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 commonly used method for aquatic plant management in the waterbody. Throughout the 2022 growing season, nearly 9 million pounds of aquatic vegetation were removed from Chautauqua Lake (CLA 2022). 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 third-annual Fall aquatic vegetation monitoring survey of Chautauqua Lake by North Carolina State University (NCSU) researchers occurred August 22nd - August 29th, 2022.

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, were uploaded to an on-board GPS enabled chartplotter with ~5 ft horizontal accuracy. Of the 1000 point locations proposed for the Fall 2022 survey, 978 points were sampled (2021: 987 points; 2020: 980 points; 2019: 865 points; 2018: 1301 points). At each sample point location, the plants that were present on two separate rake tosses were documented and a visual estimate of whole-rake density was recorded (Table 1). Each rake 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 were 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

Water quality parameters and water clarity measurements were recorded among 30 discrete point-intercept sampling locations. 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 (Figure 2).

A Eureka Waterprobes Manta 2 multiprobe data logger was deployed at the select water quality points to measure profiles of Temperature, pH, Chlorophyll a, Specific Conductivity, and Dissolved Oxygen. At each sampling point, recordings occurred 0.5 m below the water's surface, mid-water column, and 0.5 m above the sediment-water interface. These readings were averaged to determine mean conditions at each site.

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.

<u>Post-Processing and Data Analytics</u>

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

A total of 978 sample points were surveyed for aquatic plant presence and abundance within Chautauqua Lake's littoral zone during the Fall 2022 SAV survey (Figure 3). SAV was documented at 82% of the sampled sites, indicating a robust aquatic plant community within the Lake's ecosystem. The most frequent rake density across the lake was a *moderate* rating (32%), followed by *sparse* (24%) (Table 2). The mean biovolume of submersed vegetation throughout the lakewide survey area was 20.0% (Figure 4).

Of the 805 vegetated survey sites, the five most common species present included coontail (*Ceratophyllum demersum*), Eurasian water milfoil (EWM; *Myriophyllum spicatum*), wild celery (*Vallisneria Americana*), water stargrass (*Heteranthera dubia*), and common waterweed (*Elodea canadensis*). For all of these species, the most common species abundance rating was classified as *trace*, followed by *sparse* at the surveyed sites. Twenty-five other aquatic species were documented during the survey and included submersed, emergent, floating, and algal growth forms. In total, 20 of these 30 documented species were present at less than 5% of the sampled sites (Table 2).

EWM was widely distributed throughout the reservoir's littoral zone during the Fall 2022 survey and was found at just over 50% of the surveyed points (Figure 5A). In total, 1,342 acres of the lake are estimated to be occupied by EWM in all abundance categories and at biovolumes greater than 10% (Figure 6). While the majority of EWM findings were of trace abundance, EWM was also documented in the majority of the *sparse*, *moderate*, and *dense* individual species ratings. EWM was present at 499 sample points, and of those, 405 (81%) were located at water depths of 5 – 12 feet (Figure 5B). It should be also noted that EWM is a canopy-forming species, a unique growth habit among the SAV species present in the Chautauqua Lake ecosystem. Due to this, EWM has a competitive advantage over other submersed species as it is able to utilize the space and light resources in the upper water column for continued growth and proliferation. This can lead to a decline in native species abundance and overall richness within an aquatic system (Boylen et al. 1999).

The water quality throughout Chautauqua Lake was visually impaired at many of our survey sites due to active algal blooms. In the North Basin, dense *Gloeotrichia* blooms were documented, especially among the shallow shoreline survey points. The South Basin harbored *Microcystis*, *Microseira*, and *Nostoc* growth. Water samples that were collected from these field sites allowed for the confirmation of genera via microscopy in our lab (Figure 7).

Mean physical water parameters were not significantly different when comparing North and South Basin results, with the exception of pH (8.87 and 9.43 in the North and South

Basins, respectively) and Secchi Depth (North Basin = 1.26 m; South Basin = 0.35 m). Other mean recorded parameters included Temperature (24.33 ºC), Chl a (12.75 ppb), Specific Conductivity (223.71 uS/cm), and Dissolved Oxygen (9.79 mg/L; 116.6% Saturation) (Table 3).

North & Central Basin Results

Town of Chautauqua

The Town of Chautauqua's littoral zone was sampled at 375 sites (Figure 8; Table 4). Eurasian watermilfoil was the most commonly documented SAV species at 77% of the surveyed sites, an 8% increase from 2021 survey results (Table 4) (NCSU 2021). When combined with biovolume data, the estimated extent of EWM in the Town of Chautauqua covers 690 acres (Figure 9). Over time, EWM acreage has only slightly decreased in this region as its extent was estimated at 750 acres in 2020 and 718 acres in 2021 (NCSU 2020; NCSU 2021).

Other non-native species documented in the Town of Chautauqua included curly-leaf pondweed at 5% of surveyed points, starry stonewort at 1% of surveyed points, and brittle naiad at less than 1% of surveyed points. All of these non-native SAV findings were reported to be in *trace* or *sparse* relative abundance. It is important to note that brittle naiad has not been documented in this region by NCSU surveyors during previous survey efforts.

In total, 91% of the surveyed points within the Town of Chautauqua's shoreline contained SAV. Of these, nearly half (46%) were of *moderate* overall rake density, and 17% were ranked as *dense*. When compared to the other towns, the Town of Chautauqua's shoreline contains the highest overall abundance of SAV growth in Chautauqua Lake. Much of the moderate/dense SAV growth occurs along the Village of Mayville's shoreline, and spans into the deeper (10+ ft) section of the littoral shelf in this region. Due to this, it may be beneficial to extend survey points further from the shoreline in this area to capture the full extent of vegetation presence during future survey efforts.

After EWM, other dominant species within the Town of Chautauqua's shoreline included coontail (67%), water stargrass (60%), and wild celery (57%) (Table 4). As seen in previous years, the highest species richness occurred in this area of Chautauqua Lake with 21 total submersed species present.

Village of Mayville

Of the 112 surveyed points occurring in Mayville, all (100%) were occupied with SAV (Figure 10). These results agree with previous findings in 2020 and 2021 where all (100%) points also contained vegetation. Rake density estimates were greatest in this portion of the lake with 76% of locations having a *moderate* or *dense* overall abundance raking (Table 5).

Eurasian watermifoil was present at 91% of the surveyed sites in Mayville, and was generally in *trace* (65%) abundance. Despite this, of all the documented SAV species, EWM was present in the most *moderate* and *dense* individual species abundance ratings in this region. EWM was generally most abundant on the deep edge of our survey sites in Mayville, therefore, our estimate of EWM presence and distribution is likely underestimated. Additional survey points in this region could be beneficial for future efforts to delineate total SAV extent in Mayville.

Other species present at high occurrence rates in Mayville included water stargrass (76%), coontail (67%), and wild celery (63%). Species presence and richness was similar to previous surveys.

Town of Ellery

In Ellery, 284 points were surveyed and 204 (72%) contained aquatic vegetation (Figure 11). In 2021, EWM was the most abundant SAV in Ellery, documented at 58% of the surveyed sites. In 2022, EWM was the 4th abundant SAV in Ellery, and was found at only 28% of surveyed sites (Table 6). As such, the acreage of EWM was found to be reduced from 684 estimated acres in 2021, to 230 acres in 2022 (Figure 12). Most notably, EWM was not documented at any surveyed point in Bemus Point, and was found in only relatively small patches in Ellery's South Basin shoreline where EWM had been present in previous years.

Among the point-intercept sites, 28% contained no plants, while 63% of locations were either *trace* or *sparse* (Table 6). Wild celery was the most frequently encountered species at 41% of the surveyed sites, followed by coontail (36%), water stargrass (29%), and EWM (28%).

SAV presence and abundance was generally low along Ellery's South Basin shoreline, with the exception of Arnold Bay, where dense rakes were recorded. Species present in Arnold Bay included *trace* EWM, and *sparse* to *moderate* growth of water stargrass, wild celery, and coontail. Dense rakes were also retrieved along the Ellery-Ellicott boundary in the South Basin, and were composed of *sparse* to *moderate* growth of intermixed EWM, coontail, and elodea.

In Ellery's North Basin shoreline, EWM was documented in *trace* to *sparse* abundance at about half of the survey sites located to the north of Long Point State Park. Other species present included water stargrass, wild celery, slender naiad, and white stem pondweed.

Village of Bemus Point

There were 33 sampling locations within the littoral portion of Bemus Point, with 26 (79%) containing aquatic vegetation (Figure 13; Table 7). No non-native SAV were documented within the Village of Bemus Point during the 2022 survey. In 2021, EWM was present at 73% of surveyed points and curly-leaf pondweed was present at 18% of surveyed points. The most frequently-occurring SAV were Coontail (61%), followed by Ivy-Leaved Duckweed (42%). Slender naiad, wild celery, common waterweed, and water stargrass were also present in Bemus Point.

Benthic filamentous algae has increased in occurrence in Bemus Points from 18% in 2021 to 24% in 2022. The increase in this macroalgae presence could influence SAV growth and distribution due to its ability to form dense submersed mats that can cover submersed plants and reduce their opportunity to gain light and space.

South Basin Results

Town of Busti

There were 122 sites sampled for SAV in the town of Busti (Figure 14; Table 8). From survey efforts, there is an estimated 144 acres of EWM within the town of Busti (Figure 15), a decrease of 378 acres when compared to the 2021 survey - likely due to the decrease in EWM biomass in the eastern edge of Busti's shoreline. Despite this, EWM was still the most widespread SAV in Busti and was present at 43% of sampled points. Curly-leaf pondweed and starry stonewort were also present in Busti in low abundances. Other species present included coontail (40%), common waterweed (32%), and wild celery (27%).

Sherman's Bay supported the most SAV growth within the Town of Busti. EWM was most abundant within this area of Busti. Benthic filamentous algae was also distributed throughout Sherman's Bay.

Village of Lakewood

The Village of Lakewood contained 60 sampling sites, and more than half of which contained *sparse* or *trace* whole rake abundance ratings (Figure 16; Table 8). EWM was present at 47% of sites, a decrease from the 62% of sites identified in 2021. Coontail and common waterweed were also commonly present within the Village of Lakewood's shoreline. All other documented species were found at less than 15% of the surveyed sites.

In general, SAV was most frequently encountered along the shallow shoreline and was less abundant at the deeper survey locations. This is not the case for the points in the eastern edge of Sherman's Bay, where dense EWM/Coontail stands were documented along the deeper littoral edge.

Town of Ellicott

Of the 36 survey points included in the Town of Ellicott, 35 contained aquatic vegetation (Figure 17; Table 9). Of these, 48% were classified as *moderate* or *dense* overall rake abundance. Common waterweed, coontail, and EWM were the most commonly observed SAV species at 72%, 56%, and 53% presence, respectively. Overall, there are an estimated 149 acres of EWM, accounting for less than half of the acreage estimated in 2021 (Figure 18).

The overall plant health at these sites was very poor, with many plants lacking leaf material and supporting dense zebra mussel populations (Figure 19).This challenged our plant ID abilities in this section of the survey. Additionally, detached plant biomass was piled up along the shoreline in this region of the Lake (Figure 20). Detached/floating biomass was not included in our survey results. Mechanical harvesters were working in this area during the survey time period which also likely impacted our survey results.

Overall, the SAV community in the Town of Ellicott during this survey has differed significantly when compared to the results that were observed in 2021. EWM was found at 36% fewer survey points, and coontail was found at 56% more survey points (after not being documented in Ellicott in 2021).

<u>Village of Celoron</u>

Sixteen sites were sampled that fall adjacent to the Village of Celeron (Figure 21; Table 10). Common waterweed was the most common species among these points (56%), followed by EWM and western waterweed, both found at 44% of sampled sites.

Brittle naiad, had been observed among these survey points in previous years, but was not documented in 2022.

At the timing of this survey, there was *no* water chestnut (*Trapa natans*) discovered in the outlet area of Celoron.

<u>Town of North Harmony</u>

A total of 161 points were surveyed along the shoreline of the Town of North Harmony, and 131 (81%) of them contained vegetation (Figure 22; Table 11). *Dense* or *moderate* overall rake abundance ratings were recorded at 63% of the vegetated sites. Based on the echosounding and point-intercept survey conducted, there are an estimated 146 acres of EWM within the town of North Harmony (Figure 23).

In all, there were 17 submersed species with Coontail as the most frequently discovered SAV (61% occurrence), followed by wild celery (52% occurrence), water stargrass (47%), and common waterweed (43% occurence). EWM was the 5th most common species present at 38% occurrence.

The most dense SAV growth was found in the shallow areas of North Harmony's southeastern shoreline and in its central region around the Southern Tier Expressway Bridge and in Hadley Bay. The dense growth was most commonly composed of wild celery, coontail, and elodea species.

Discussion

Results from the Fall 2022 survey of SAV at Chautauqua Lake demonstrate that Eurasian watermilfoil is still one of the most dominant submersed aquatic plant species in Chautauqua Lake (Table 2). Similarly, the native SAV species of coontail, water stargrass, and wild celery continue to maintain relatively stable populations within the lake as well. When compared to the 2021 survey results, EWM presence has been reduced by 18% at our survey points (Table 12), and the overall extent of its distribution has also decreased in acreage throughout the lake (2021: 2,345 acres; 2022: 1,342 acres). Despite this, EWM is still present in high abundance in Chautauqua Lake and is able to quickly recolonize areas in which its presence has been reduced. As such, continued systematic management and monitoring of the SAV population at Chautauqua Lake is important.

Over the past 5 years, survey efforts have identified the persistent EWM plant beds throughout the Chautauqua Lake's littoral zone (Figures 24 - 30). The most dense of which occur in Burtis Bay (Chautauqua Lake's outlet region), along the shoreline of Long Point State Park, and in Chautauqua Lake's north Basin near Mayville and Lakeside Park (Figures 31 - 35). This information can help future management efforts as these areas are likely acting as source populations for further distribution throughout the waterbody.

When comparing overall species presence, 7 of the 33 plant species recorded at Chautauqua Lake have declined in presence at our survey points between 2021 and 2022 (Table 12). The other 26 species have increased at our survey sites or have not experienced a change in population size. Future management should consider maximizing non-native species control while minimizing native species impacts to avoid further declines in species abundance.

As noted in previous years, curly-leaf pondweed was found throughout the waterbody at 3% of sampled sites during the Fall 2022 survey, however estimates of presence and abundance from late summer and fall surveys likely under represent abundance that would be present earlier in the year (April – June). Based upon previous surveys conducted at Chautauqua Lake, 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 biomass has mostly senesced, or is 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.

In Chautauqua Lake, CLP has historically been most abundant in Burtis Bay at the South Basin's outlet. A comparison of CLP distribution in Burtis Bay during Spring 2020 and Spring 2021 surveys show widespread CLP growth, with the most dense regions generally overlapping along the shoreline up to the approx. 6 - 7 foot depth contour (Figures 36 - 39).

Please note that active mechanical harvesting of the aquatic vegetation throughout the lake likely impacts the data that was collected during this survey. Generally, this work would decrease mean biovolume estimates as well as overall rake/species density ratings. The mechanical harvesting work occurs at Chautauqua Lake is targeting both shallow and deep-water locations and will therefore influence the composition of the aquatic plant community around docks and shorelines where Mobi Trac and other shoreline services occur, as well as in the main body of the lake where navigational paths are cut for boating needs (CLA 2022).

Additionally, chemical methods to target Eurasian watermilfoil and curly-leaf pondweed growth were utilized in 2022 in predetermined regions of the Lake. This activity also is likely reflected in our survey results. A total of 370 acres for treatment were approved for EWM and applied in mid-June. Curly-leaf pondweed applications occurred in the Spring and covered 105 acres.

The management and monitoring activities of the non-native and nuisance aquatic plant presence at Chautauqua Lake will continue to be a key factor in the effort to conserve and restore the Lake’s robust aquatic ecosystem. Chautauqua Lake acts as a foundation for many important environmental and economic processes and its health and wellbeing are an important priority.

Conclusions

- During the Fall 2022 survey, the water quality in the North and South Basins was generally not significantly different in the North Basin when compared to the South Basin with the exception of water clarity readings, which were greater in the North Basin, and pH which was lower in the North Basin (Table 3).

- Dense algal blooms were present throughout the lake, with *Gloeotrichia* documented in the North Basin, and *Microseira*, *Microcystis*, and *Nostoc* found in the South Basin (Figure 7). These are all potentially toxinogenic cyanobacterial species that can also impact water quality through the production of taste and odor compounds.

- Eurasian watermilfoil was present at half (51%) of surveyed point-intercept sites and was most often intermixed with native species including coontail, waterweed, and naiad. 81% of the sites where EWM was present were at water depths of 5 – 12 feet.

- Coontail, a native SAV species, is the most widespread submersed plant species during the Fall 2022 survey with 53% occurrence across the lake.

- While CLP was present in *trace* abundance during the survey, most of the vegetative portions of the plant had senesced. Therefore, a spring or early summer survey would be more appropriate to identify the distribution of CLP.

- The lakewide average hydroacoustic biovolume estimate was 20%, with the greatest biovolume recorded in the north basin.

References

Boylen CW, LW Eichler, JD Madsen. 1999. Loss of native aquatic plant species in a community dominated by Eurasian watermilfoil. Hydrobiologia. 415: 207-211.

[CLA] Chautauqua Lake Association. 2022. Chautauqua Lake Association Work Performance Results for 2022. Accessed from: https://chautauqualakeassociation.org/management/work-reports/

EcoLogic, LLC. 2018. 5-year implementation strategy for the management of Chautauqua Lake and its watershed. Report. Prepared for Chautauqua Lake and Watershed Management Alliance, Jamestown, NY. 1 – 42.

Johnson RL. 2018. Early Fall 2017 presence and abundance of the aquatic plants in Chautauqua Lake with additional Bemus Bay survey. Racine-Johnson Aquatic Biologists. Ithaca, NY. 1 - 115.

Madsen, J. D. 1999. Point intercept and line intercept methods for aquatic plant management. APCRP Technical Notes Collection (TN APCRP-M1-02). U.S. Army Engineer Research and Development Center, Vicksburg, MS. 1-17.

[NCSU] North Carolina State University. 2020. Chautauqua Lake Monitoring Program Submersed Aquatic Vegetation Survey Results - August 2020. Prepared for Chautauqua Lake Partnership, Bemus Point, NY.

[NCSU] North Carolina State University. 2021. Chautauqua Lake Monitoring Program Submersed Aquatic Vegetation Survey Results - August 2021. Prepared for Chautauqua Lake Partnership, Bemus Point, NY.

Smith ZJ, Conroe DE, Schulz KL, Boyer GL. 2020. Limnological differences in a two-basin lake help to explain the occurrence of anatoxin-a, paralytic shellfish poisoning toxins, and microcystins. Toxins. 12: 559.

Solitude Lake Management. 2019. Chautauqua Lake monitoring program: 2019 delineation of aquatic vegetation in Chautauqua Lake. Report. 1 – 23.

Solitude Lake Management. 2018. Chautauqua Lake monitoring program: 2018 delineation of non-native macrophytes and other submersed aquatic vegetation (SAV) in Chautauqua Lake. Report. 1 – 21.