = moderate
Y = present in sample
- = absent from sample

Table E.2 Percent composition of macrophytes collected by rake toss on June 25, 2015 by sample site.

	Percent composition																			
Site No.	*Chara* sp.	*C. demersum*	*E. canadensis*	*H. dubia*	*Isoetes* sp.	*M. spicatum*	*N.* flexilis	*Nitella* sp	*P. amplifolius*	*P. diversifolius*	*P. foliosus*	*P. gramineus*	*P. illinoensis*	*P. pusillus*	*P. robbinsii*	*P. zosteriformis*	*R. aquatilis*	*S. graminea*	*Utricularia* sp.*	*V. americana*
1	-	-	Y	-	-	Y	-	Y	-	-	-	-	-	-	Y	-	-	-	-	-
2	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	Y
3	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	5	2	-	80	-	-	-	5	6	-	-	-	-	-	-	-	-	-	2
5	-	-	-	-	-	75	-	-	-	-	-	-	-	-	25	-	-	-	-	-
6	-	65	-	-	-	-	-	5	5	5	-	-	-	-	15	-	-	-	-	-
7	-	-	5	-	-	10	-	1	-	10	-	-	-	-	65	-	7	1	-	1
8	-	-	-	-	-	75	-	-	-	25	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	10	-	90	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	99	-	-	-	-	-	-	-	-	-	-	-	-	-	1
14	-	-	-	-	95	2.5	-	2.5	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	1	-	-	-	-	-	-	-	-	95	-	-	-	-	4
18	-	40	10	-	-	15	-	20	-	-	-	-	-	-	15	-	-	-	-	-
19	-	-	2	-	-	75	-	2	2	-	-	-	-	-	-	-	15	2	-	2
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	5	-	50	-	35	-	-	-	-	5	-	-	-	-	5
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	Y	-	-	-	Y	-	-	-	-	Y	-	-	-	-	-

*The *Utricularia* sp. observed was not identified to species, but was identified as not being the known invasive species, *Utricularia inflata*.

KEY

Y = plant species was present, but the percent composition was not estimated.

- = absent from sample

Table E.3 Percent composition of macrophytes collected by rake toss on August 7, 2015 by sample site.

Site No.	Percent Composition																			
	Chara sp.	*C. demersum*	*E. canadensis*	*H. dubia*	*Isoetes* sp.	*M. spicatum*	*N. flexilis*	*Nitella* sp	*P. amplifolius*	*P. diversifolius*	*P. foliosus*	*P. gramineus*	*P. illinoensis*	*P. pusillus*	*P. robbinsii*	*P. zosteriformis*	*R. aquatilis*	*S. graminea*	*Utricularia* sp.*	*V. americana*
1	-	-	-	-	-	25	25	-	-	-	-	-	-	-	25	-	-	-	-	25
2	-	-	-	-	-	75	15	3	-	-	3	-	-	-	-	-	-	-	4	-
3	1	-	-	-	-	-	66	-	1	-	10	-	-	-	20	-	-	-	1	1
4	-	-	-	-	30	-	10	15	-	-	5	-	30	-	-	-	-	-	10	-
5	-	-	1	-	-	40	-	9	-	-	-	-	-	-	50	-	-	-	-	-
6	-	-	25	-	8	25	10	10	-	-	2	-	10	-	-	-	-	-	10	-
7	-	-	-	-	40	-	-	8	40	-	-	-	-	-	-	-	2	-	-	-
8	-	-	-	-	-	-	-	40	-	-	-	-	-	40	20	-	-	-	-	-
10	-	-	-	-	-	80	20	-	-	-	-	-	-	-	-	-	-	-	-	-
12	5	-	-	-	-	75	10	10	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	50	25	10	-	-	-	-	-	-	-	-	-	-	15	-
14	20	-	-	-	-	-	20	20	-	-	-	-	-	-	-	-	-	-	-	-
17	5	-	-	-	-	30	10	5	-	-	-	5	-	30	10	-	-	-	5	-
18	-	4	1	-	-	35	5	5	-	-	-	-	-	35	-	-	-	-	15	-
19	20	-	2	-	-	50	25	-	-	-	-	-	-	-	-	1	-	-	1	1
22	-	-	-	-	-	50	10	-	-	-	-	15	-	10	10	-	-	-	-	5
25	2	-	-	-	-	50	1	-	-	-	-	7	-	-	40	-	-	-	-	-
27	-	-	-	-	-	50	-	5	-	-	-	-	-	5	40	-	-	-	-	-
28	40	-	-	-	-	-	50	5	-	-	-	-	-	-	-	-	-	-	5	-

*The *Utricularia* sp. observed was not identified to species, but was identified as not being the known invasive species, *Utricularia inflata*.

KEY

Y = plant species was present, but the percent composition was not estimated.

- = absent from sample

Table E.4 Percent composition of macrophytes collected by rake toss on September 11, 2015 by sample site.

Site No.	Percent Composition																			
	Chara sp.	*C. demersum*	*E. canadensis*	*H. dubia*	*I.* sp.	*M. spicatum*	*N. flexilis*	*Nitella* sp.	*P. amplifolius*	*P. diversifolius*	*P. foliosus*	*P. gramineus*	*P. illinoensis*	*P. pusillus*	*P. robbinsii*	*P. zosteriformis*	*R. aquatilis*	*S. graminea*	*Utricularia* sp.*	*V. americana*
1	-	-	-	-	-	75	5	10	-	-	-	-	-	10	-	-	-	-	-	-
2	-	-	-	-	-	97	1	1	-	-	-	-	-	1	-	-	-	-	-	-
3	-	-	-	-	-	-	10	50	-	-	-	20	20	-	-	-	-	-	-	-
4	-	-	-	-	-	95	-	-	-	-	-	-	-	-	5	-	-	-	-	-
5	-	-	-	-	30	10	1	10	-	-	-	8	1	-	30	-	-	-	10	-
6	-	-	20	-	1	50	1	5	-	-	-	15	2	-	1	-	-	-	5	-
7	-	-	-	6	-	60	-	1	-	-	-	20	5	-	6	-	1	-	-	1
8	-	-	-	1	-	30	1	50	-	-	-	5	-	-	10	-	-	-	4	-
10	20	-	8	-	-	1	10	50	-	-	-	-	1	-	-	-	-	-	10	-
12	-	-	-	-	-	90	1	9	-	-	-	-	-	-	-	-	-	-	-	-
13	1	-	-	-	-	60	3	10	-	-	-	3	10	-	-	-	-	-	10	3
14	-	-	-	-	-	95	4	0.5	-	-	-	-	-	-	-	-	-	-	-	0.5
17	-	-	1	-	-	75	1	3	-	-	-	5	15	-	-	-	-	-	-	-
18	-	25	5	-	-	50	1	15	-	-	-	-	-	1	1	-	-	-	1	-
19	-	-	-	-	-	-	-	95	-	-	-	-	-	-	5	-	-	-	-	-
22	-	-	10	-	-	60	-	1	-	-	-	10	-	-	10	-	-	-	-	9
25	-	-	-	-	-	20	-	75	-	-	-	-	-	5	-	-	-	-	-	-
27	-	-	-	-	-	10	75	10	-	-	-	-	-	1	-	-	-	-	1	3
28	1	-	-	-	-	75	10	1	-	-	-	10	-	2	-	-	-	-	1	-

*The *Utricularia* sp. observed was not identified to species, but was identified as not being the known invasive species, *Utricularia inflata*.

KEY

Y = plant species was present, but the percent composition was not estimated.

- = absent from sample

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