THE STATE OF BIG BOWMAN POND

AND

A PLAN FOR THE MANAGEMENT OF BIG BOWMAN POND

A Thesis

by

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Chapter I: Lake Basin, Watershed Conditions, and History of Big Bowman Pond

Introduction

Big Bowman Pond is a small, glacially formed dimictic lake located in eastern New York State within the Town of Sand Lake in Rensselaer County. This lake is one of 350 lakes in the Lower Hudson River basin and is one of 55 lakes in the county. Big Bowman Pond is one of the smaller lakes within the region, having a surface area of 12.2 hectares (ha). It has a watershed area of 235 ha which gives the lake a drainage basin area ratio of approximately 19:1 (Table 1.1, Figure 1.1, Figure 1.2). The lake has a maximum depth of about 10 meters (m) (Table 1.1).

Waterbody classification and Lake Use

Big Bowman Pond is classified as a Class B waterbody by the New York State Department of Environmental Conservation (NYSDEC). This means that the best intended use is for contact recreation, such as swimming and bathing, and non-contact recreation, such as boating and fishing. Motorized boating is prohibited due to an ordinance passed by the town of Sand Lake in 1988. This was consistent with an informal policy on the lake supporting swimming and other recreational use. There is a small dam (2 feet long by 0.5 feet high) on the west side of the lake which is used to control water level. It is classified as a Class A or low hazard dam, meaning that dam failure is unlikely to result in damage to the surrounding area (FEMA 2004). The lake has no public access and is privately owned by the surrounding land owners.

Table 1.1 Morphological characteristics of Big Bowman Pond and its drainage basin. All in-lake calculations are based on the bathymetry map provided by the NYSDEC. Volume was calculated following the method of Wetzel (2001) which takes the sum of truncated cones. Hydraulic retention time was obtained from CSLAP reports.

Characteristic	Metric	English
Surface area	12.2 ha	30.2 ac
Max depth	10.1 m	33.13 ft
Mean depth	4.5 m	14.76 ft
Relative depth		
Volume	437000 m^3	350 ac-ft
Max length	0.724 km	0.45 mi
Max effective length	0.724 km	0.45 mi
Max width	0.273 km	0.17 mi
Max effective width	0.273 km	0.17 mi
Mean width		
Shoreline length	1.93 km	1.2 miles
Shoreline development index		1.67
Drainage basin	235 ha	580.70 ac
Drainage basin: lake area ratio		19.26
Hydraulic retention time		0.4 years

LaMere (2003).

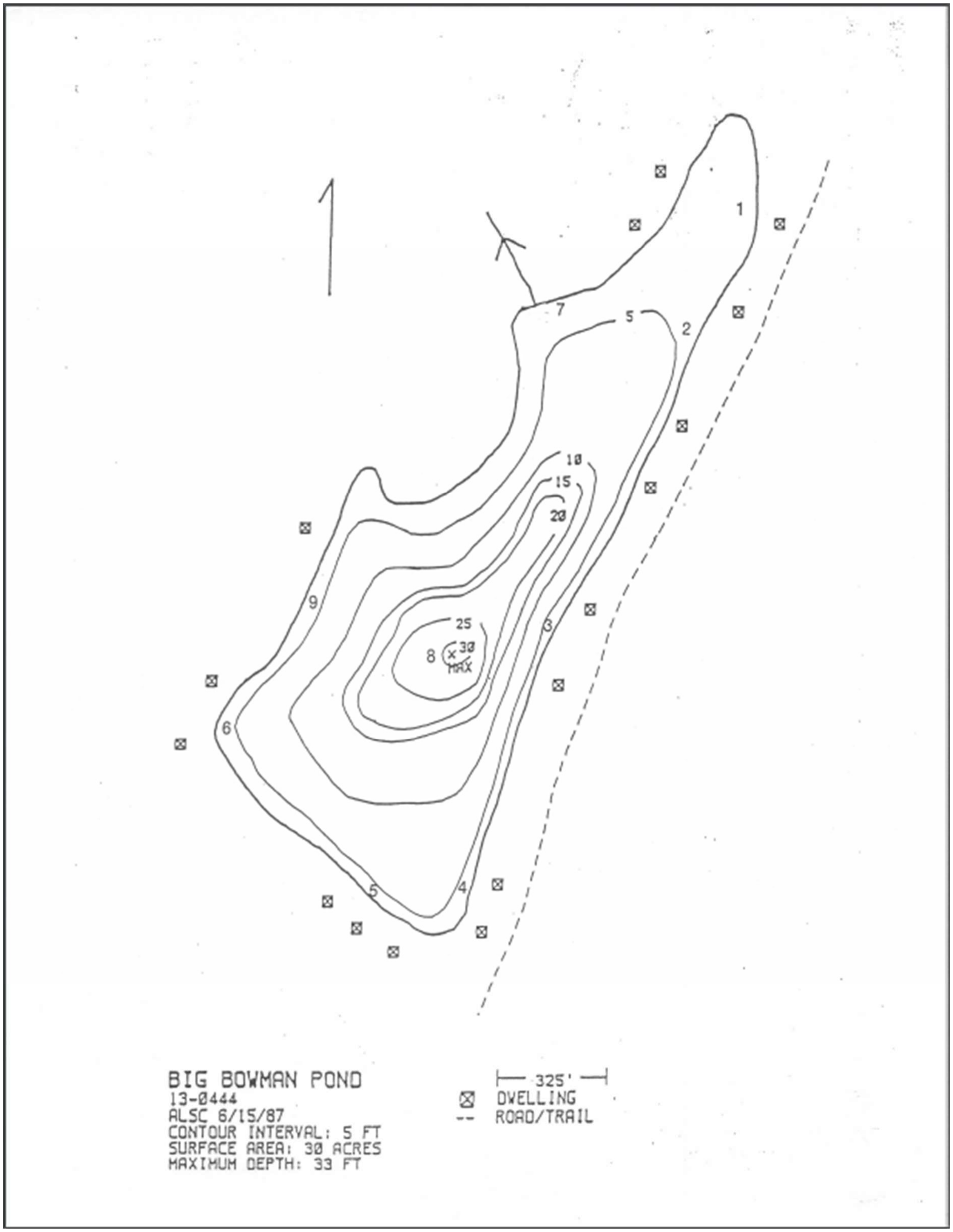

Figure 1.1 Bathymetric map of Big Bowman Pond in Rensselaer County NY. Adapted from LaMere (2003).

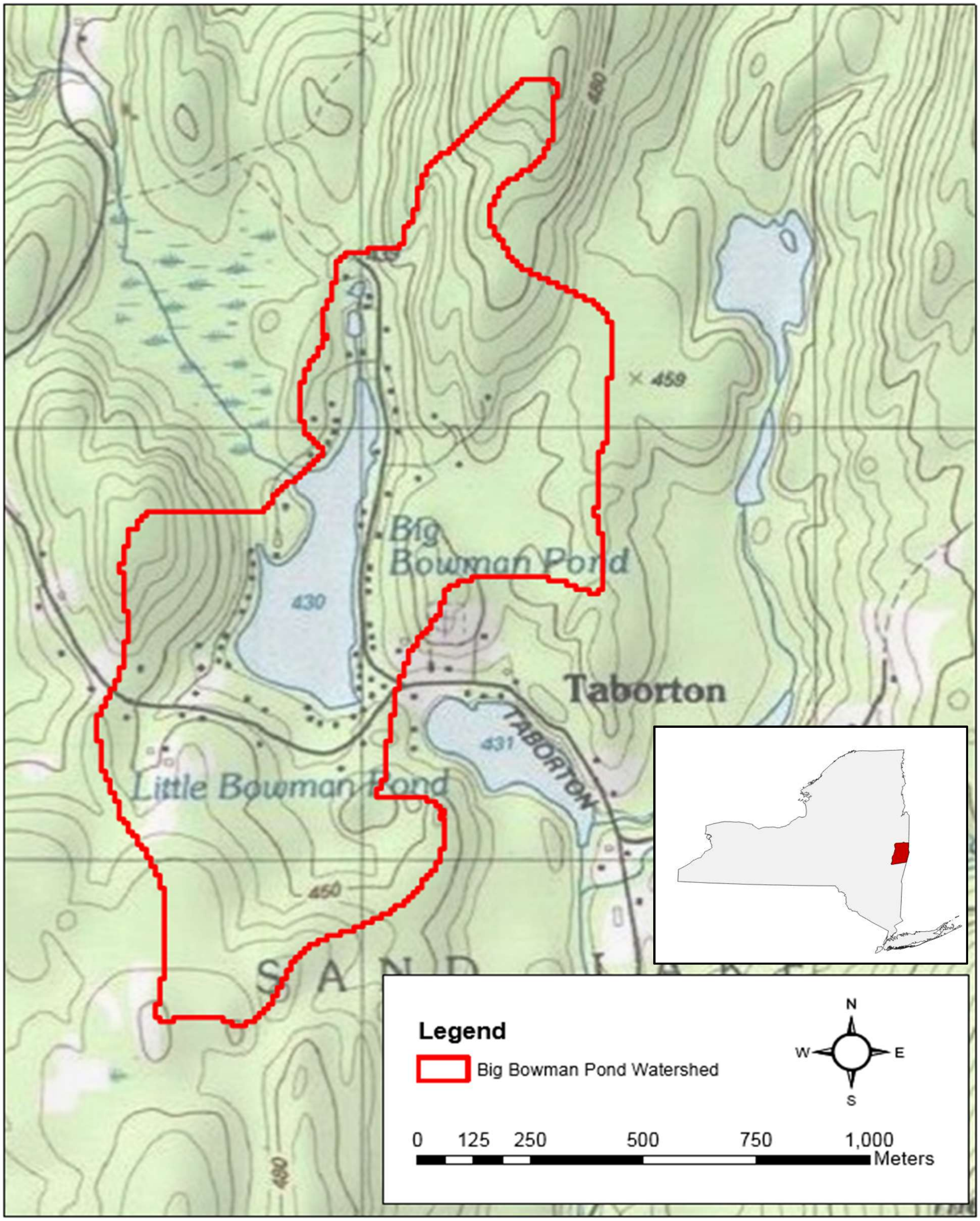

Figure 1.2. Watershed map of Big Bowman Pond in Rensselaer County NY.

Land Use and Land Cover

Big Bowman Pond is in a primarily forested watershed with moderate amounts of developed and agricultural land. Forested land is dominant and covers 81.8 % of the total area (Figure 1.3). The next most prevalent land cover type is developed land, which covers 7.8 % of the watershed. Development is primarily residential and is concentrated at the southern end of the lake, although homes do exist along most of the shore. The remaining 10.4% of the watershed is a combination of wetlands and agricultural land (U.S. Geological Survey 2012). One wetland area surrounds the outlet at the northern end of the lake. Another wetland area is west of the center of the lake and was most likely created by over-surface flow. One section of land classified as agricultural is in the southwest corner of the watershed and consists of a small farm (Figure 1.3).

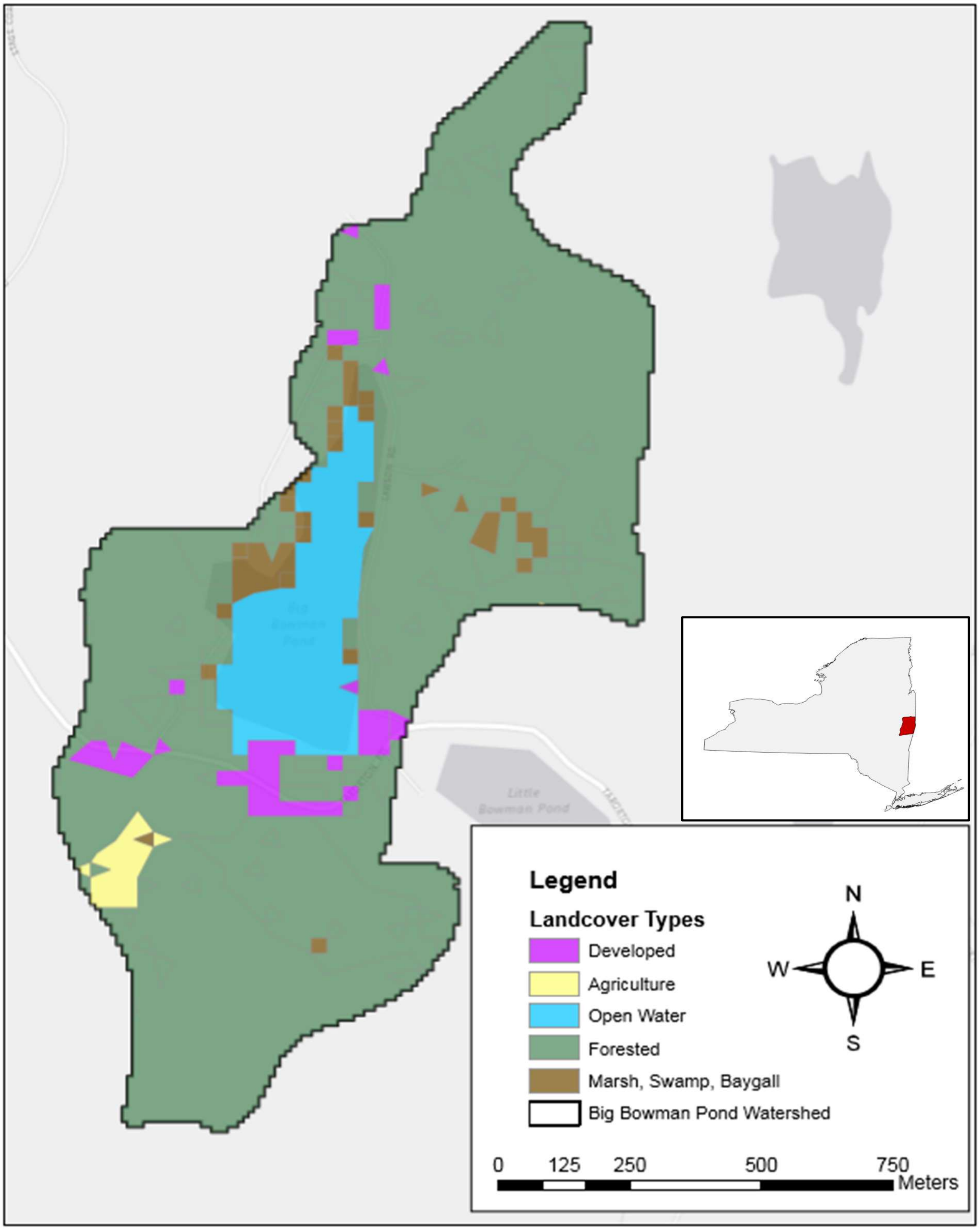

Figure 1.3. Land cover classification within the Big Bowman watershed in Rensselaer County NY (NYSDEC 2013).

Bedrock, Soils, and Septic Suitability

The New York State Department of Environmental Conservation (NYSDEC) soil data indicate that only one type of bedrock is present within the area of interest (AOI). The bedrock of the area is a tectonic overthrust (allochthonous) sequence and is described to be mainly greywacke sandstone and shale (Natural Resources Conservation Service [NRCS] 2017). Greywacke sandstone is generally characterized by its hardness, dark color, and poorly sorted angular grains. Shale is described as a fine-grained sedimentary rock, which is formed by the compaction of silts and clay mineral particles. This indicates that the buffering capacity of the lake is low due to deficient calcium, and that the lake is susceptible to changes in pH.

There are five types of soil that make up the Big Bowman Pond watershed (Natural Resources Conservation Service [NRCS] 2017). The most abundant soil type within the watershed is Buckland very stony loam, moderately steep (BuD), which comprises 40.3% of the AOI. Following this is Buckland very stony loam, sloping (BuC), which makes up 39.0% of the AOI. These two soil types encompass the entire lake basin and comprise most of the watershed. The three other soil types represent a smaller percentage of the watershed and consist of Brayton very stony silt loam (BrA) (9%), Buckland very stony loam, very steep (BuF) (1.3%), and Glover very stony loam (GlD) (1.3%). Overall, it should be noted that each one of these soil types are classified as poorly drained, meaning water is slow to infiltrate the soil. The soils are also all classified as steeply sloping which indicates that water could flow rapidly into the lake system, causing increased erosion on the surrounding landscape.

Soil septic suitability was determined for the Big Bowman Pond watershed using the Web Soil Survey (WSS) tool provided by the NRCS (2017). All soils within the watershed are ranked as “very limited” in their ability to serve for on-site waste disposal (Figure 1.4). This means that even with careful planning or modification, the soils are poorly suited for conventional septic systems.

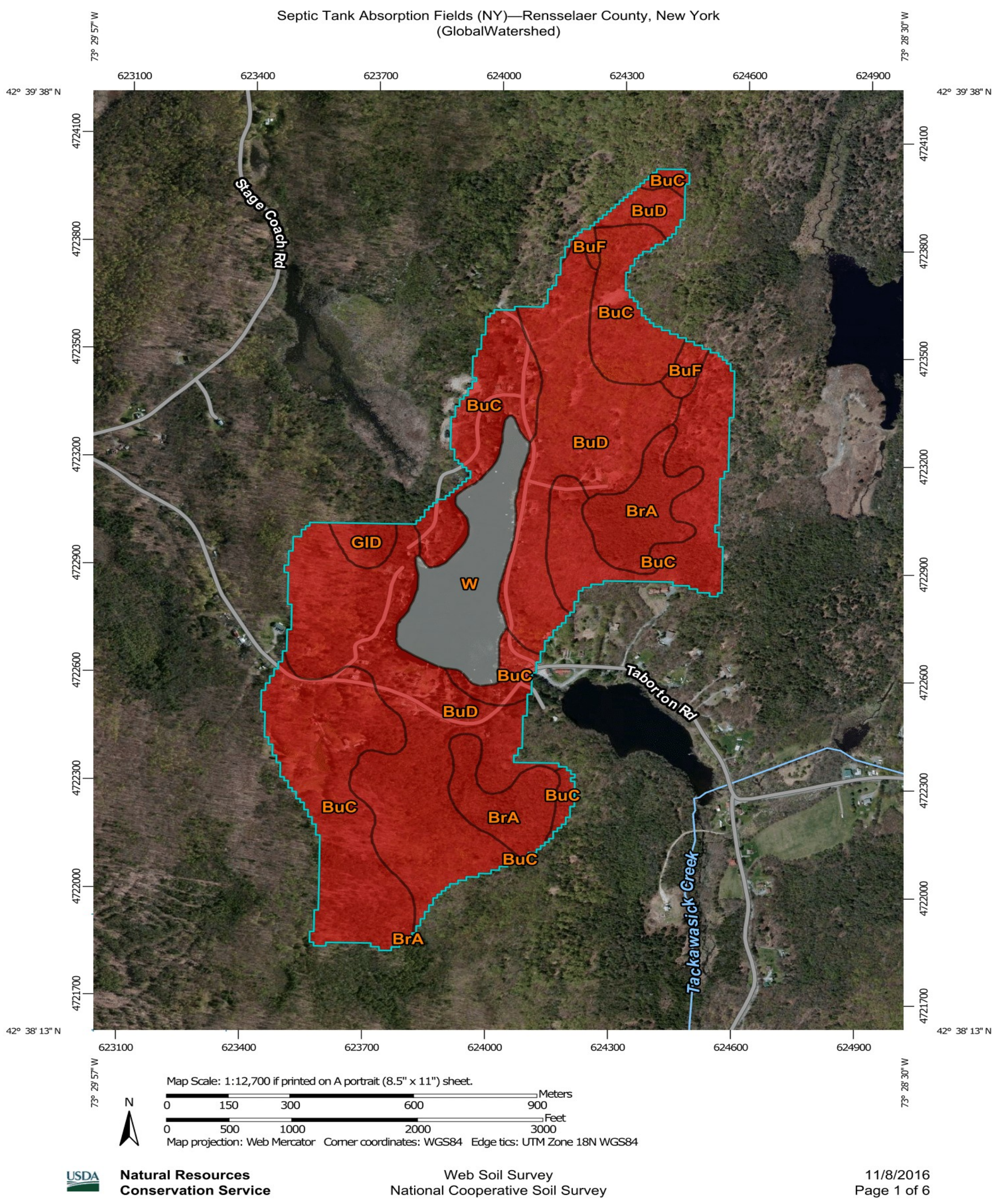

Figure 1.4. Septic suitability map of Big Bowman Pond watershed. Red indicates that soil conditions are poor for absorption, and that they are areas unsuitable for conventional septic systems absorption fields. (NRCS 2017).

Socioeconomics

As of 2010, the population in the Town of Sand Lake was 8,530 (U.S Census 2010) (Table 1.2). This population consisted of approximately 50 % males and 50 % females. The average age of a person living in the county was around 43 years, with 23 % of the population being younger than 18, and 12 % older than 65 years.

The total number of households within the town in 2010 was 3,353, with 89 of those being found around Big Bowman Pond (Figure 1.5). Seventy-four percent of these households were classified as family homes, with an average of three people per household. Just nine percent of the houses in the area were classified as vacant as of 2010. Based on these numbers, I estimated that the total population in the watershed was approximately 267 people (U. S. Census 2010).

Table 1.2. 2010 census data for the Town of Sand Lake, Rensselaer County, New York (U.S. Census 2010).

Subject	Number	Percent
Sex and age		
Total population	8,530	100
Male population	4,229	49.6
Female population	4,301	50.4
Below the age of 18	1,969	23.1
Over the age of 65	1,040	12.2
Median age	43	N/A
Households by type		
Total households	3,353	100
Family households	2,505	74.7
Nonfamily households	848	25.3
Average household size	2.54	N/A
Average family size	2.91	N/A
Housing occupancy		
Total households	3,353	100
Occupied housing units	3,353	91.3
Vacant housing units	320	8.7

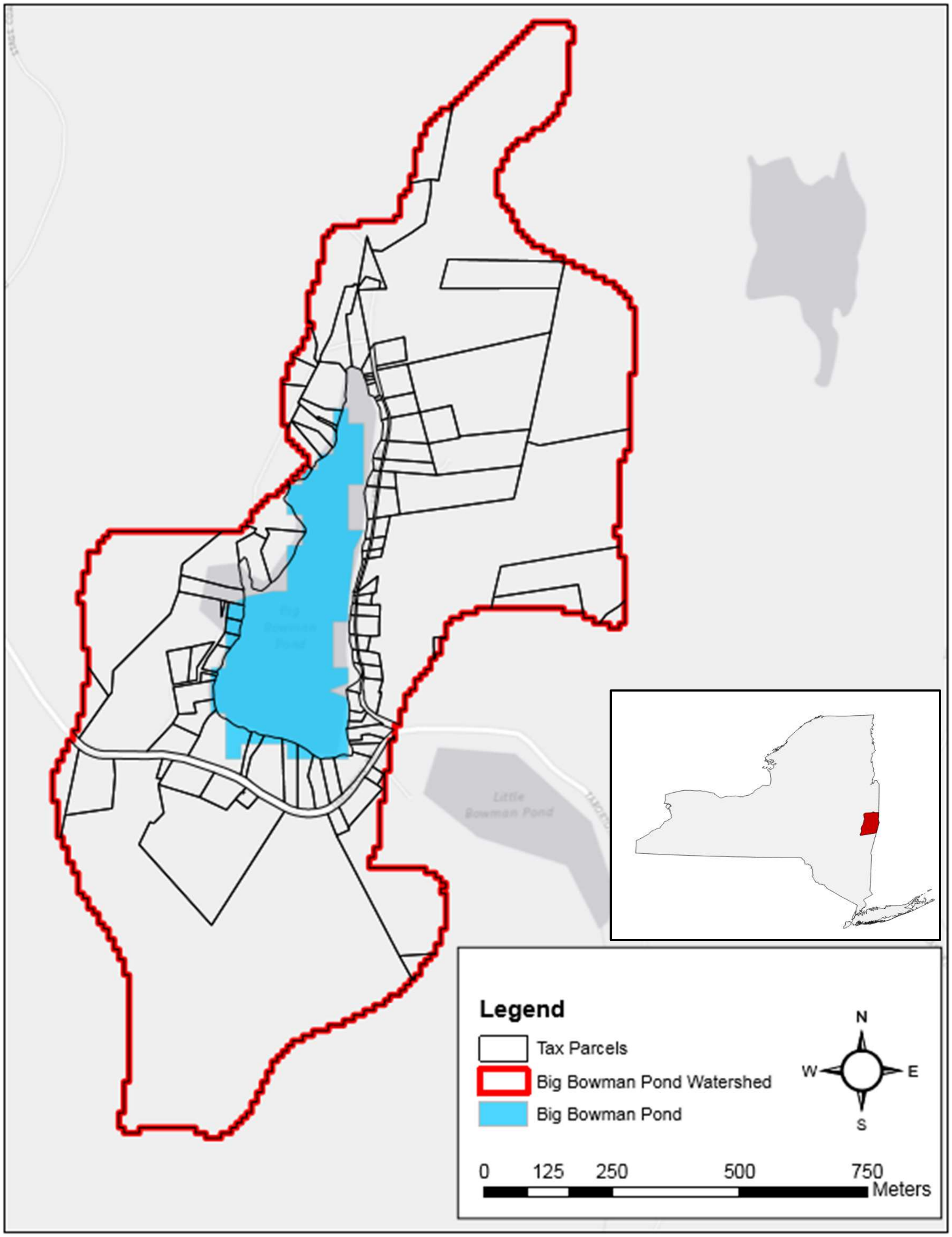

Figure 1.5. Tax parcels within the Big Bowman Pond watershed in Rensselaer County, NY (County Chamber of Commerce 2013).

History of Studies

Big Bowman Pond has always been a privately-owned lake; however, it has been sampled throughout the years by public and private agencies. The oldest study on the lake was part of a biological survey of the Lower Hudson River in 1934 conducted by the Conservation Department, the predecessor to the NYSDEC (NYSDEC 2013). The lake was also sampled in 1972 (Scavia 1972), 1986 (Eichler and Soracco 1986), 1991 (Soracco et al. 1991), and 2003 (LaMere 2013).

When sampled in August 1934 (NYSDEC 2013), the lake was weakly stratified, with lower oxygen levels within the hypolimnion than in the epilimnion. Water clarity was approximately 15 feet. There was abundant vegetation in the lake, although no species were identified. Fish were identified to species level and included bullhead catfish (*Ameiurus spp.*), chain pickerel (*Esox niger*), common sunfish (*Centrarchidae spp.*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), and an unknown species noted as “zebra darter”.

In 1972, a study was performed by the Rensselaer Polytechnic Institute (RPI) on all lakes within Rensselaer county for the proposal for Environmental Management Actions (Scavia 1972). This study was more detailed than the 1934 report by the Conservation Department and included data on the chemical and biological conditions in each lake, including information about water clarity, oxygen levels, calcium levels, phosphorous, fisheries community, and plant communities. At the time, water clarity in the lake was greater than recorded in the 1972 report and dissolved oxygen concentration in the hypolimnion was recorded as high, with levels over 6ppm being recorded. During the sampling period, it was noted that the lake was “strongly” stratified. Also, it was stated that chloride averaged 4.5 mg/l within the lake, which may have been elevated due to road salt applications. Fisheries sampling indicated that yellow perch and rock bass were dominant. Finally, 12 species of aquatic plants were identified, including several species of bladderwort (*Utricularia* spp.), which were dominant, and one invasive species, curly-leafed pondweed (*Potomogeton crispus*) (NYSDEC 2013).

In 1986, RPI conducted sampling in Big Bowman Pond (Eichler and Soracco 1986). The work addressed water chemistry, water depth, degree of shoreline development, and density of aquatic weed growth. The chemistry of the lake had remained stable since the 1972 study, except for total nitrogen and total phosphorus. Total nitrogen decreased from 0.1 mg/l to 0.01 mg/l and total phosphorus increased from 0.005 mg/l to 0.008 mg/l (Eichler and Soracco 1986). It was reported that aquatic plants within the lake did not appear to be problematic, but the densities observed in the northern bay and, to a lesser extent, the outlet bay provided undesirable conditions for swimming. This report did not mention which species caused the undesirable conditions (Eichler and Soracco 1986).

In 1991, another study was performed by RPI to assess the aquatic plant community, water quality and watershed activities (Soracco et al. 1991). They determined that there was a shift in the plant community and a new species was present, *Nymphoides cordata* (floating heart). They also noticed that *Nymphaea ordorata* and *Potamogeton epihydrus* were prominent throughout the lake, where previously *Potamogeton robbinsii* and *Potamogeton amplifolius* were dominant. The dominance of *Utricularia vulgaris* and *Saggittaria graminea* was noted within the northern cove, Turtle Cove as it is called today. As for water chemistry, they concluded that runoff was the primary driver of water chemistry, which was supported by peaks in their data during heavy run off events (Soracco et al. 1991).

In 2003, a study was performed by Adirondack Ecologist with the objective of determining the current water quality, and to assist in the establishment of a benchmark for future studies (LaMere 2013). This study occurred during summer and concluded that the lake could be classified as an early eutrophic lake, with oxygen depletion in the hypolimnion through the months of July and August. It was stated that roughly 52% and 74% of the total depth of the lake did not possess enough DO to support aquatic life. He noted that internal loading was observed and that phosphorus levels had increased since 1986 from an average 0.006 mg/l to 0.010 mg/l. Water clarity also decreased from 11.9 ft to 8.6 ft (LaMere 2013).

Currently, the stakeholders of Big Bowman Pond have participated in the Citizen Statewide Lake Assessment Program (CSLAP) since 2013. The CSLAP reports indicate that Big Bowman Pond is a mesotrophic water body. Additional documentation describes common water quality indicators such as temperature, dissolved oxygen, pH, water clarity, total phosphorus, total nitrogen and chlorophyll *a*.

Chapter II: Physical and Chemical Limnology

Introduction

The physical and chemical characteristics of a lake affect the ecology, which in turn impact the recreational opportunities available to people. Any sizable change in productivity, due to anthropogenic or natural impacts, could influence the entire lake, from altering algal communities to affecting the fisheries (Wetzel 2001). Depending on how the ecosystem is altered, the effects of a given change could be either beneficial or undesirable for different uses. For example, increased nutrient concentrations can cause shifts in algal communities from green algae to cyanobacteria, also known as blue-green algae, which can be harmful to humans and pets, and can prevent recreational uses such as swimming. Understanding the overall physical and chemical limnology of the lake can be help gauge the current state of a lake and help stakeholders understand these nuanced impacts on desired uses of the resources.

Consistent monitoring of limnology in Big Bowman Pond began in 2013 with participation in the Citizens Statewide Lake Assessment Program (CSLAP). This program entails bi-weekly monitoring during the summer season and relies on volunteer participation through lake associations. The data collected include measurements of total phosphorus, Secchi depth, and chlorophyll *a* (NYSDEC and NYSFOLA [New York State Federation of Lake Associations] 2018). Prior to the involvement with CSLAP, this lake had monitoring occurring approximately every decade (see above), which reported similar physical and chemical variables. This has provided historical background information that can be compared to current monitoring to gauge whether the lake has undergone any major physical or chemical shifts since 1972; however, the historical data only consist of one or two sampling dates per year and there are prolonged periods between sampling dates. This limits the understanding of the limnological process as that occurred during that period. Regular and frequent monitoring is necessary as freshwater ecosystems are susceptible to environmental and anthropogenic stressors, such as road salt and chemical runoff.

There were two major goals of this study. The first was to characterize the current state of the physical and chemical limnology of Big Bowman Pond. The second was to determine if any changes had occurred within the lake since the collection of CSLAP data began in 2013. Completion of these goals will allow for a more complete understanding of the status of the limnology of Big Bowman Pond and will provide information needed for future management.

Methods

Field Sampling and Preservation Protocol

Sampling of the physical and chemical parameters in Big Bowman Pond started in October 2016 and ended in November 2017. The lake was sampled bi-weekly during the open-water season and at least monthly, if weather and ice permitted, during ice cover. All limnological data were collected at the deepest point within the lake (see Figure 1), which was determined using the most recent bathymetric map from 2013 and verified using a Speedtech® Depthmate portable sounder. Temperature, alkalinity, pH, dissolved oxygen (DO), and specific conductivity were measured using a YSI ® 650 MDS with a 6-series multiparameter sonde, calibrated according to manufacturer instructions (YSI 2010). Water transparency was measured using a Secchi disk as described by Wetzel and Likens (2000).

Water samples were collected using a Kemmerer or a Van Dorn water sampler for laboratory chemical analyses. Sample analyses included measurements of total phosphorus (TP), total nitrogen (TN), and nitrate and nitrite combined. Samples were collected every two meters starting from the surface, 0 m, to a depth of approximately 8 m. Samples were kept on ice in acid-washed, translucent, 125 ml polyethylene bottles until sulfuric acid was added as a preservative (Liao and Marten 2001). Alkalinity, calcium, chloride and chlorophyll *a* (chl. *a*) were all sampled at 4 m intervals from the surface (0 m, 4 m, 8 m). These samples were stored in 500 ml acid-washed polyethylene bottles and were kept refrigerated before being processed within a month of collection.

Sample Processing

Nutrients

Nutrient analyses were performed using a Lachet 8000 series autoanalyzer. Total phosphorus was analyzed by persulfate digestion followed by the ascorbic acid method (Liao and Martin 2001). Total nitrogen and nitrate + nitrate were assessed by using the cadmium reduction method (Pritzlaff 2003), with TN undergoing peroxodisulfate digestion prior to analysis as described in Ebina et al. (1983). Ammonia was determined using the phenolate method (Liao 2001).

Chlorophyll a

Water for chlorophyll. *a* analysis was stored in a 1 L brown, opaque polyethylene bottle to limit photosynthesis. Samples were then prepared by filtering approximately 250 ml of lake water thought a Whatman ® GF/A glass fiber filter using a low-pressure pump to prevent the rupturing of chloroplast. The filter was then folded in half, dried, stored in a small dish wrapped in aluminum foil and stored in a freezer. After retrieving the prepared filters, each filter was cut up, placed in a 15 ml centrifuge tube and buffered acetone (90 % acetone, 10 % $MgCO_3$) was added to the sample. After steeping for three hours, each sample was centrifuged at 10,000 rpm for 10 minutes, the supernatant was removed, and was analyzed with a Turner Designs™ TD-700 fluorometer (Turner Designs, San Jose, CA, USA). The final concentrations, in parts per billion (µg/l), were determined from the methods of Arar and Collins (1997) as:

Chlorophyll *a* (µg/l) = concentrated Chl.*a* × final volume / ml sample filtered

Alkalinity

Water samples were processed for alkalinity using titrimetric methods (Section 2320 B, APHA 1989). Lake water (100 ml) was titrated to an endpoint pH of 4.6 using a 0.020 N HCl solution. Alkalinity was then calculated as:

Alkalinity (mg/l as CaCO3) = ml of titrant × 0.020 × 50,000 / ml sample

Calcium

Calcium concentrations were determined using the ethylenediaminetetraacetic (EDTA) titrimetric method (section 3500-Ca D, APHA 1989). Lake water (50 ml) was added to a glass beaker with 0.2 g of murexide indicator and 1 ml of 2 N NaOH. The sample was then titrated to the endpoint color of pink using 0.01 M EDTA. Calcium concentration was calculated as:

Calcium (mg/l of Ca^{2+} = ml 0.001 N EDTA titrant × (400.8/ml samples)

Chloride

Chloride concentration was determined using the titrimetric mercuric nitrate method (section 4500-CL C, APHA 1989) whereby 100 ml of sample was added to a beaker along with 1.0 ml of indicator acidifier reagent. samples were titrated with standardized 0.0141 N mercuric nitrate. Chloride concentration was calculated as:

Chloride (mg/l) = (sample value - blank value) × 0.0141 N × (35,459 / sample volume (ml))

Data Analysis

Isopleths

Isopleths were generated using R (R Core Team 2016). Values for each of the physical and chemical parameters tested (temperature, DO, pH, specific conductivity, TP, TN, and nitrate and nitrite) were each interpolated across sampling dates and depths using linear interpolation within the range of dates and depths observed with the “akima” package (Akima et al. 2015).

Trophic Status

Trophic status index (TSI, Carlson 1977) was used to determine the trophic status of Big Bowman Pond for each separate sample occasion during the sampling season and then averaged. Separate TSI values were calculated for TP, SD, and Chl. *a* concentration (Carlson 1977). A TSI less than 30 generally indicates oligotrophic conditions,30-50 mesotrophic, 50-70 eutrophic, and greater than 70 hypereutrophic (Wetzel 2001). Equations used to calculate TSI were as follows:

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

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

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

Zooplankton

Samples were taken monthly at the deepest location of the lake to evaluate temporal variation in the zooplankton community. A conical 63 µm plankton net with a 0.2 m diameter opening was used for the collection of zooplankton. The end of the cup was weighted, the net was lowered to $z = 7$ m, and then brought to the surface. Concentrated samples were persevered with 70 % ethanol. The volume of ethanol used was equal to the volume of concentrated sample present.

Samples were analyzed one ml at a time on a gridded Sedgwick Rafter cell. Zooplankton were identified and recorded using a research grade compound microscope with digital imaging capabilities. At least 100 organisms were viewed per sample. Percent composition of the community is presented.

Results

Temperature

Big Bowman pond is a dimitic lake characterized by mixing events during the fall and spring and exhibiting thermal stratification during the summer and winter. Fall turnover was observed from late November to early December and spring turnover was seen during March, shortly after ice-out. Ice cover started to form in early December and completely covered the lake by December 24, 2016 and was then completely melted by the end of March. During summer stratification temperatures ranged from ~20 °C at the surface to 6 °C at the sediment surface. The thermocline was located at approximately 3-5 m from the surface (Figure 2.1).

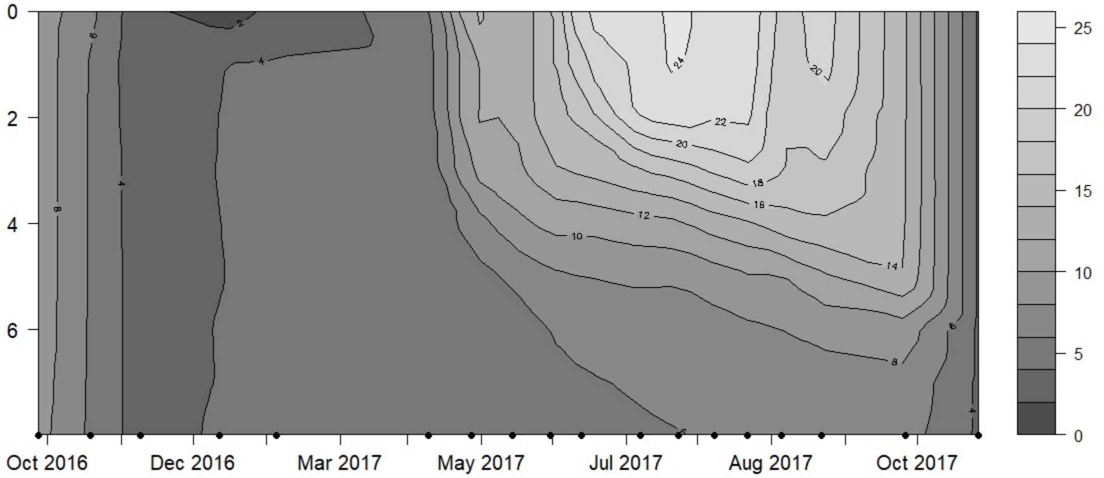

Figure 2.1 Temperature isopleth (°C) detailing stratification for Big Bowman Pond. Black dots indicate sampling dates.

Dissolved Oxygen

Prior to summer stratification, DO concentrations were uniform within the water column, ranging from 8-11 mg/l at the surface to 7-9 mg/l at the bottom (Figure 2.2). During stratification (April 27, 2017 to November 26, 2017) DO was highest at approximately 3 m. Anoxia was observed for the first time on April 9, 2017 and persisted through October 26, 2017 it was most severe on September 9, 2017 with 5 m of anoxia. During January, the DO at the surface under ice was 14.06 mg/l and continued to decrease throughout the winter season. The areal hypolimnetic oxygen depletion (AHOD) was calculated at 0.55 mg/m^2/day.

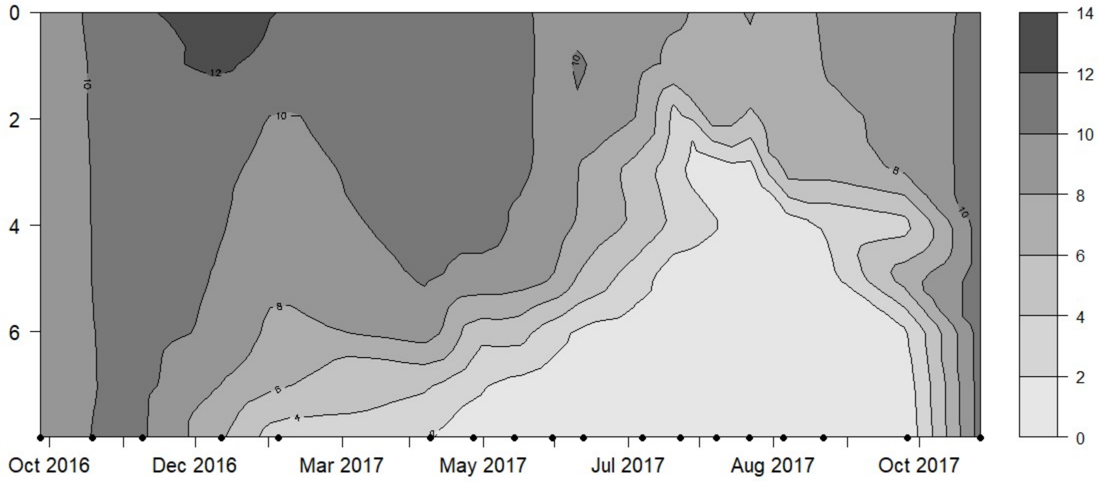

Figure 2.2. Dissolved oxygen (DO) isopleth (mg/l) for Big Bowman Pond. Black dots indicate sampling dates.

pH

The pH of the lake averaged 6.7 when comparing data across all sample dates and depths (Figure 2.3). At the surface of the lake the pH averaged 7.0 and at z = 8 m the pH averaged 6.0. The maximum pH was observed on July 7, 2017 at 8.05 at the surface. The lowest pH recorded during the sampling season was 5.6 at z = 6 m on May 30, 2017, which was recorded with 24 hours of a rainfall event. During the sampling period, total pH levels fluctuated ±1 from the mean.

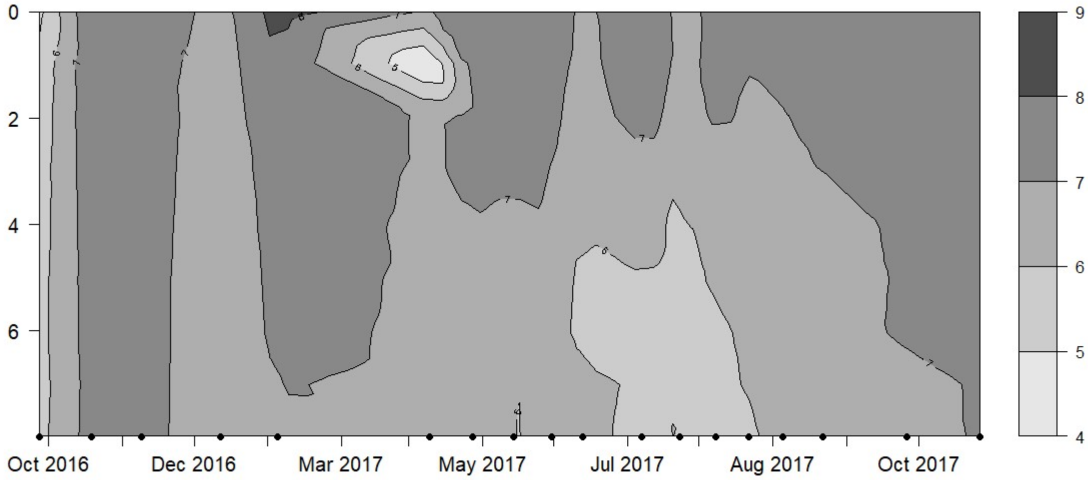

Figure 2.3. pH isopleth for Big Bowman Pond. Black dots indicate sampling dates.

Alkalinity, Calcium, Chloride

Average surface values for alkalinity, calcium, and chloride were 16.75 mg/l (as $CaCO_3$), 8.15 mg/l, and 5 mg/l, respectively. Average bottom samples were 19.90 mg/l, 10.74 mg/l, and 6 mg/l (Table 2.1). Due to the geology of the watershed (Natural Resources Conservation Service [NRCS] 2017) surrounding Big Bowman Pond, low levels of alkalinity were observed within the lake. Alkalinity was highest at 26 mg/l $CaCO_3$ at z = 8 m on July 7, 2017 and lowest at 11 mg/l $CaCO_3$ at z = 0 m on February 4. The highest recorded calcium, concentration was 14.43 mg/l on August 21 at z = 8 m, and the lowest was 5.61 mg/l on May 14 at z = 0 m. The greatest chloride level was 31 mg/l at z = 8 m on March 9 and the lowest was 1.5 mg/l on July 7 at z = 0 m

Table 2.1 Major ions (calcium, chloride, and alkalinity) present within Big Bowman Pond from October 2016 to November 2017. Surface samples were taken at z = 0 m and bottom samples were taken at z = 8 m.

	Range	Average surface (0 m)	Average bottom (8 m)	Water column average (0 – 8 m)
Alkalinity (mg/l)	11 - 26	16.75	19.90	17.03
Chloride (mg/l)	1.5 - 31	2.7	11.2	8
Calcium (mg/l)	5.61 - 14.43	8.15	10.74	8.82

Water Clarity

The average Secchi depth (SD) for the sampling period was 2.35 m. The maximum SD was 4.5 m on April 9, 2017. The minimum that was recorded was 1.00 m on July 21, 2017 (Figure 2.4). This coincided with a period of heavy rainfall during the previous 24 hours on July 21, 2017 which could have influenced the SD. Overall Secchi depth has increased at a rate of 0.05 m/year since 2013 (Figure 2.5).

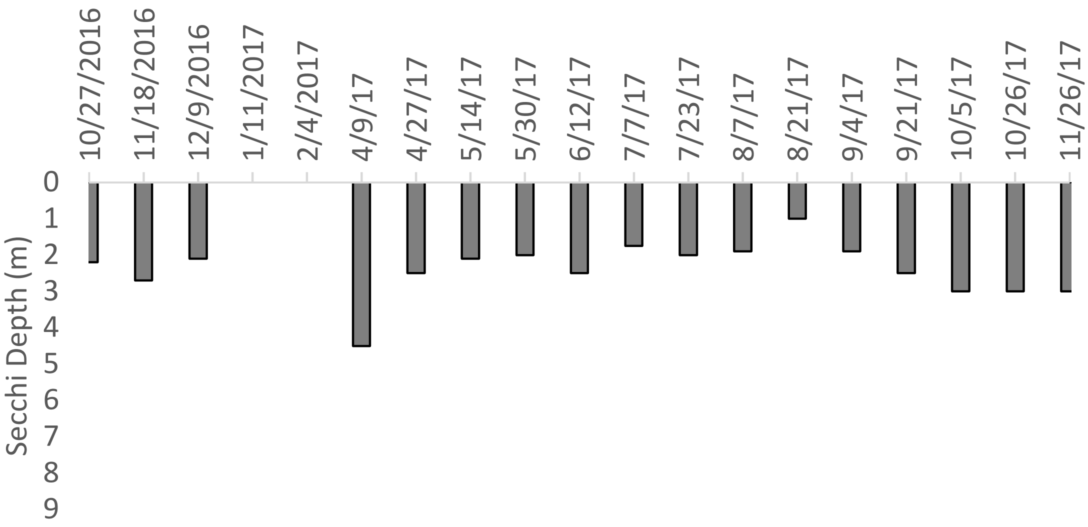

Figure 2.4. Secchi depth during the sampling season. No data were collected from December to March due to ice cover.

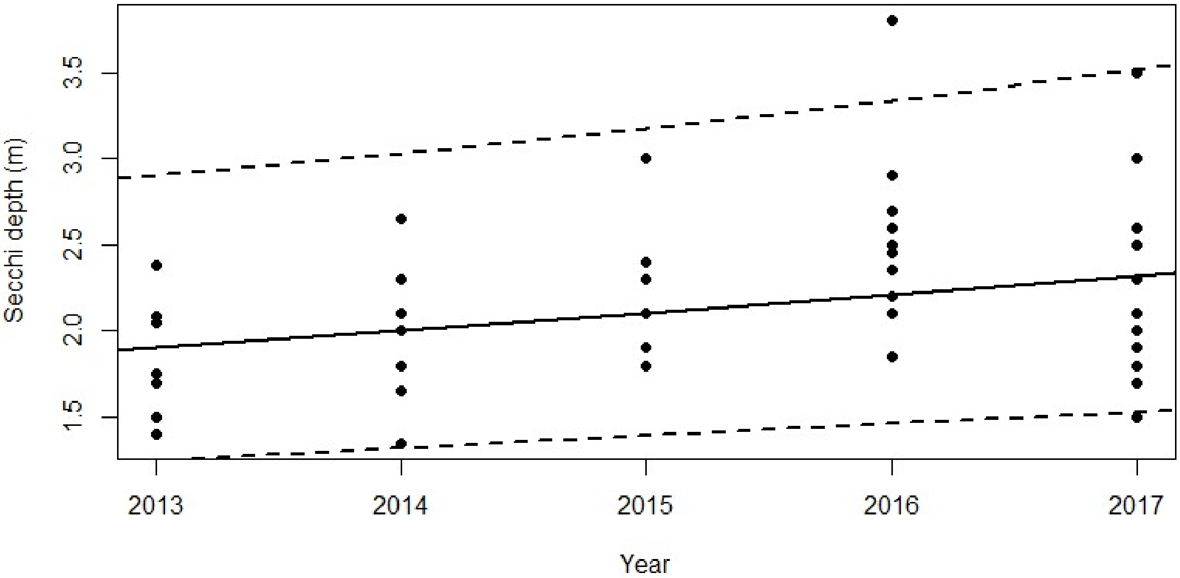

Figure 2.5. Average Secchi depth from 2013 to 2017. The solid line indicates the average, the dashed line is the upper and lower 95% confidence interval, and the points indicate individual samples.

Total Nitrogen

The average nitrogen concentration throughout the water column was 0.31 mg/l during the 2017 sampling season. The maximum concentration of 1.38 mg/l was observed on January 11, 2017 at the surface. The minimum concentration was 0.07 mg/l, which was on April 4, 2017 at 4 m. Surface levels of nitrogen have decreased at a rate of 0.12 mg/l over the last four years (Figure 2.6).

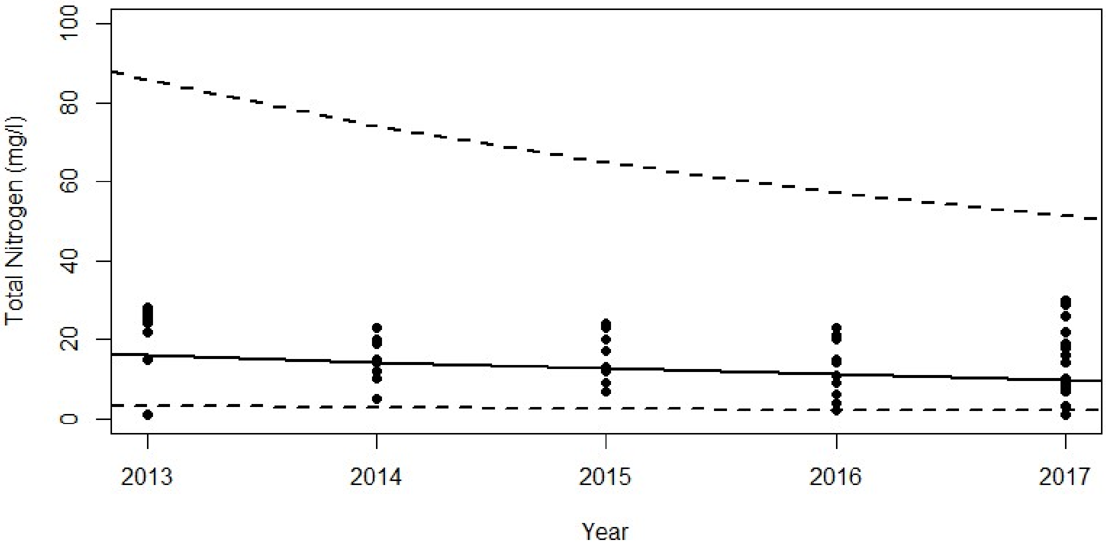

Figure 2.6. Average total nitrogen concentration from 2013 to 2017. The solid line indicates the average, the dashed line is the upper and lower confidence interval and the points indicate individual samples.

Total Phosphorus

The average TP concentration among all depths and sampling dates was 17 µg/l, which is below the threshold of 20 µg/l for classification as a eutrophic lake in New York (6 NYCRR X A 2 703). The highest TP concentration recorded at the surface of the lake was 116 µg/l on July 23,

2017. The highest TP concentration recorded at the deepest point was collected on August 21, 2017 at z = 8 m (Figure 2.7). Total phosphorus decreased at a rate of 0.03 µg/l/year from 2013 through 2017 (Figure 2.8).

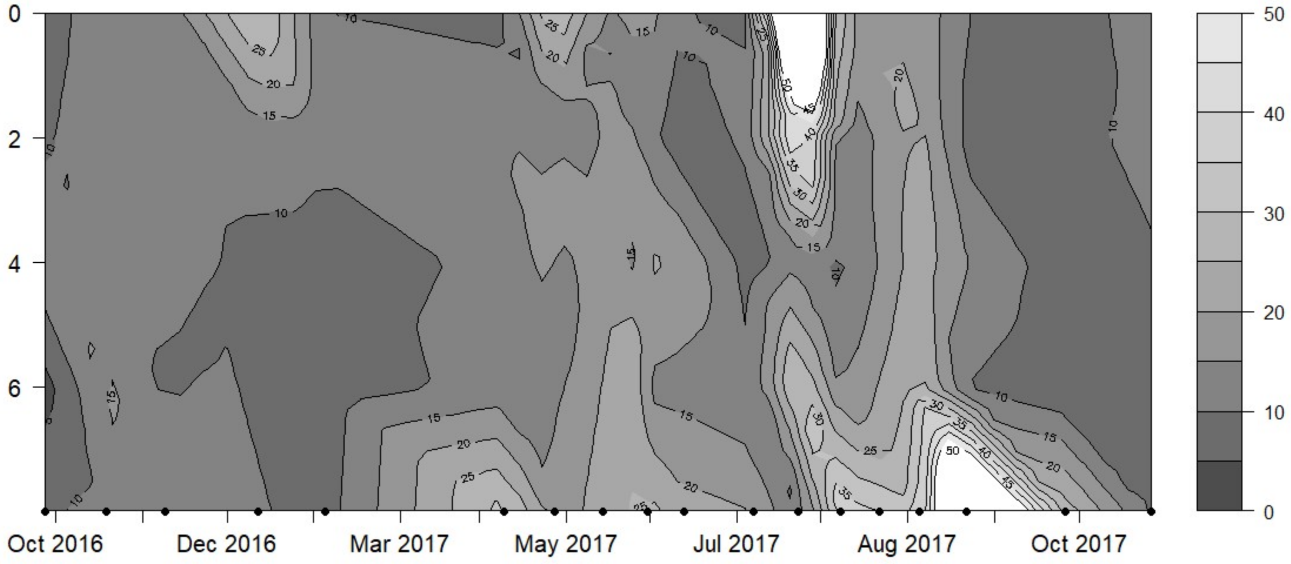

Figure 2.7. Total phosphorus isopleth (µg/l) for Big Bowman Pond. Black dots indicate sampling dates.

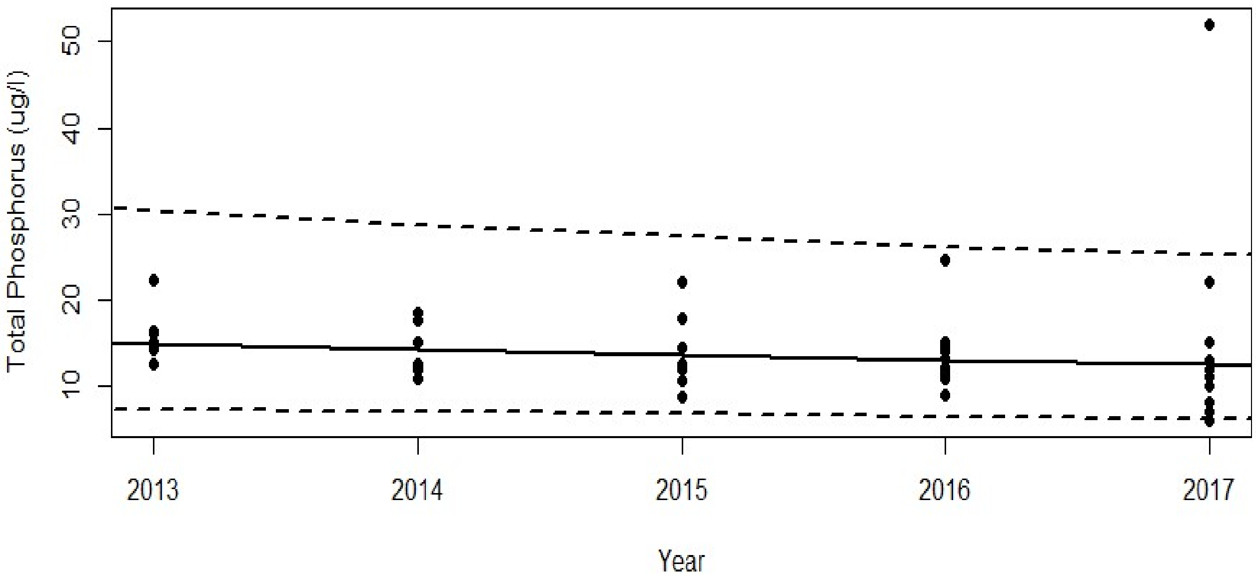

Figure 2.8. Average total phosphorus concentration from 2013 to 2017. The solid line indicates the average, the dashed line represents the upper and lower 95% confidence intervals and the points indicate individual samples. Over the years TP has decreased at a rate of 0.03 µg/l/year.

Chlorophyll a

The average water column chlorophyll *a* concentration during the sampling season was 7.01 µg/l. The maximum chlorophyll *a* concentration was 44.42 µg/l on August 4, 2017 at z = 8 m, while the minimum chlorophyll *a* was 0.45 µg /l on April 9, 2017 at z = 0 m. These values are estimates of primary productivity based on an equation presented by Jones and Bachmann (1976) and do not reflect actual values. Chlorophyll *a* level decreased slightly at a rate of 0.02 µg /l per year since 2013 (Figure 2.9).

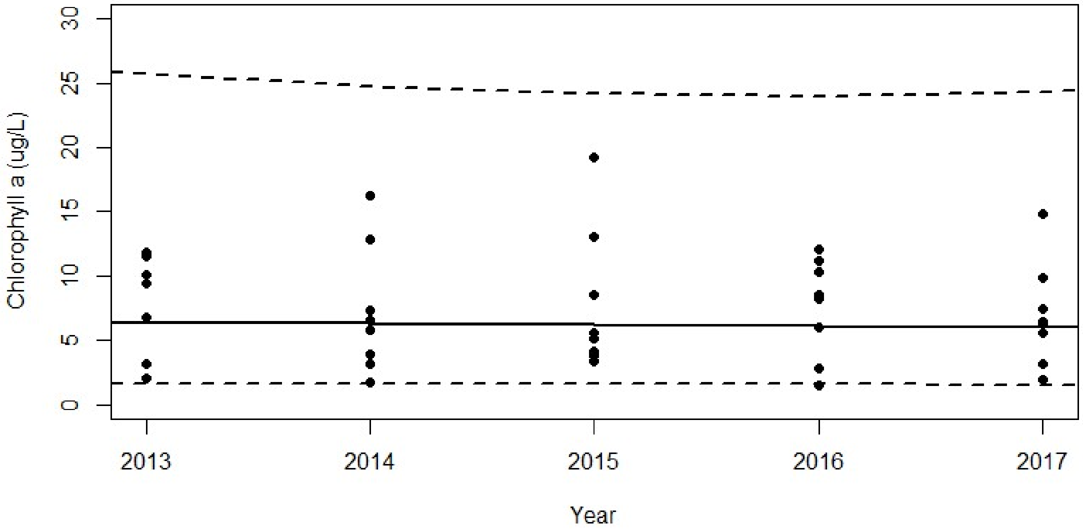

Figure 2.9. Average surface chlorophyll *a* concentration from 2013 to 2017. The solid line indicates the average, the dashed line is the upper and lower 95 % confidence interval and the points indicate individual samples.

Trophic Status

The trophic status indices (TSIs) indicates that the lake is mesotrophic. The highest TSI for TP was recorded on July 7, 2017 with a value of 72.70, a low of 19.65 on October 26, 2017, with an average value being 42. TSI for SD had a high of 54.16 which occurred on August 21, a low of 38.33 on March 9, 2017 with an average TSI of 48. TSI based on chl. *a* was highest at 67.83 on August 21, a low of 20.58 on November 26, 2017 and an average TSI of 39 (Table 2.2).

Table 2.2. Trophic status indices for Big Bowman Pond calculated using total phosphorus (TP), Secchi depth (SD), and chlorophyll *a* (Chl. *a*).

TSI Parameter	TSI Range	Average	Avg. Status
TP	19.65 - 72.70	42	Mesotrophic
SD	38.33 - 54.16	48	Mesotrophic
Chl. *a*	20.58 - 67.83	39	Mesotrophic

Zooplankton

The zooplankton community did change slightly from post-mixing on March 27, 2017 to pre-mixing on November 26, 2017. Cladocerans were in higher percentages post mixing and early summer (30 %, 45 %) compared to the late summer and post mixing samples (15 %, 18 %). Copepod abundance fluctuated within the samples and was high post mixing and late summer (41 %, 52 %) and low in early summer and pre-mixing samples (28 %, 18 %). Nauplii were seen in low percentages throughout the year (10 %, 5 %, 11 %) except for the pre-mixing sample where the percentage increased (36 %) (Figure 2.10). Lastly, relative abundance of rotifers increased slightly throughout the sampling season.

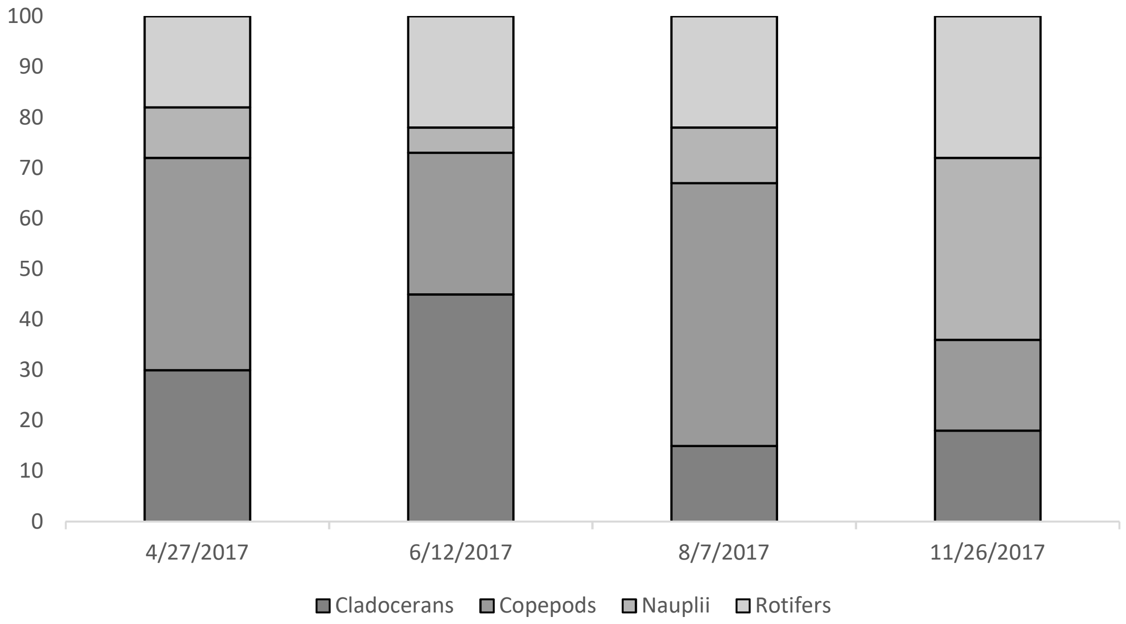

Figure 2.10. The zooplankton community percent composition present within Big Bowman pond throughout the year. Samples were picked based on the time of year for pre- and post-turnover and the summer season. Samples represent the number of each group identified when 100 specimens were identified.

Discussion

The limnology of Big Bowman Pond indicated that historically there have been minimal impacts on this system. Trophic status for SD, TP, and chl. *a* were all below the New York State standard for eutrophic conditions (NYSDEC 2015). There were multiple gaps in limnological data prior to when Big Bowman became part of CSLAP in 2013; however, similarities between CSLAP, older reports, and present data all indicated that the trophic status has not changed within the last half century. While all these values averaged within the mesotrophic range, it should be noted that during the summer seasons TSI average was higher and was within the eutrophic range described by Wetzel (2001). Overall, the results suggest that Big Bowman Pond has been mesotrophic since the early 1970s.

Present data also indicate that the lake was dimitic which is in agreement with past CSLAP reports and historical data. Winter stratification occurred from late December through March and Summer stratification occurred in from late May to early October with corresponding turnovers occurring between stratification periods. Spring turnover was not documented due to thin ice cover, but mixing was indicated by trends in data such as saturation of hypolimnetic dissolved oxygen during early summer stratification. Assumed data were added on the first of April so the isopleth (Figure 2.1) would accurately represent the known conditions within the lake.

Secchi depths collected during this study were like those obtained by CSLAP volunteers. Pooled data indicated that Secchi depth has increased during recent the years. Within New York State there are no standards for Secchi depth regarding water quality, but guidance values set by the NYS Department of Health require $z = 1.2$ m of water clarity for it to be considered a swimmable beach (6 NYCRR § 700-706). Water clarity in Big Bowman Pond exceeded this depth throughout the year.

Chlorophyll *a*, unlike Secchi depth, has remained relatively constant though the years CSLAP data were collected. During the 2017 summer season the data collected indicated that surface chlorophyll *a* was much higher than in samples collected in the same season by the CSLAP volunteers. This may also be due to the method in which chlorophyll *a* was processed within the lab, but at this time the reason is unclear.

The pH observed during the study fell mostly within the state water quality standard range of 6.5 to 8.5. This is important because the survival of most aquatic organisms is strongly dependent on the pH. Many organisms do not properly function in water below 6.5 or above 8.5 (6 NYCRR § 700-706). During sampling, pH below 6.5 was recorded near the sediment at the deepest point on specific dates but did not persist for long periods of time.

AHOD is the measure of hypolimnetic oxygen consumption over the growing season and reports the daily consumption within the hypolimnion of the lake and can be used as another means of determining trophic state. The AHOD in the lake was 0.55 mg/m^2/day. According to a study performed by Nürnberg, this value indicates that the lakes trophic states is equivalent to oligotrophic lakes within the northeast (Nürnberg 1996). This is different from what was calculated using Secchi depth, chl. *a,* and total phosphorus which indicated the lake as mesotrophic.

Anoxic conditions occurred in the deepest area of the lake basin starting around mid-July and continued until mixing occurred mid-November. During this anoxic period, internal loading of phosphorus was observed, with elevated concentrations of phosphorus being detected near the substrate. Internal loading generally refers to phosphorus being released from anoxic sediment surfaces into the water column and becoming an available nutrient source (Brönmark and Hansson 2005). High concentrations of phosphorous were also observed during early July, but near the surface of the water column. This could be caused by rain events with increased nutrient concentrations in runoff. When present data were compared with historical CSLAP data, a slight decrease in phosphorous was noticed. Overall, TP concentrations were below the NYSDEC threshold of 20 µg/l for lakes intended for contact recreation (NYSFOLA 2009).

Chloride concentrations within the lake are low and are within the NYS drinking water standard which is 250mg/l. Currently, no standards exist for the protection of aquatic life (NYSDEC 2018). According to CSLAP, the lake is within the 50th to 75th percentile of New York state lakes, which indicates that if chloride levels continue to rise there may be potential implications in the future. Increases in chloride concentrations have been documented in other lakes regionally, such as Otsego Lake (Albright 2005). The mean chloride level within that lake doubled from 1994 to 2005 and has been variable since (Waterfield and Albright 2013). This is most likely due to anthropogenic sources, such as run-off from road de-icing, inorganic fertilizers, and septic tanks effluents (WHO 1996).

There is no water quality standard for calcium in New York State. Concentrations reflect local geology. Calcium is necessary for the growth and reproduction of zebra mussels (*Dreissena polymorpha*). Studies state that lakes with levels above 20 mg/l of calcium are susceptible, but zebra mussel populations have been reported in lakes with calcium levels as low as 12 mg/l (D'Itri1997 & 6 NYCRR § 700-706). As for Big Bowman Pond, calcium levels were extremely low with an overall average of 9 mg/l, meaning that there is low chance of a successful invasion by this species.

Conclusion

Future data should be collected to observe if any changes occur over the years, especially TSI scores as they were close to the threshold of eutrophic waters. Lastly, zooplankton could be monitored post bladderwort treatment to see if there is a shift in the zooplankton community.

Chapter III: Plant Community

Introduction

Understanding the dynamics of the macrophyte community is a key component of many lake management plans. Of the primary producers found within a lake ecosystem, macrophytes constitute a major part, and as a result are essential to ecosystem function. Roles of aquatic plants include harboring aquatic insects that serve as food for vertebrates and providing nurseries and spawning areas for amphibians, fish, and zooplankton (Kalff 2003). This ultimately supplies food for waterfowl and other animals that inhabit the area. Macrophytes also create structural support for soil and sediment in and around the lake and help dampen effects of wave action, which can reduce erosion and sedimentation along the shore (Wetzel 1990). They can also aid in the water purification processes by providing habitat for microbial degradation and by directly sequestering toxic compounds or converting them into useful raw-materials. These are only some of the ways in which aquatic macrophytes are important to the ecosystem and why they must be understood and managed.

Despite the benefits that aquatic plants provide, us they can also be considered a nuisance within New York State according to a survey administered in the late 1980s (NYSDEC 2004). This survey had over 1,000 responses from lake residents statewide. Macrophyte cover in lakes was also rated the second highest concern on the state Priority Waterbody List and Waterbody Inventory (PWL-WI). The PWL-WI is a compendium of water-quality and use-impairment related issues that are identified through inventories of water-quality databases, government assessments, and public input (NYSDEC 2002). Aquatic plants are often seen as a nuisance in lakes due to the negative impacts that excessive growth can have on recreational accessibility.

At Big Bowman Pond, most lake residents recognize the important role of aquatic plants within their lake; however, they also consider some species to be nuisances as they impede recreation. According to a survey conducted prior to sampling in 2017, most homeowners around the lake agreed that the primary management concern was an overabundance of bladderwort (*Utricularia*) species, during the summer season, which is when residents use the lake most frequently. Bladderwort is a free floating aquatic macrophyte enabling it to be located lake wide. Some homeowners also mentioned that lily pad beds (*Nymphaea, Nuphar*) were preventing recreational use of their waterfronts. When homeowners were surveyed it was noted that they were dissatisfied with growth of the vegetation because it impeded recreation for a substantial portion of the summer season.

Historically, excessive vegetation did not pose a nuisance in Big Bowman Pond. A study conducted in 1972 indicated that Big Bowman Pond supported minimal macrophyte life and was primarily dominated by green algae, specifically desmids (Scavia 1972). The issue of excessive vegetation was first recorded during 1986 in a water quality report published in that year (Eichler and Soracco1986). Bladderwort species, recently identified as the problem by homeowners, were not recorded within the lake until 1991 (Soracco and Taggert1991). From these historical data it can be assumed that there were shifts in the conditions of Big Bowman Pond that altered the vegetative community from one dominated by algae to one that is presently overgrown with aquatic macrophytes. Also, there could have been a possible introduction event in which bladderwort species were brought into the lake after 1991.

The goal of this study was to determine the composition of the vegetation present within the lake and to identify the areas which have the highest abundances of vegetation. From the results, management strategies can be suggested that will manage nuisance vegetation within the lake. Ultimately, these strategies will need to meet stakeholders' recreational needs without negatively affecting primary production or nursery habitat of the fisheries within the lake.

Methods

Site Selection

Selected locations were defined to avoid subjectively creating points in the field. Sites were selected using Gmaps (Gmap4 2017), a javascript library utilized in R (R Core Team 2016). Sites were then selected using a 50 m E x 100 m N universal transverse Mercator (UTM) grid. In total, 31 sites were created using this process (Figure 3.1).

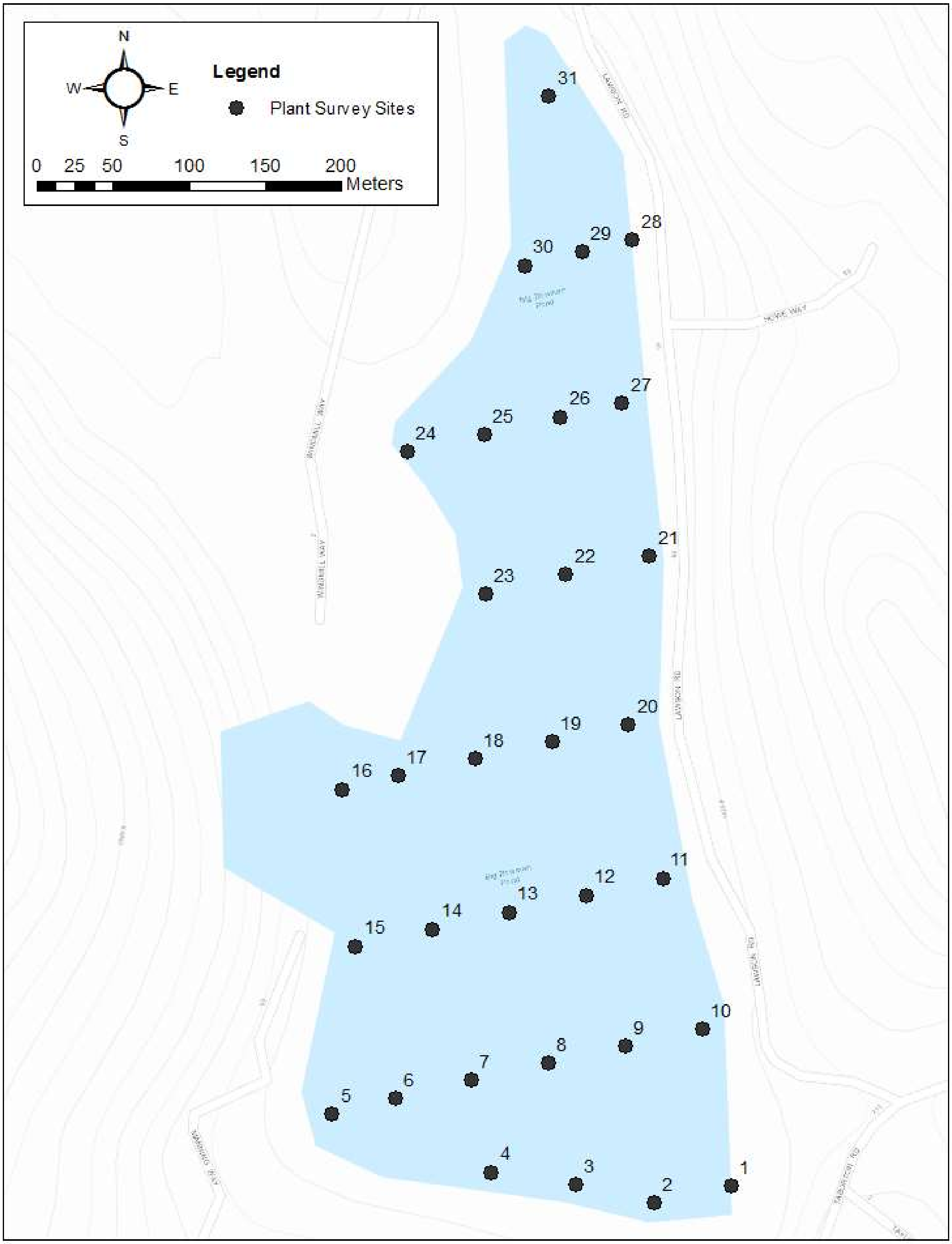

Figure 3.1. Plant surveys were conducted at each of the 31 sites indicated on the map.

Plant Community Surveys

The Point Intercept Rake Toss Relative Abundance Method (PIRTRAM) was used to sample the plant community within Big Bowman Pond (Madsen 1999 and Lord and Johnson 2006). Two plant surveys were conducted using this method, the first on 07/17/2017 and the second on 8/21/2017. Samples were collected using two garden rake heads, connected back-to-back and connected to a 10 m nylon cord which would allow it to reach the deepest point. At each site, the rake was thrown into the water three times, each time in a different direction. Once the rake settled to the bottom of the lake it was slowly pulled into the boat. The depth, species, relative abundance, and environmental observations were recorded. Depth was determined using a Lowrance fish finder, which was also used to navigate from site to site. Relative abundance was determined for each throw for the overall rake and a percentage was assigned to each species present on the rake. The relative abundance was assigned to one of five categories: "no plants" ("Z" = no plants), "fingerful" ("T" =trace), "handful" ("S" = sparse), rake-full ("M" = medium) and "unable to bring into boat" ("D" = dense).

Maps were created using ArcGIS software to show relative abundance and plant density at each site present during both sampling dates (ESRI 2011). This was done by importing the survey data into GIS and symbolizing the relative abundance of bladderwort by color and the overall plant density by size. The lake border was created using Google Earth Pro by outline the lake and exporting the data as a shapefile (Google 2009).

Results

The plant survey of Big Bowman Pond indicated that there were 10 species present in the plant community. All were collected during both sampling dates; however, differences in plant abundance were noted between locations. Additionally, out of the 10 species present, three of them were bladderwort species: *Utricularia inflata, U. vulgaris, U. purpurea* (Table 3.1). The dominant plant species in the lake were *Nuphar lutea*, *Nymphaea odorata*, *Nitella flexilis, Potamogeton epihydrus,* and the three *Utricularia* species.

Table 3.1. A list of aquatic plants species found in Big Bowman Pond during surveys conducted in 2017. Data were collected via PIRTRAM and the "x" indicates if the species was present on that day (Madsen 1999).

Scientific Name	Common Name	7/17/2017	8/21/2017
Nuphar lutea	Yellow pond lily	x	x
Nymphaea odorata	White pond lily	x	x
Potamogeton epihydrus	Ribbon leaf pondweed	x	x
Nymphoides cordata	Little floating-heart	x	x
Nitella flexilis	Stonewort	x	x
Pontederia cordata	Pickerel weed	x	x
Acorus americanus	Sweetflag	x	x
Utricularia inflata	Swollen bladderwort	x	x
Utricularia vulgaris	Common bladderwort	x	x
Utricularia purpurea	Eastern purple bladderwort	x	x

Each of the dominant species could be found in specific regions or zones of the lake where they were present in high densities. White and yellow pond lilies were found in the shallow waters of the lake; the largest beds were located in the north end, at sites 23, 24, 27, 28, 30, and 31. *Nitella flexilis* was primarily found growing near the lake bottom despite being shaded out by lilies species and along the shore at southern sites 1 through 5, 10, and 15. This species was found in densities that did not exceed trace amounts along the lake bottom, near the center of the lake, or in the northern end. *Potamogeton epihydrus* grew in the deeper regions of the lake on the southern side; the highest densities of this species were recorded at sites 6 through 9, 14, 17, and 18. *Utricularia* species were found in every region of the lake, though the most densely populated areas were recorded in the northern sites and along the edges of the lily pads.

Other species present within the lake were noted in lower abundances and formed less dense growth. *Nymphoides cordata* was found in small quantities among the larger yellow and white lily pad beds. *Pontederia cordata* was located close to the shoreline in shallow water and was only recorded in low abundance at sites 29 through 31. *Acorus americanus* was only recorded in Turtle Cove and at sites 30 and 31 in low abundance.

Plant abundance increased between the two sampling events. Most of the sites from 1 through 20, which were located along the southern end of the lake, were not recorded as having any changes in plant abundances. Sites 11, 19, and 20 were the exception to this. High densities of *Utricularia* spp. were recorded during both vegetation surveys. Notable increases in plant abundance were seen in the northern end of the lake where 7 out of the 11 total sites increased in abundance category by at least one level (*e.g.*, medium to dense). The other four sites had dense vegetation and were inaccessible with a boat during both visits to have the plant community is generally dominated by bladderwort species, which tend to most inhibit recreational activities. They are the focus of management objectives, and their contribution is highlighted in Figures 3.2 and 3.3. Here, their dominance relative to the overall plant abundance at each site is shown on each sampling date.

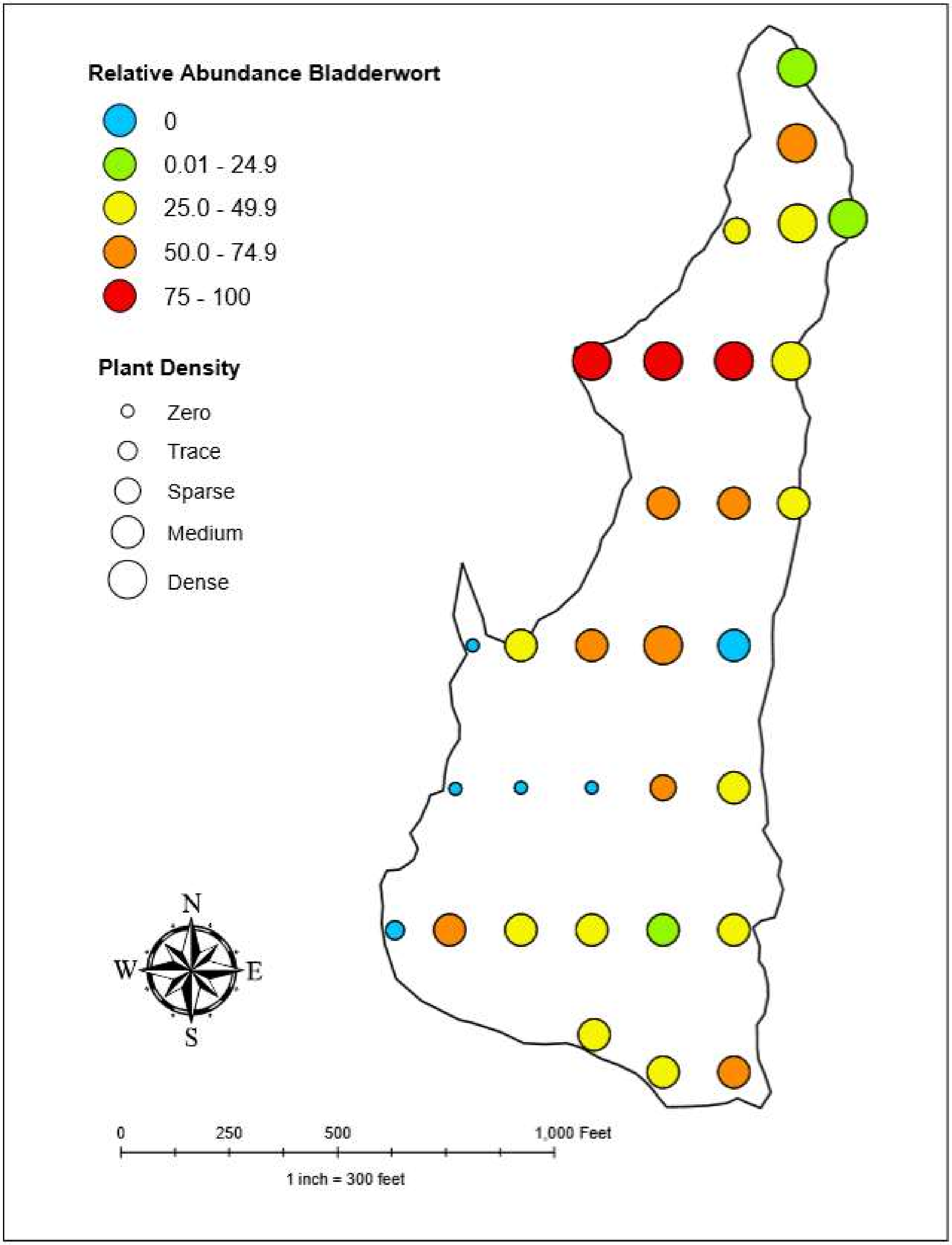

Figure 3.2. Vegetation density and bladderwort relative abundance within Big Bowman Pond on July 17, 2017. Density is represented by the size of the circles and abundance of bladderwort is represented with colors.

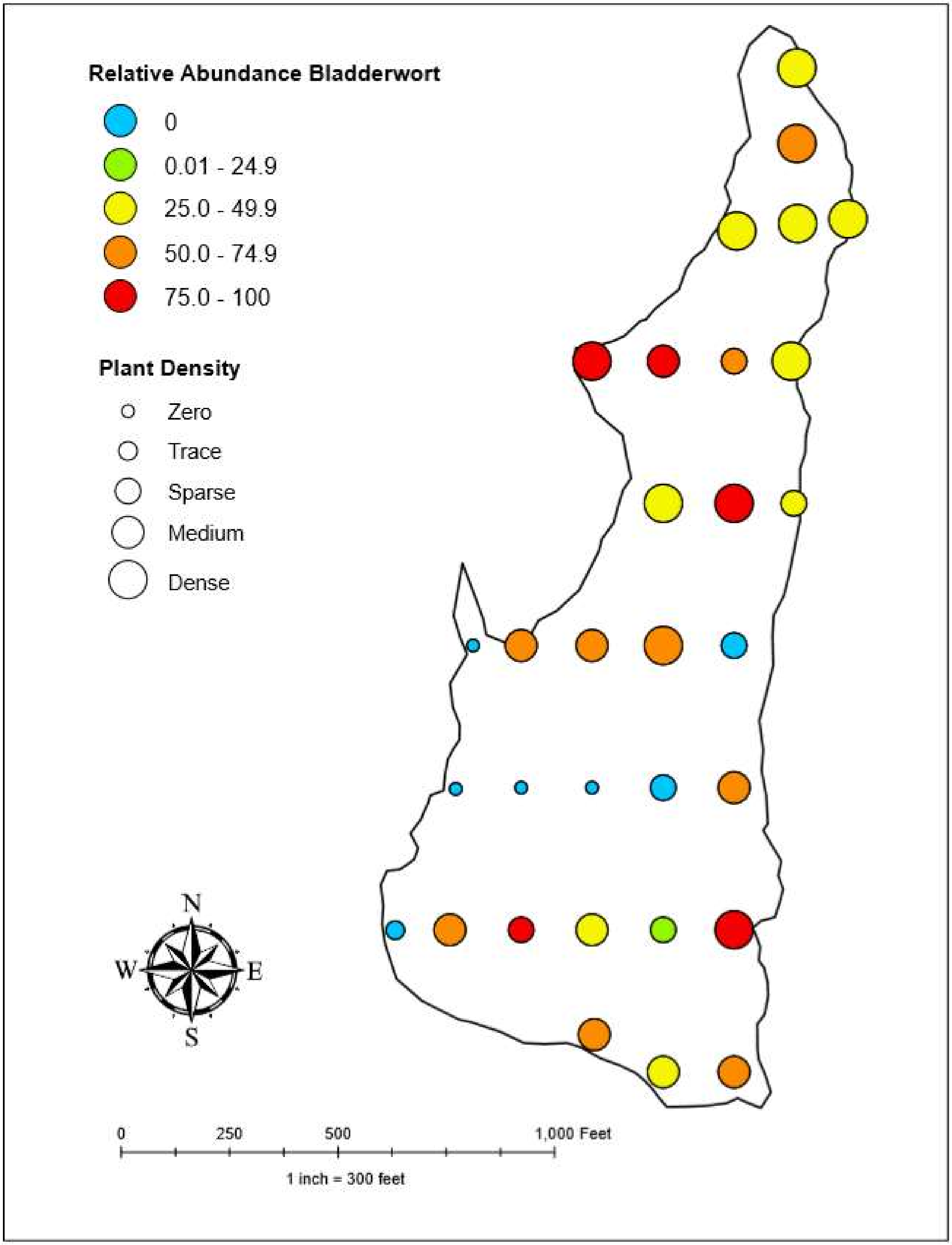

Figure 3.3. Vegetation density and bladderwort relative abundance within Big Bowman Pond on August 21, 2017. Density is represented by the size of the circles and abundance of bladderwort is represented with colors.

Discussion

The results of the two macrophyte surveys during the summer of 2017 showed a community dominated by three species of bladderwort: *Utricularia inflata, U. vulgaris,* and *U. purpurea.* These species were recorded during both surveys and were observed as the most widespread genus represented in the lake. This is most likely because the species are a floating aquatic macrophyte, and as such it is not tethered to the sediment and can be found anywhere along the surface. Together, *Utricularia* species had one of the greatest total biomasses within the lake, followed closely by the two lilies. During the summer of 2018 observations were taken while fish data were being collected and bladderwort was noticed to be in less abundance than the previous summer, but no quantitative data were collected for comparison.

The ability of bladderwort to thrive in the lake may come from its ability to thrive in nutrient poor, acidic waters. Bladderwort, unlike most plant species, does not obtain all its nutrients through the sediment or water, but through predation. The "bladders" present on this species enable the plant to consume zooplankton to obtain nutrients, hence this genus's unique name (Kosiba 1994). Other species recorded in the lake, including the lilies and *Potamogeton epihydrus*, were also quite prevalent and may thrive due to their ability to grow long stems up through the water column. This allows these species to remain tethered to the lake bottom and obtain their nutrients through the sediment while also growing to the surface to obtain light.

It should be mentioned that *Utricularia* species were not recorded as being present within the lake during the 1972 survey (Scavia 1972). This may indicate that the lake conditions shifted and altered the plant community within the last 27 years. Stakeholders have expressed concern that it may be due to previous hurricanes and storms, after which these changes in the vegetation were noted. This is possible as increased sedimentation could have occurred during these storm events, which would in turn have increased amount of nutrients available, introduced new seed banks to the lake, or otherwise altered the characteristics of the lake ecosystem. The 1972 survey also recorded desmids as being the dominant photosynthetic algae within the lake, and these types of organism are generally found in less productive waters as they are easily outcompeted by other larger plant or algae species (Coesel 1983).

Other notable species with the lake were lily species (*Nymphaea* and *Nuphar*), *Potamogeton*, and *Nitella*. These species were perceived as problematic species by some homeowners and were thought to be potentially easier to manage than bladderwort; however, these species do not immediately impact many popular recreational activities. Lilies are confined to the edges of the lake and are only seen as issues when inhibiting access to the water. Many homeowners who do struggle with this species have already implemented methods to manage them in order to allow access to the lake. Other species, such as *Potamogeton*, grow within the deeper areas of littoral zone up to the water surface. The density of *Potamogeton* has not yet caused major recreational impact but could be perceived as a minor nuisance when trying to canoe or kayak. Lastly, *Nitella* is not seen as a problem because it strictly grows along the bottom and close to shore. Large quantities of *Nitella* were located among the lily pad beds which are not typically areas of recreation and should not be an issue requiring management.

Areas of dense macrophyte growth were generally found in shallower areas, around the perimeter of the lake and at the northern end. Water depth at the northern end is much shallower than in the southern end. The substrate in the northern end was also finer substrate (*e.g.*, mud and muck) than that in the southern end of the lake. The increased availability of sunlight, combined with the fine substrate, likely provide better growing conditions at the northern sites. During the

2018 summer season plant abundance was anecdotally reduced compared to 2017. It is possible that this was due to dredging undertaken by residents in the northern end of the lake. This dredging process also increased water depth and most likely removed fine, nutrient-rich substrate.

Monitoring of plants in Big Bowman Pond should be continued to record trends within the plant community. These studies should occur more frequently than they have in the past so that more efficient management of the waterbody can take place. Additionally, if treatment does occur to reduce the amount of vegetation growth, then it would be pertinent to conduct sampling of the plant community before and after treatment to understand effects of management actions. Sampling and observation of other lake indicators will ensure that the other components of the ecosystems, such as the fisheries, are not negatively impacted by these activities.

Chapter VI: Fisheries

Introduction

Fish are important components of aquatic ecosystems and fisheries are generally a key component of many lake management plans. Understanding the status of fish populations and structure of the fish community assemblage can help detect issues within the food web structure and with water quality (Jeppesen et al. 2000). Despite this, the results of a survey presented to the stakeholders at Big Bowman Pond, New York indicated that the recreational fishery in the lake was not perceived as a current management priority, suggesting that most stakeholders are content with the current state of the fishery. Due to this feedback, the fisheries study performed during 2018 was limited to characterizing the current status of commonly sought-after species so that these data could be used as a baseline should the views of stakeholders change in the future.

No stocking has been completed by public agencies, such as the NYSDEC, as the lake has no public access. The fishery in Big Bowman Pond has not been studied intensively to date, though there have been a couple of water quality reports produced by the Rensselaer Fresh Water Institute, which include species observations within the lake. There was a single fisheries survey conducted in 1987 by the Adirondack Lake Survey Corporation (1989), which was a part of an acidification study in protected watersheds. Big Bowman Pond was included in this study because the lake is within the Hudson River watershed. The survey consisted of a one-day gill net survey (Adirondack Lake Survey Corporation 1989). This lack of studies may be due to the private status of the lake and because the anglers on the lake have not seen or perceived any problems with the fisheries.

According to the 2018 stakeholder survey (Management Plan), both open-water and ice fishing in Big Bowman pond are popular recreational activities for the anglers who live along the lake. Largemouth bass (*Micropterus salmoides*) are generally the most popular fish, indicated by recreational anglers; however, the lake is dominated by panfish, such as bluegill (*Lepomis macrochirus*), redbreast sunfish (*Lepomis auratus*) and black crappie (*Pomoxis nigromaculatus*). Anglers on this lake also follow a catch and release policy, which is a technique often used for the conservation of species and populations within a waterbody.

The goals of the study were to assess the current fish community in Big Bowman Pond, to provide a contemporary baseline against which future studies can be compared, and to determine what is generally being caught by anglers. An angling survey was used to determine the catch frequency of various species Big Bowman Pond and to characterize size structure of specific populations using proportional size distribution (PSD) (Anderson et al. 1996).

Methods

The absence of a boat launch precluded the use of boat electrofishing, which is the most common standardized sampling gear for studying warm-water fish communities typified by Big Bowman Pond. Instead, trap netting and angling surveys where both used to sample the fish community in the lake. These techniques can be selective towards certain species and year classes. The use of multiple gear types increased the likelihood of sampling fishes present.

Trap Netting

Three trap nets were set on Big Bowman Pond on October 5, 2017 at three different locations that were noted as popular fishing spots along the shoreline (Figure 4.1). No nets were placed in the northern end of the lake due to large quantities of vegetation and limited boat access. Each net was deployed for approximately for 24 hours before being pulled. All fish collected were identified and measured, and total length (mm) was recorded.

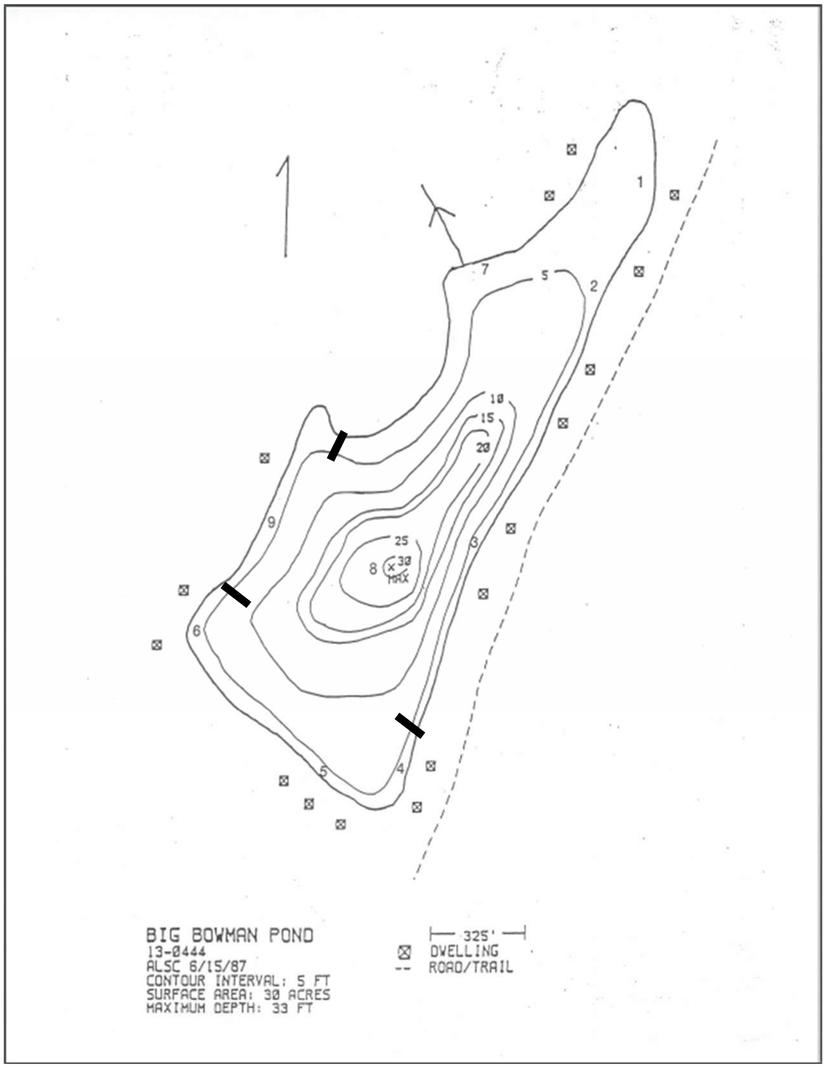

Figure 4.1. Locations of trap nets for fish survey which occurred on October 5th, 2017. Black lines indicate the location where the nets were deployed.

Angling Survey

Angling surveys occurred primarily during the summer of 2017, beginning in May and ending in August. Fishing occurred along the shorelines to assess near-shore fish communities. Random sites were not generated prior to these surveys due to the small size of the lake. Surveys lasted approximately 4 to 5 hours, and fishing occurred around the entire edge of the lake before limnological sampling was completed. Species and length (mm) of individuals that were caught was recorded. Gear varied based on angler(s); however, tackle was generally selected to target popular species such as largemouth bass and black crappie. After several trips, the gear was altered to target smaller species and individuals so that observations would encompass more than one year class.

Statistical Analysis

Length categories proposed by Gabelhouse (1984) were used to understand species-specific population size structures based on the length of individuals. Proportional size distribution (Guy et al. 2007) was calculated with all the fish measured using the quality and stock lengths for each species (Table 4.1) in the following equation:

$$PSD = \frac{\#\ of\ fish\ \geq quality\ length}{\#\ of\ fish\ \geq stock\ length} * 100$$

Length frequency histograms were created using R software (R Core Team 2016) with the FSA package (Ogle 2018) in order to understand the population size structure for all species present. There was a lack of data present for many of the species as length data was only available from the most current year of sampling.

Table 4.1. Gabelhouse lengths (mm) for each species caught within Big Bowman Pond.

	Stock	Quality	Preferred	Memorable	Trophy
Bluegill	80	150	200	250	300
Pumpkinseed	80	150	200	250	300
Black Crappie	130	200	250	300	380
Largemouth Bass	200	300	380	510	630
Chain Pickerel	250	300	510	630	760

Results

Over the last 30 years, 10 species of fish have been observed within Big Bowman Pond (Eichler and Soracco 1986 & Soracco et al. 1991), and 8 of those were observed during the 2017 survey (Table 4.2). Species that were noticed in the past and not observed during the present survey included smallmouth bass (*Micropterus dolomieu)* and golden shiners (*Notemigonus crysoleucas*). Other species, such as chain pickerel (*Esox lucius*) and black crappie, were observed in 1986 and 2017 but not during the 1991 survey. Smallmouth bass were recorded in 1986 but have not been observed since then, which may indicate that the species is no longer present here. Golden shiners were only recorded in 1991 and were not seen during the most current or oldest surveys.

Table 4.2. List of species that have been observed within Big Bowman Pond over all studies. X indicates that a species was present during a given year.

Species		Years Present		
Common Name	Scientific Name	1986	1991	2017
Largemouth bass	*Micropterus salmoides*	x	x	x
Smallmouth Bass	*Micropterus dolomieu*	x		
Chain Pickerel	*Esox niger*	x		x
Brown Bullhead	*Ictalurus nebulosus*	x	x	x
Pumpkinseed	*Lepomis gibbosus*	x	x	x
Rock Bass	*Ambloplites rupestris*	x	x	x
Black Crappie	*Pomoxis nigromaculatus*	x		x
Yellow Perch	*Perca flavescens*	x	x	x
Bluegills	*Lepomis macrochirus*			x
Golden shiner	*Notemigonus crysoleucas*		x	

The most frequently caught species during the 2017 survey was bluegill with a total of 74 individuals. Out of the 74 bluegills, 72 of were stock size. About 68 % of the stock-size bluegill were greater than quality size (PSD-Q = 68), and 28 % of them were also greater than preferred size (PSD-P = 28). Three % of the stock-size were also of memorable size (PSD-M = 3, Figure 4.2). The values for PSD indicate a bluegill population that is skewed toward larger fish.

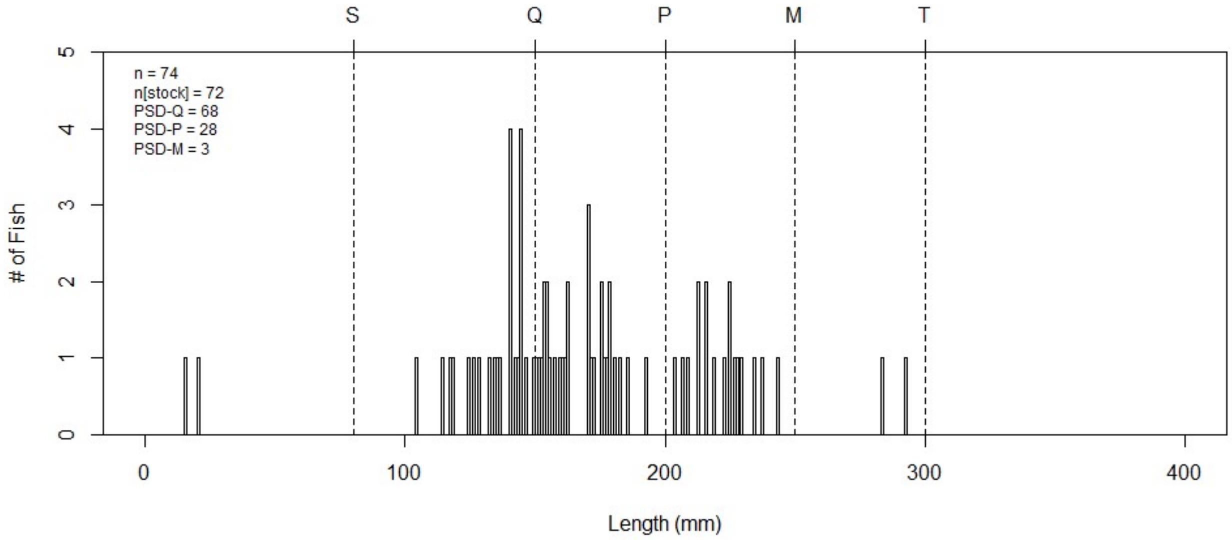

Figure 4.2. Length-frequency histogram for bluegill caught during the angling survey. The vertical dashed lines indicate the Gabelhouse lengths for the species. The letters over the dash lines indicate Gabelhouse length categories for stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) sizes.

Black crappie was the second most abundant fish observed during the 2017 survey, with a total of 30 individuals caught. The black crappies observed during this survey were all greater than the stock length, and 2 individuals were shorter than quality size. The PSD-Q was 93, PSD-P was 70, while PSD-M was 3. As with bluegills, the PSD values also indicated a population skewed toward larger individuals (Figure 4.3).

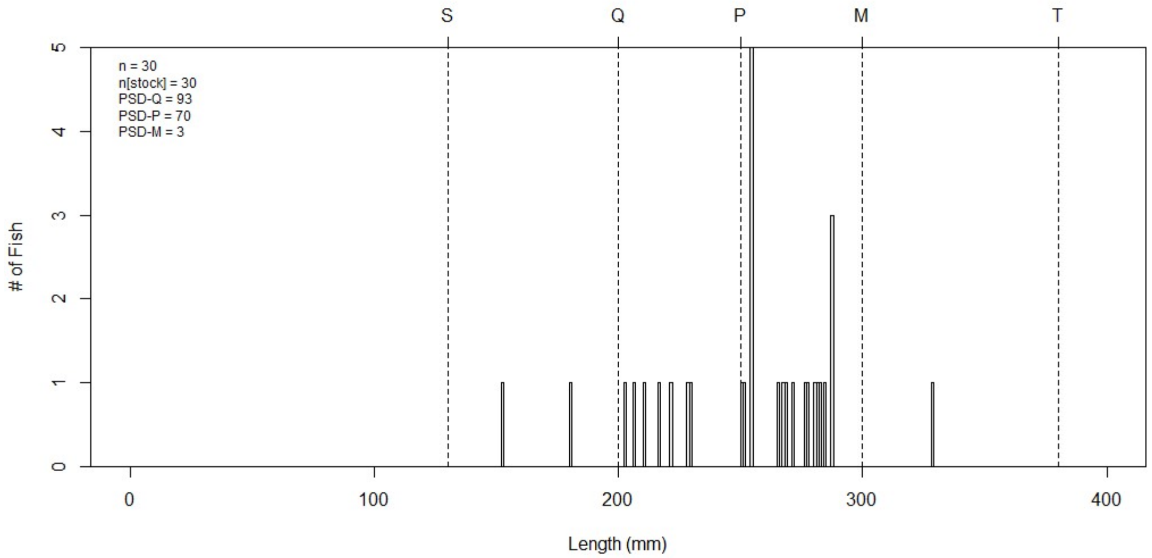

Figure 4.3. Length-frequency histogram for black crappie caught during the angling survey. The vertical dashed lines indicate the Gabelhouse lengths for the species. The letters over the dash lines indicate Gabelhouse length categories for stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) sizes.

During the survey, certain species such as largemouth bass, chain pickerel, and pumpkinseed, were not caught in large enough quantities to accurately estimate PSD. However, this information can still be useful in determining the average size of species that are being caught by anglers. The nine largemouth bass caught ranged from below sub stock size to preferred size, which indicates a good balance between large and small fish (Figure 4.4). Nine chain pickerel were caught and more than 75 % of those individuals were greater than quality size (Figure 4.5). Lastly, 12 pumpkinseeds were collected during the sampling period. All (100 %) of those individuals were greater than quality size, and 75 % were greater than preferred size. This indicates that the population was skewed toward large individuals (Figure 4.6).

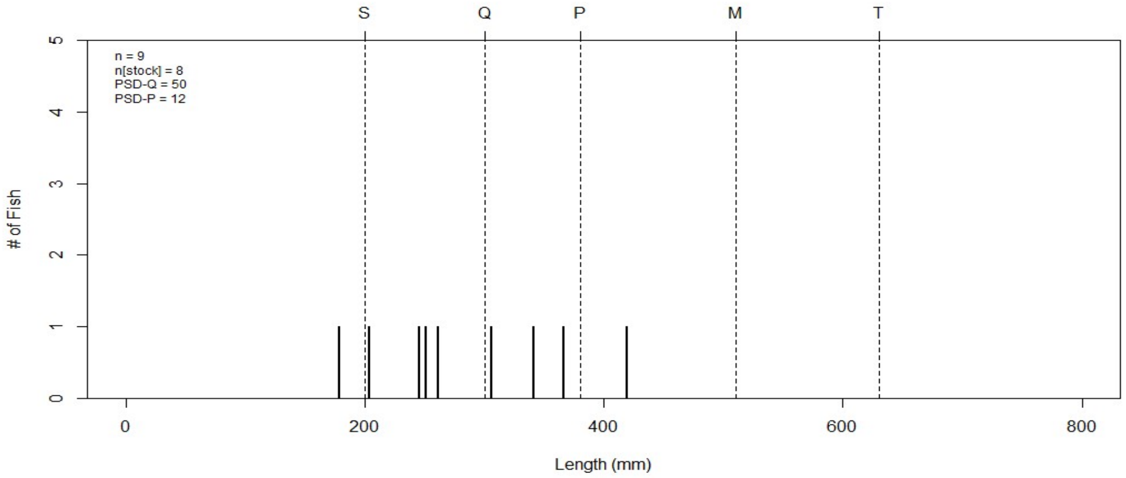

Figure 4.4. Length-frequency histogram for largemouth bass caught during the angling survey. The vertical dashed lines indicate the Gabelhouse lengths for the species. The letters over the dash lines indicate Gabelhouse length categories for stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) sizes.

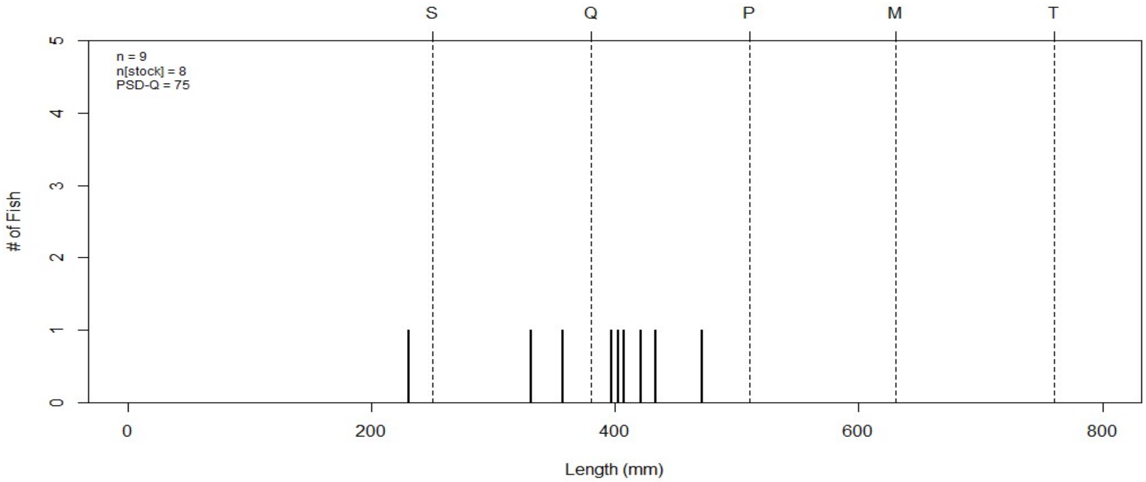

Figure 4.5. Length-frequency histogram for chain pickerel caught during the angling survey. The vertical dashed lines indicate the Gabelhouse lengths for the species. The letters over the dash lines indicate Gabelhouse length categories for stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) sizes.

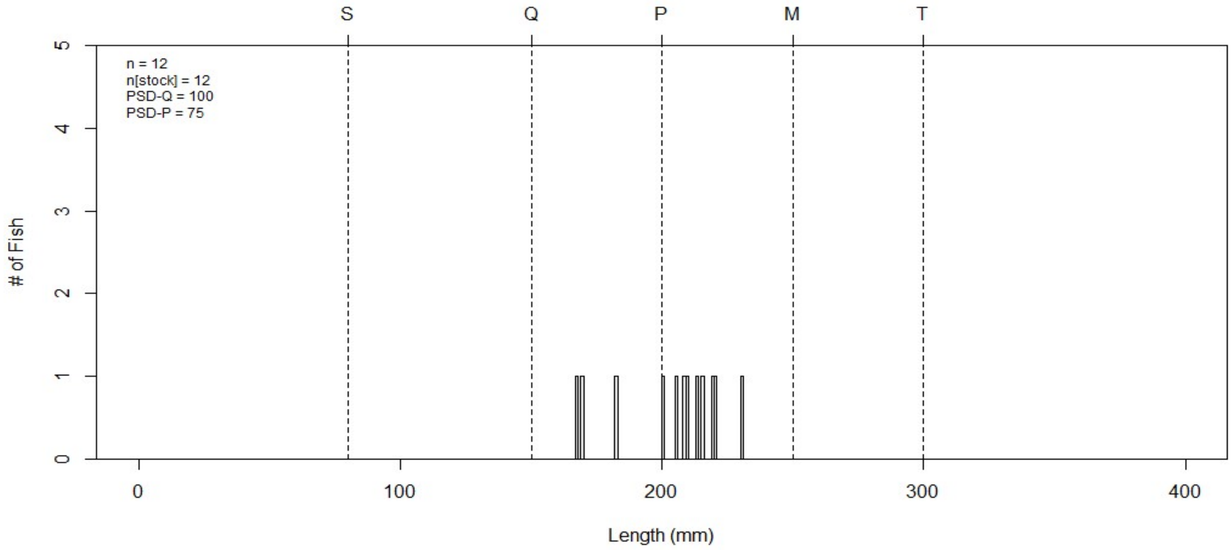

Figure 4.3. Length-frequency histogram for pumpkinseed caught during the angling survey. The vertical dashed lines indicate the Gabelhouse lengths for the species. The letters over the dash lines indicate Gabelhouse length categories for stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) sizes.

Discussion

Big Bowman Pond supports a warm-water fishery typical of small lakes and ponds in the Northeast. A warm-water fishery is characterized by fish species that have their best reproductive success in summer water temperatures from 75 to 85 °F (U.S. Forest Service 2015). Warm-water species typically occupy shallow, weedy littoral zones with warm water temperature and abundant food sources.

The dominant species collected during the 2017 survey were sunfishes, specifically bluegills. Most of the estimated PSDs for the sunfishes indicated that populations were skewed toward larger individuals. However, this was likely influenced by both sampling gears and timing of the survey. In any case, the survey indicated that the warm-water fishery in Big Bowman Pond is ideal for recreational fishing.

Angling surveys are known to produce estimates of PSD that are generally higher than conventional sampling gears such as electrofishing (Gabelhouse 1984; Gabelhouse and Willis 1986). However, because the waterbody is private, and because access prevents launching of standard electrofishing vessels, this may be the most useful and consistent way to monitor these populations in the future. Although PSD estimates from angling are higher than electrofishing PSD, when used consistently, this approach can provide valuable information about changes to size structures of target species over time. Furthermore, the sampling methods used for the angling survey are easily employed by amateur anglers, and PSD values are readily calculated by any individual who could calculate a percentage.

Angling surveys are good starting points for collecting fish data but are not considered standardized surveys that can accurately be used to interpret PSD due to some inherent biases. However, angling data allows anglers to see general catch size and may allow management to potentially improve populations for the angler experience. Likewise, it can be used to understand changes in population and community size structure over time, and in response to management activities in the lake because PSD values from angling are correlated with those from standardized sampling methods (Gabelhouse 1984). If a more generalized interpretation of PSD is sought in the future, this is best achieved using standardized sampling methods such as electrofishing to obtain information about population and community balance.

Fisheries have never been intensively studied within Big Bowman Pond and if they ever become an issue then future studies should be performed. These studies could take one of two forms. First, local anglers or volunteers (e.g., residents or college students) could conduct an angling survey like the one conducted here. That survey should produce results that can be compared directly. Citizen-based approaches are beneficial because one does not need to obtain a permit to collect, they require little to no funding, and have minimal impact on the fisheries. Also, engaging the community in environmental monitoring activities can lead to faster implementation of decisions based on the study performed (Danielsen et al. 2010). Alternatively, standardized sampling using boat electrofishing could be performed by an outside contractor or a local college, which would produce data that are directly comparable to those collected throughout NYS under standardized protocols, and even in the absence of a previous electrofishing survey would provide meaningful insights for management.

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