Chautauqua Lake Monitoring Program
Submersed Aquatic Vegetation Survey Results
August 2023

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Submitted to:
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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. The lakeshore is heavily developed and spans through 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 created an extensive littoral zone which supports a highly productive ecosystem. Historical records and recent surveys have determined that the submersed aquatic vegetation (SAV) community of Chautauqua Lake is exceptionally diverse with over fifty total recorded aquatic plant species present since first surveyed in 1937 (Johnson 2018). Records indicate that at least five non-native aquatic vegetation species, Eurasian watermilfoil (*Myriophyllum spicatum*), brittle naiad (*Najas minor*), starry stonewort (*Nitellopsis obtusa*), water chestnut (*Trapa natans*) and curly-leaf pondweed (*Potamogeton crispus*) continue to be periodically or continually present in the lake.

Non-native species growth 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.

Survey methodology was developed so results may be directly comparable to previous efforts at Chautauqua Lake. Aquatic plant species presence and abundance data were collected following a point-intercept rake toss methodology that had been previously

applied within this system. Concurrent with the rake-toss survey, hydroacoustic (sonar) data were recorded to determine SAV biovolume and associated acreage estimates.

Methods

The fourth-annual fall aquatic vegetation monitoring survey of Chautauqua Lake by NCSU researchers occurred August 13 to August 19, 2023.

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 2023 survey, 946 points were sampled (2022: 978; 2021: 987 points; 2020: 980 points; 2019: 865 points; 2018: 1301 points). Sampling in select areas of the lake was limited in 2023 due to windy weather conditions and difficulty accessing select shallow sites (<3 ft). 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 rating system (present or absent). 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. When possible, boat speed did not exceed 7 mph between point-intercept locations to ensure accurate interpolation of SAV presence and abundance. High wind events could lead to compromised sonar data as wave action leads to water level fluctuations and the inability to determine accurate water depth and plant height estimates. 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 YSI handheld data logger was deployed at the select water quality points to measure profiles of Temperature, pH, 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. At sites with less than 3 feet of water depth, a single reading was taken. These data 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.

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

Of the sampled points during the Fall 2023 survey of Chautauqua Lake, 822 (87%) contained SAV (Table 2). Within these sampled points, the overall SAV abundance at most sites was classified as *sparse* (52%), followed by *trace* (30%) (Table 2; Figure 3). Only 15% and 3% of the surveyed points were of *moderate* or *dense* abundance, respectively (Table 2; Figure 3). Hydroacoustic data determined that the mean biovolume of SAV throughout the surveyed area was 21.1% (Figure 4).

Of the 822 vegetated survey sites, the five most common species present included Eurasian water milfoil (EWM; *Myriophyllum spicatum*), water stargrass (*Heteranthera dubia*), wild celery (*Vallisneria Americana*), coontail (*Ceratophyllum demersum*), and slender naiad (*Najas flexilis*) (Table 2). Percent occurrence of these species ranged from 45% (EWM) to 27% (slender naiad). Species abundance for all of these species were most commonly classified as *trace* followed by *sparse* at the surveyed sites. Twenty-seven other aquatic species were documented during the survey and included submersed, emergent, floating, and algal growth forms. In total, 16 of these 30 documented species were present at less than 5% of the sampled sites.

EWM was the most abundant species documented in the lake during the Fall 2023 survey and was distributed throughout the lake in various abundance levels (Figure 5). It was estimated the EWM may be present in 1,140 acres throughout the lake (Figure 6). In general, EWM was most often classified with *trace* abundance (86% of points). This correlates to the presence of a few stems on the retrieved rakes (Table 1). EWM was also documented as *sparse* at 11% of the points where it was present, followed by *moderate* at 3% and *dense* at less than 1%.

Other non-native SAV species present during the Fall 2023 survey included curly-leaf pondweed (CLP; *Potamogeton crispus*), brittle naiad (*Najas minor*), and starry stonewort (*Nitellopsis obtusa*). CLP biomass was found at 136 surveyed points (14%). When including the documented CLP turion presence, CLP was distributed within 164 surveyed points (20%) and was mainly documented at points located within the South Basin (Figure 7). The presence of turions at 79 survey sites is likely an underestimate as the rake toss sample method does not accurately collect CLP turion biomass. The presence of CLP biomass at 136 survey sites is likely also an underestimate due to survey timing and CLP phenology.

The presence of starry stonewort at 24 sample sites is greater than previously documented in any other surveyed year. Based on this result, it estimated that 90 acres of Chautauqua Lake's littoral zone may contain starry stonewort biomass (Figure 8). Small bulbils (vegetative reproduction structures) were observed in several collected samples of starry stonewort during our Fall 2023 survey (Figure 9). These had not been observed during previous survey years which could be attributed to the accumulated density of starry stonewort or the slightly earlier survey time period that occurred in 2023.

Brittle naiad was also documented in more sites in 2023 (5%) than it has been in past surveys. Additionally, brittle naiad was classified as *dense* in 2 survey sites located in Chautauqua Lake's outlet within the Village of Celeron. At these sites, brittle naiad completely inundated the rake toss samples and low native species diversity was mixed in (Figure 10). In previous years, brittle naiad has only been documented in *trace* or *sparse* abundance at Chautauqua Lake.

Water quality during the 2023 survey was measured at 30 sites throughout the lake. In general, sites in the South Basin were warmer, had a higher pH and lower secchi depth (water clarity) than those in the North Basin (Table 3). Dissolved oxygen was relatively high at sampled point (14.81 mg/L and 175.2%) which was likely attributed to the windy weather conditions during the survey that brought high water mixing through wave action.

The presence of algal blooms was relatively low during the Fall 2023 survey, with the exception of *Gleotrichia* in many surveyed areas. *Microcystis* scums were also present in some surveyed areas, but not to the extent that has been observed during previous survey efforts. Gelatinous *Nostoc* algal colonies were identified growing directly onto plant biomass as has been observed in previous years. This growth is likely impacting the overall condition of SAV in Chautauqua Lake.

North & Central Basin Results

Town of Chautauqua

The Town of Chautauqua's littoral zone was sampled at 364 sites (Figure 8; Table 4). Eurasian watermilfoil was the most commonly documented SAV species at 60% of the surveyed sites, a 17% decrease from 2022 survey results (Table 4) (NCSU 2022). When combined with biovolume data, the estimated extent of EWM in the Town of Chautauqua covers 611 acres (Figure 12). Over time, EWM acreage continues to slightly decrease in this region as its extent was estimated at 690 acres in 2022, 718 acres in 2021, and 750 acres in 2020 (NCSU 2020; NCSU 2021; NCSU 2022). Of all surveyed towns, EWM presence was the highest in the Town of Chautauqua at a total of 60% of the surveyed sites (Table 4).

Curly-leaf pondweed was present at 4% of surveyed points and starry stonewort at 3% of surveyed points in the Town of Chautauqua, both reported to be in *trace* or *sparse* relative abundance where they were present. Despite having low relative species abundance, the presence of starry stonewort has increased from 1% of surveyed points to 3% of surveyed points in this area relative to the Fall 2022 survey (NCSU 2022).

In total, 94% of the surveyed points within the Town of Chautauqua's shoreline contained SAV (Table 4). Of these, just over half (59%) were of *sparse* overall rake density, and 19% were ranked as *trace*. Further, 22% of surveyed points were classified as *moderate* or *dense*. SAV species composition in the Town of Chautauqua contained 21 total submersed species. After EWM, coontail, water stargrass, wild celery, and white stem pondweed were the most abundant SAV present and ranged in presence from 48% to 33% of sampled points

Village of Mayville

The Village of Mayville's shoreline was sampled at 108 sites, and all of which contained SAV (Table 5; Figure 13). This result of 100% vegetated points in the Village of Mayville has been observed during all survey years by NCSU (NCSU 2022; NCSU 2021; NCSU 2020). High SAV density occurred at points on the deep edge of the littoral zone (Figure 13). In general, these sites contained high to moderate density of EWM intermixed with coontail of variable abundance.

Of all the SAV species sampled in the Village of Mayville, EWM was the most widely distributed with presence at 85 total sites. Of those sites, EWM was documented as trace at 62 sites (73%), sparse at 17 sites (20%), moderate at 5 sites (6%) and dense at 1 site (1%) (Table 5). As mentioned, moderate and dense EWM was generally located in deep sample sites (>6') and trace/sparse EWM was distributed in the shallow shoreline points.

Other species present at high occurrence rates in Mayville included water stargrass (62%), coontail (58%), and wild celery (35%). Species presence and richness was similar to previous surveys.

Town of Ellery

The SAV along the Town of Ellery's shoreline was sampled at 275 points (Table 6; Figure 14). No vegetation was documented at 73 sites. In turn, 202 points (73%) contained SAV (Table 6). The overall abundance at almost all surveyed points was classified as either *trace* or *sparse* in Ellery. Presence of SAV was generally very low throughout the Village of Bemus Point and along Ellery's South Basin shoreline (Figure 14). In 2023, the most abundant species in Ellery was water stargrass, documented at 85 survey sites, followed by wild celery, slender naiad, and EWM (Table 6).

EWM was the most abundant species in Ellery during 2020 and 2021 surveys, and the 4th abundant species in 2022 (NCSU 2020; NCSU 2021; NCSU 2022). Therefore, the results of abundance of EWM in Ellery in 2023 are mirroring the results that were documented in 2022. A total of 112 acres of littoral zone in the Town of Ellery are estimated to contain EWM based off of 2023 survey results (Figure 15). The majority of EWM in Ellery occurs North of Long Point State Park and is present in patchy distribution in the South Basin near the outlet in Ellicott (Figure 15).

CLP biomass was present at 14% of Town of Ellery survey points in *trace* abundance. Brittle naiad was also recorded at 6 total points in *trace* abundance in the Town of Ellery, all of which occurred in the South Basin near the Lake's outlet.

Village of Bemus Point

SAV within Bemus Point was sampled at 32 sites during the 2023 survey, with 19 (59%) containing aquatic vegetation (Table 7; Figure 16). The most abundant species included water stargrass (28%), wild celery (25%) and southern naiad (16%). EWM was documented at 3 points and CLP biomass was found at 1 survey point. It should be noted that benthic filamentous algae was present at 17 survey sites (53%) and could be decreasing light and space availability for other SAV species in Bemus Point. Benthic filamentous algal species extent more than doubled in this area of the lake since the Fall 2022 survey by NCSU.

South Basin Results

Town of Busti

There were 107 sites sampled for SAV in the Town of Busti (Table 8; Figure 17). We estimated 120 acres of EWM within the Town of Busti (Figure 18). With this, EWM was the most widespread SAV in Busti and was present at 52 (46%) sampled points. Curly-leaf pondweed was the 5th most abundant SAV species within the Town of Busti and was present at 37% of surveyed sites. Starry stonewort and brittle naiad were also present in Busti in relatively low abundances (7% and 4%, respectively). Other species present included western waterweed at 51 sample sites, slender naiad at 50 sampled sites, and coontail at 46 sampled sites (Table 8).

As documented in previous years, Sherman's Bay continues to support the most SAV growth within the Town of Busti (Figure 17). Benthic filamentous algae was also distributed throughout Sherman's Bay.

Village of Lakewood

The Village of Lakewood contained 60 sampling sites, and nearly all contained *sparse* or *trace* whole rake abundance ratings, with the exception of 3 sites with no SAV (Table 9; Figure 19). EWM was the second-most abundant species and was present at 45% of

sites. Slender naiad was the most abundant and was classified as trace at 96% of the sites where it was present. CLP was documented in relatively high abundance in the Village of Lakewood in 2023. CLP was not documented here in 2022 or 2020 and was found at just 2 sites in 2021. High abundance of CLP was observed in this region in Spring 2023 (G. Sullivan, Personal Communication).

In general, SAV distribution along the Village of Lakewood's shoreline was classified as sparse or moderate along the shallow shoreline points and trace in sites that were a rather distance from the shoreline (Figure 19).

Town of Ellicott

Thirty-six survey points were included in the Town of Ellicott, and 35 contained aquatic vegetation (Table 10; Figure 20). Of these, 66% were classified as *sparse* or and 17% were classified as *moderate* overall rake abundance. Slender and brittle naiad were most abundant species, respectively, at 89% and 81% presence at surveyed sites in the Town of Ellicott (Table 10). EWM and CLP were moderately abundant in this region of Chautauqua Lake at 36% and 33% overall abundance at survey sites (Table 10). Based on EWM presence at sample sites and the interpolated biovolume of SAV, it is estimated that the Town of Ellicott contains 115 acres of EWM extent (Figure 21). This estimation has been reduced from 149 acres in 2022.

Most SAV documented in the Town of Ellicott was observed along the Village of Celeron's shoreline and in close proximity to the marinas and public access sites in the area including the Lucille Ball Memorial Park (Figure 20).

Brittle naiad has increased in presence in the Town of Ellicott over time as it was not documented in 2022 or 2021 but was present at 20% of survey points in 2020 (NCSU 2022; NCSU 2021; NCSU 2020). Brittle naiad can prolifically spread through the development of seeds that are transported on brittle plant stem fragments.

Village of Celoron

All 16 survey points in the Village of Celeron contained SAV during the Fall 2023 survey (Table 11). Slender naiad was present at all of those 16 points, followed by brittle naiad which was present at 15 survey points (Table 11). Water celery and CLP were both present at 6 survey points (38%). EWM was documented at 3 sites mainly distributed along the shoreline that is shared with the Chautauqua Harbor hotel.

Town of North Harmony

A total of 157 sites were assessed within the Town of North Harmony, and 136 (87%) contained SAV (Table 12; Figure 23). EWM was the most abundant species present at just over half (52%) of sampled points. Of these points, EWM was classified as *trace* in

79%, *sparse* in 16%, *moderate* in 4% and *dense* at 1% of sites (Table 12). It is estimated that the EWM extent in the Town of North Harmony covers 182 acres (Figure 24).

After EWM, water stargrass, wild celery, and coontail were the most abundant and present at greater than 30% of total survey points . CLP was present at 29 total points (18%) and was most often found in North Harmony's South Basin points (Figure 7). Starry stonewort was observed at 5 survey points and were all located in or in close proximity to Asheville Bay.

Discussion

Overall, the SAV community at Chautauqua Lake was generally low in density and distribution during the Fall 2023 survey. Eurasian watermilfoil continues to be one of the most abundant SAV species at Chautauqua Lake, but was documented in generally low densities throughout the littoral zone (Table 2). Although it was present in low densities, stems and leaves were generally in good condition and actively growing in the waterbody (Figure 25). In comparison to previous survey years, the estimated acreage of EWM has decreased, with major changes in the Towns of Ellery and Busti (Figure 26a). The percent of overall occurrence of EWM has also generally decreased over the past several years but still remains present at just below 50% of the total survey sites (Figure 26b).

Other commonly documented SAV throughout the lake in 2023 included water stargrass, wild celery, and coontail. Generally, these populations were also noted to be in healthy condition and actively growing in Chautauqua Lake during the time of survey. The wild celery population was observed to be flowering and forming seed pods. In comparison to previous survey years, the water stargrass and wild celery populations have remained relatively stable over time. The occurrence of coontail has slightly decreased in comparison to 2022 results, but is comparable to 2021 levels (Figure 26b).

When comparing the past 4 years of Fall SAV data collection, survey efforts have identified persistent EWM plant beds throughout the Chautauqua Lake's littoral zone (Figures 27 & 28). EWM continues to occur in Burtis Bay (Chautauqua Lake's outlet region), along the shoreline of Long Point State Park, around the Ashville Bay area, and in Chautauqua Lake's north Basin near Mayville and Lakeside Park, among other locations (Figure 28). These survey data can help future management efforts as areas with reoccurring presence of EWM are likely acting as source populations for further plant spread throughout the waterbody.

In 2023, CLP biomass was present at more sites than it has been documented in previous years (Figures 7 & 29). The invasive plant was found as mature biomass, newly sprouted turions, and unsprouted turions during this year's survey. As noted previously, estimates of presence and abundance from late summer and fall surveys generally under represent CLP 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 biomass growth, which occurs late spring in the Northeast. 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. However, the rake-toss sampling methodology that is applied for monitoring SAV presence and density does not effectively sample for CLP turions. Therefore, turion distribution was also likely underestimated during this survey effort.

Please note that active mechanical harvesting of the aquatic vegetation throughout the lake likely impacts the data that was collected during the 2023 survey. Generally, active management would decrease mean biovolume estimates as well as overall rake/species density ratings. Mechanical harvesting 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 EWM and CLP were applied in 2023 among select predetermined regions of the Lake are likely reflected in our survey results. A total of 73 acres of EWM infestation were approved for herbicide application and florpyrauxifen-benzyl was applied in mid-June to target EWM biomass. Targeted endothall applications to CLP biomass occurred in the spring (May) spanning 125 acres of the infestation.

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

Conclusions

- EWM was present at 45% of surveyed point-intercept sites and was most often intermixed with native species in trace abundance. Despite having low abundance, EWM stems were most often observed to be in good condition and actively growing.

- CLP biomass was present at more sites in 2023 than recorded in previous years, especially throughout the South Basin's littoral zone. This likely represented carry-over from dense CLP stands in Spring 2023. Management of CLP prior to turion formation (early spring) would be expected to reduce CLP biomass in future years at Chautauqua Lake.

- Starry stonewort has increased in percent occurrence and is estimated to cover 90 acres within Chautauqua Lake as of Fall 2023. During the 2023 survey event, star-shaped bulbils were present at some sites where starry stonewort was present. As mentioned for CLP, the rake-toss methodology was not designed for sampling of vegetative reproductive structures and therefore the presence of starry stonewort bulbils is likely underestimated at this time. A more formal sediment sampling effort should be considered to better determine starry stonewort distribution and reproductive potential in Chautauqua Lake.

- Native species presence remains high in Chautauqua Lake with 19 submersed species recorded in 2023. Populations of major native species have remained stable over time, with the exception of coontail which decreased from 53% occurrence in 2022 to 35% occurrence in 2023. Since coontail is a non-rooted SAV, plant presence and distribution can be expected to vary by year.

- The lakewide average hydroacoustic biovolume estimate was 21.1%, with the greatest biovolume recorded in the north basin. Windy weather conditions limited data collection in select regions of the shoreline during the 2023 survey effort.

- Measured water quality during the Fall 2023 survey demonstrated that dissolved oxygen levels and secchi disk readings were high, conductivity was relatively stable, and pH was low in comparison to previous surveys. Levels recorded in 2023 were generally good indicators of healthy aquatic ecosystem function.

- Algal blooms were present throughout the lake during the time of the survey, but were of lesser density than had been observed in previous years. *Gloeotrichia* and benthic filamentous algae were both more apparent throughout the lake. Benthic filamentous algae could be influencing SAV abundance and distribution by competitively using space, light, and nutrients that other species depend on.

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