Chautauqua Lake Monitoring Program
Submersed Aquatic Vegetation Survey Results
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Introduction

Chautauqua Lake, located in Western New York's Chautauqua County, is a popular destination for boating, fishing, and other forms of outdoor recreation. Its shoreline is heavily developed and spans across the towns of Busti, Chautauqua, Ellery, Ellicott, and North Harmony. The waterbody supports 42 miles of shoreline, spans over 13,000 surface acres, and is divided into two unique basins. Despite being similar in size, the southern basin tends to be shallower, warmer, and more nutrient rich when compared to the northern basin (Smith 2020; EcoLogic 2018).

The topography surrounding Chautauqua Lake has resulted in an extensive littoral zone that has the ability to support a highly productive ecosystem. Historic records and recent surveys have determined that the submersed aquatic vegetation (SAV) community of Chautauqua Lake is exceptionally diverse with over 50 total recorded aquatic plant species present since first surveyed in 1937 (Johnson 2018). Of these, five non-native SAV species, Eurasian watermilfoil (*Myriophyllum spicatum*), brittle naiad (*Najas minor*), starry stonewort (*Nitellopsis obtusa*), water chestnut (*Trapa natans*) and curly-leaf pondweed (*Potamogeton crispus*) have been periodically documented within the waterbody over time.

The growth of these non-native species can impair the recreational, ecological, and economical uses of Chautauqua Lake. To date, mechanical harvesting has been the most widely used method for aquatic plant management in the waterbody. In 2021, nearly 14 million pounds of aquatic vegetation were removed from Chautauqua Lake (CLA 2021). More recently, select regions of the lake have also been treated with herbicides to target nuisance plant growth. Continual monitoring for abundance and distribution of both the native and non-native SAV species within Chautauqua Lake is a critical step in evaluating the overall sustainability of the aquatic ecosystem, and for determining an appropriate long-term management strategy.

This study was developed such that our results can be comparable to the research that has been done at Chautauqua Lake in previous years. SAV species presence and abundance data were collected following a point intercept-based methodology that had been previously applied within this system. Concurrently, hydroacoustic (sonar) data were recorded to determine SAV biovolume and acreage estimates.

Methods

The lakewide aquatic vegetation monitoring survey of Chautauqua Lake occurred September 10th - September 17th, 2021.

Macrophyte Survey

Point-intercept methods followed the guidelines proposed by Madsen (1999) and Racine-Johnson (2019) to provide direct survey effort and historical data comparisons between macrophyte survey years. Pre-established survey points, originally provided by Solitude Lake Management and surveyed in Fall 2020 by NCSU, were uploaded to an on-board GPS enabled chartplotter with ~5 ft horizontal accuracy. Of the 1000 point locations proposed for the 2021 Fall survey, 987 points were sampled (2020: 980 points; 2019: 865 points; 2018: 1301 points). Among each sample point location, *two* rake tosses were conducted where a visual estimate of whole-rake density was recorded (Table 1). Each retrieved rake also received a species-specific relative abundance estimate (Figure 1). When applicable, floating and emergent shoreline species were also documented at each point location using a binary system. Abundance ratings of non-SAV were not recorded.

Sonar-Based Biovolume Survey

The survey vessel was configured with a Lowrance HDS-7 Gen3 consumer-grade fish-finding echosounder and chartplotter to record passive sonar tracks during the point-intercept survey (Figure 1). The echosounding transducer emits a 200kHz acoustic signal through the water column which is returned back to the receiver. Sonar data was saved by the echosounder to 32GB memory cards for further processing. Boat speed did not exceed 7mph between point-intercept locations to ensure accurate interpolation of SAV presence and abundance. Sonar logs were recorded for ~2 hrs each.

Raw .Sl2 sonar data files were uploaded to BioBase C-Map cloud-based processing service to extract bathymetry estimates and SAV biovolume (quantity of the water-column occupied by SAV; *0-100%*) from boating transects. All processed sonar logs were then exported as tabular data for further GIS post-processing, mapping, and statistical analysis.

In Situ Water Quality & Turbidity Survey

Among 30 discrete point-intercept sampling locations, water quality parameters and water clarity measurements were recorded. Sampling locations were defined prior to the start of the lake wide survey to ensure uniform spatial representation across the lake with 1.13 mile average spacing between points.
A YSI handheld data logger was deployed at the select water quality points to measure profiles of Dissolved Oxygen (DO), Temperature, pH, and Conductivity. At each sampling point, recordings occurred 1.5 ft from the benthic layer.

To determine relative turbidity, a Secchi disk with industry standard recording measurements was utilized. A secchi measurement was taken when the disk was no longer visible to the surveyor when lowered in the water column. These readings can be useful in locating the boundaries of suspended solids, specifically planktonic algal blooms, between the north and south basins.

Post-Processing and Data Analytics

To create rake-toss density estimates for mapping and for relative species abundance estimates, both rake-toss throws were averaged to represent each survey point. For example, at any given point, two rake estimates of *moderate* density would be provided a weighted average score of *moderate*, whereas one rake toss of *no plants* and one rake toss of *moderate* density would be given a score of *sparse*. The weighted density values were then deployed in point and heat density mapping.

Point-intercept data was further tabulated in Microsoft Excel to provide appraisals of SAV species presence, frequency, and abundance. Species abundances were classified as *trace*, *sparse*, *moderate*, or *dense* as a function of their estimated percent cover on the rake and the respective rake fullness estimate. For example, a *sparse* rake with 50% occupancy of Eurasian watermilfoil and 50% Coontail resulted in a *trace* estimate of both Eurasian watermilfoil and Coontail at the surveyed point. Further, a *dense* rake with 100% cover of Eurasian watermilfoil resulted in a *dense* species rating for Eurasian watermilfoil. Resulting values were then used to identify native and non-native dominance and distribution throughout the lake.

Since sonar data does not provide species specific information, but rather a generalization of SAV water column occupancy and spatial breadth, point-intercept data was attributed to biovolume estimates. To provide acre estimates of SAV, specifically Eurasian watermilfoil, rake-toss point data was combined with the exported echosounding outputs from BioBase into ArcMap 10.8.1. Survey point interpolation occurred using an inverse distance weighted (IDW) geostatistical function. An IDW is utilized to predict the non-surveyed areas between survey points. Input variables for IDW considered the mean buffered distance between rake-toss locations to account for nearest neighbor influence. That is, alike SAV species were given a higher probability of occupying an area than plants which were less prevalent in proximity. The resulting interpolation raster was then clipped to the sonar biovolume areas where a non-

occupancy threshold of <10% biovolume was set. This value is standard for interpolated biovolume datasets to reduce the possibility of false-positive SAV detection when evaluating submersed plant bed breadth using sonar.

Results Summary

This survey evaluated the SAV growth throughout much of Chautauqua Lake's littoral zone (Figure 2). In total, 987 sites were sampled for SAV presence and abundance. Lakewide, no plants were found at 148 of the 987 sampling sites. The most frequent rake density across the lake was a *moderate* rating (37%), followed by *sparse* (27%) (Figure 3). SAV biovolume was highly variable along the shoreline of the lake but was generally most dense the outlet area of the south basin (Figure 4). The mean biovolume throughout the lakewide survey area was 35.2%.

Of the 839 vegetated survey sites, the five most common species present included Eurasian watermilfoil (EWM; *Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*), water stargrass (*Heteranthera dubia*), wild celery (*Vallisneria Americana*), and western waterweed (*Elodea nutalli*). For all of these species, the most common species abundance rating was classified as *trace*, followed by *sparse* at the surveyed sites. Despite having high *trace* and *sparse* species abundance ratings, these five species also had the most *moderate* and *dense* ratings when compared to other documented species. Twenty-six other aquatic species were documented during the survey and included submersed, emergent, floating, and algal growth forms. In total, 19 of these 31 documented species were present at less than 5% of the sampled sites (Table 2).

EWM was widely distributed throughout the lake's littoral zone during the Fall 2021 survey. In total, 2,345 acres of the lake are estimated to be occupied by EWM in all abundance categories (Figure 5). When looking at relative density of EWM throughout the lake, the densest patches occur in and around the south basin's outlet area and the north end of the north basin near Lakeside Park (Figure 6). These dense patches of EWM have stayed consistent over time when compared to the Fall 2020 survey results with the exception of the south basin's outlet region where EWM density has increased (Figure 7).

The densest areas of native SAV growth occurred in the north basin near the northern end and around Whitney Bay during the Fall 2021 survey. Some native SAV growth was recorded in the south basin's outlet area but was generally documented in *sparse* quantities (Figure 8). In comparison, native species occurrence and density in Chautauqua Lake's outlet was minimal during the Fall 2020 survey (Figure 9).

In total, the percent of vegetated survey sites decreased from 88% in Fall 2020 to 85% in Fall 2021. Despite this, EWM occurrences increased by 7% lake wide. Alternatively, coontail, water stargrass, and wild celery occurrences decreased by 16%, 2%, and 2%,

respectively (Table 3). Additionally, the percent of *dense* rake tosses increased by 4% between the two surveys (Figure 10). *Dense* and *moderate* EWM and *sparse* coontail and water stargrass ratings increased in the Fall 2021 survey (Figure 10).

Of the 30 water quality sample sites visited, 17 were located in Chautauqua Lake's north basin and 13 were located in the south basin (Table 4; Figure 11). On average, the sites in the north basin were deeper, and had greater secchi depths and lower pH values than those in the south basin. Other tested parameters did not have a significant difference in value based on location. Dissolved oxygen levels were measured to be relatively low throughout the lake during the survey timepoint and may have been influenced by plant decay or active algal blooms that were observed south of Long Point State Park. Many of the submersed plants south of Long Point State Park also supported epiphytic algal growth on their leaves and stems during the survey period (Figure 12). The identity of this algal species was not determined through microscopy but may have been a species in the order *Nostocales* due to its gel-like texture.

North & Central Basin Results

Town of Chautauqua

The Town of Chautauqua's littoral zone was sampled at 378 sites in Fall 2021 (Figure 13). Of these sites, 95% contained vegetation and 38% of rakes tossed were classified as *moderate* density and 31% were *dense* (Table 5). The foremost SAV species present was EWM and it was found at 69% of the surveyed points (Table 5). Based on these results and the collected biovolume data, a total of 718 acres of EWM are estimated to occur within the Town of Chautauqua (Figure 14).

Compared to the 2020 survey, coontail presence decreased by 10% throughout the town of Chautauqua and EWM presence increased by 5% (NCSU 2020). Other common species occurring in the Town of Chautauqua included water stargrass (59%), wild celery (54%), and common waterweed (46%). Similar to past reports, it was found that the Town of Chautauqua had the highest species richness, containing 20 of the 21 submersed species found in the lake. Three native SAV species were found among at least 50% of the sampling locations. Curly-leaf pondweed and starry stonewort were both documented in *trace* quantities at 2 points outside of Chautauqua Marina. An apparent *Gloeotrichia* bloom was active in Dewittville Bay.

The biovolume estimate from hydroacoustic within the town of Chautauqua had an average of 39%, a decrease from the Fall 2020 mean of 52% (NCSU 2020).

Village of Mayville

112 sites were surveyed within the Village of Mayville's littoral zone and SAV was documented at 100% of those locations (Figure 15; Table 6). Rake density was consistent with previous reports as they were mainly comprised of *moderate* (38%) and *dense* (32%) ratings. In general, SAV density was higher at sites that were further from

the shoreline in the deeper region of the littoral zone. The northern section of the Village of Mayville's shoreline is sandy and shallow which generally restricts SAV growth.

The most frequently documented species within the Village of Mayville was EWM at 87% of points visited, followed by coontail (71%), water stargrass (71%), common waterweed (59%), and wild celery (58%). Curly-leaf pondweed and starry stonewort were both documented in *trace* quantities at 2 points outside of Chautauqua Marina.

Town of Ellery

In total, 285 sampling locations were surveyed representing most of the littoral zone of along the town of Ellery and Bemus Bay (Figure 14; Table 7). EWM was the main species present along the Town of Ellery's shoreline and was estimated to cover 684 acres (Figure 17). The average biovolume estimate was slightly less than the lake average at 31% vertical water column occupancy.

Among the point-intercept areas, 21% contained no plants, while 55% of locations were either *moderate* or *dense* (Table 7). Among sites sampled, 17 SAV species were located, including curly-leaf pondweed (n=3 sites), brittle naiad (n=2 sites) and starry stonewort (n=1 sites). EWM (58%) was the most common species, with native water stargrass as the second most abundant (33%) (Table 7).

Compared to the 2020 survey, EWM distribution has decreased along the Town of Ellery's shoreline south of Bemus Point but increased in the southern outlet area (NCSU 2020; Figure 17). Benthic filamentous algal growth also increased from 4% to 9% between the two survey time points and was mostly located within Bemus Bay and Long Point State Park (NCSU 2020; Table 7). It was also noted that an active planktonic algal bloom was occurring around the Long Point State Park boat access during the time of the Fall 2021 survey.

In Spring 2021, curly-leaf pondweed was the most frequently-documented species within the Town of Ellery where it was found 143 of the 283 surveyed points (NCSU 2021). EWM was documented at 108 (38%) of the surveyed points during this time as well (NCSU 2021).

Village of Bemus Point

There were 33 sampling locations within the littoral portion of Bemus Point, with 94% supporting SAV, and 64% having a *moderate* or *dense* rating (Figure 18; Table 8). The most frequently occurring SAV was coontail (85%), followed EWM (73%). This portion of the waterbody had the highest frequency of ivy-leaved duckweed (48% occurrence) and was the only region where EWM was not the most frequent species documented. Further, where EWM was found within the Village of Bemus Point, it was mainly in *trace* (84%) quantities. In Fall 2020, curly-leaf pondweed was discovered among 18% of sampling sites but in Fall 2021, curly-leaf pondweed was absent from the Village of Bemus Point's shoreline (NCSU 2020; Table 8).

South Basin Results

Town of Busti

There were 124 sites sampled for SAV in the town of Busti and 81% contained SAV (Figure 19; Table 9). The hydroacoustic survey estimated an average of 38% biovolume throughout the surveyed shoreline. It is estimated that 403 acres of EWM occur within the Town of Busti (Figure 18). EWM was present at 59% of the surveyed sites, and was categorized as either *trace* or *sparse* at 80% of those locations (Table 9).
Curly-leaf pondweed was present at 6% of sites, most of which were those in the outlet area where curly-leaf pondweed density was high in Spring 2021, as well as the shoreline abutting Smith Boys Marina. In comparison, curly-leaf pondweed was the most dominant species documented within the Town of Busti during the Spring 2021 survey as it was found at 84 of the 112 surveyed points (NCSU 2021)

Native species presence throughout the Town of Busti was relatively low in comparison to other regions of Chautauqua Lake's shoreline and included western waterweed (34%), water stargrass (31%), coontail (27%), and wild celery (23%) (Table 9). Benthic filamentous algae presence was relatively high within this area with a presence at 15% of the surveyed points. It was noted that epiphytic algal growth (Figure 12) was quite dense on the plants growing within this region of the waterbody.

Village of Lakewood

The 62 sites visited within the Village of Lakewood revealed 21% of sampling locations contained no vegetation, with the majority of rake estimates being either *trace* or *sparse* (66% collectively) (Figure 21; Table 10). Rake density was greatest at sites in and around the outlet basin (Figure 21). The dominant SAV species throughout the Village of Lakewood was EWM which occurred at 68% of survey sites (Table 10). Other species present included western waterweed (31%), water stargrass (26%), and coontail (21%), however their relative abundance ratings were generally all documented as either *trace* or *sparse* (Table 10).

Curly-leaf pondweed was present in *trace* abundance at 2 sampled sites in the outet basin. In Spring 2021, curly-leaf pondweed was the most dominant species present in this region of the lake and was documented at 73% of the surveyed points (NCSU 2021).

Town of Ellicott

The Town of Ellicott contained 36 survey points and 100% of those contained SAV (Figure 22; Table 11). The average biovolume estimate from hydroacoustic monitoring in Ellicott was 45%, the highest of all surveyed regions. Overall, there are an estimated 315 acres of EWM (Figure 23). Boating through this region to complete the survey was difficult due to dense SAV growth. The dense SAV growth also likely impacted sonar data collection and the respective biovolume estimations in this area.

Rake density within the Town of Ellicott was most commonly *moderate* or *dense*, with 64% frequency combined (Table 11). Only 8 SAV were located in this portion of the lake (Table 10). Similar to previous surveys, native SAV presence and abundance was relatively low within the Town of Ellicott as there were only 5 native species documented. Unlike most of the other towns encompassing the lake, coontail was absent from this region of the waterbody.

EWM was found at almost all of the surveyed sites (89%) and shared the same abundance with western waterweed. This portion of the waterbody also had the greatest occurrence of brittle naiad (14%). Curly-leaf pondweed was present at 9 of the 36 sampled sites (Table 11). In Spring 2021, curly-leaf pondweed was present at 97% of these points, followed by EWM at 53% of the sites (NCSU 2021).

Village of Celoron

All sites sampled within the Village of Celeron contained SAV in Fall 2021. The dominant species included EWM and western waterweed, both of which occurred at 88% of the sampled points (Figure 24; Table 12). Curly-leaf pondweed was present at 38% of these sites despite being present at 94% during the Spring 2021 survey (NCSU 2021). Brittle naiad was also present at 3 of the sampled sites in Fall 2021 (Table 12). At the timing of this survey, there was *no* water chestnut (*Trapa natans*) discovered in the outlet area of Celoron.

In comparison to Fall 2020 results, the Village of Celeron contained fewer native SAV species and had a higher occurrence of non-native SAV (NCSU 2020).

Town of North Harmony

The 164 point-intercept locations were contained within the Town of North Harmony (Figure 25). Based on the echosounding and point-intercept survey conducted, there are an estimated 225 acres of EWM (Figure 26). The town of North Harmony biovolume average was estimated to be 35% water column occupancy.

In North Harmony, 74% of sites contained SAV, and 40% of sites had *moderate* rake density estimates. EWM and coontail were the most abundant SAV species present in North Harmony with presence at 50% and 49% of surveyed points, respectively. Curly-leaf pondweed and starry stonewort were also present in North Harmony in low abundances. While EWM was found widely distributed along the shoreline, it was most commonly documented in *trace* densities. It was noted that epiphytic algal growth (Figure 12) was quite dense on the plants growing within this region of the waterbody.

Discussion

The Fall 2021 survey of Chautauqua Lake revealed that EWM continues to be the most widespread species of SAV within the system. Similarly, the native SAV species of coontail, water stargrass, and wild celery are in relatively stable populations within the lake as well. In much of the surveyed regions of the lake, EWM was present in trace or sparse abundance and was intermixed with other SAV. An exception of this trend occurred in Chautauqua Lake's outlet bay area where EWM biomass was nearly topped out and dominating much of the littoral zone.

Similar to previous years, species richness (number of SAV species at a given point) was greatest from Snug Harbor Marina north to Chautauqua Marina in the north basin. While non-native species can reduce ecologic and recreational function by dominating the habitat, future management direction should consider maximizing EWM control while minimizing native species impacts in the highly diverse portions of the lake.

Curly-leaf pondweed was found in trace quantities in Chautauqua Lake during this Fall 2021 survey. As stated in past reports, the greatest seasonal CLP abundance is likely found at peak growth, which occurs late spring. Unlike other SAV found throughout the lake, the unique growth pattern of CLP allows for early season competition with other SAV. However, by late-July the plant has mostly senesced, or no longer in vegetative form. Therefore, when conducting a fall survey, CLP plants will most often be present among areas of high turion density and often found as recently sprouted turions (Appendix). The greatest turion density was found near the mouth of the outlet in the towns of Ellicott, Ellery, and Busti (Figure 8). A high density of CLP turions is in this portion of the lake could be attributed to water flow and plant fragment deposition.

While water quality was not the main focus of this work, the tested basic water quality parameters and visual observations suggested that algal presence within Chautauqua Lake may be influencing the SAV distribution and overall health of the plants. The epiphytic algae that was observed on many plants in the south basin is likely limiting the plants' ability to photosynthesize and grow. This algae also interfered with plant identification and may have hindered the identification of minor, delicate species during the survey.

In general, the results of this work closely agree with the findings from the Fall 2020 survey that was conducted by NCSU, with slight differences in species abundance. Species that were recorded in 2020 that were not documented in 2021 included white water crowfoot (*Ranunculus aquatilis*) and leafy pondweed (*Potamogeton foliosus*), however both of these were found in minimal abundances in 2020 and their presence may have been influenced by survey timing. No new species were identified in Fall 2021.

Conclusions

- Eurasian Watermilfoil is the most widespread submersed plant species in Chautauqua Lake, with 62% occurrence documented across the lake in Fall 2021.
- Curly-leaf pondweed was found at 4% of point-intercept sampling sites in Fall 2021 and at 61% of point-intercept sampling sites in Spring 2021. Due to its life history traits, it is best to determine curly-leaf pondweed infestation size in the Spring months when it is in its most active growth phase.
- Starry stonewort was identified at 7 sampling locations distributed across the waterbody.
- Benthic filamentous algae was found among 60 sites; the highest density and occurrence was in Bemus Bay and Shermans Bay. While considered native to the region, dense *Lyngbya* spp. growth can impact the recreational use of a waterbody due to its thick mat-forming tendencies.
- The lakewide average hydroacoustic biovolume estimate was 35.2%, with the greatest biovolume recorded in the southern outet basin.
- Water quality during the Fall 2021 survey was generally poor throughout the lake. In addition to low dissolved oxygen levels lakewide, algal growth in filamentous, planktonic, and colonial forms was also frequently documented.

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