Macrophyte Loss to Chautauqua Lake by Mechanical Harvesting

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Cover

The top pictorial shows the harvested plot area on August 26, 2021, before we collected any plant material left by the harvesting operation. This experimental plot is in Whitney Bay on Chautauqua Lake. The bottom pictorial shows the mechanical harvester in the process of transferring plant material from the harvester to the transport barge. The transport barge took the harvested plant material back to a shore elevator that filled a dump truck. This truck transported all material to a scale for wet weight determination.

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Background and Introduction

Chautauqua Lake, located in western New York State, has reported excessive growth of aquatic plants well into its recorded history. Current references show management with public funds for algae control going back to 1935. Control of macrophyte growth began on a larger scale in the early-to-mid 1950s. In 1955, Sodium Arsenite was applied through 1961, 2,4-D in 1959 and 1965, Diquat from 1965 to 1987, and Aquathol-K from 1981 to 1987 **(Luensman *et al.* 1990)**. Along with these herbicide treatments, mechanical harvesting was the main method of macrophyte control that continues to the present **(Bowman and Mantai 1993, Luensman *et al.* 1990, Johnson *et al.* 2021)**. In 2002, a small plot was evaluated using Aquathol-K. From 2017 to 2021 further experimentation with various herbicides, including the older 2,4-D and Aquathol-K, along with a new herbicide ProcellaCOR EC has been applied in Chautauqua Lake **(Chautauqua Lake Alliance 2021)**.

Mechanical harvesting has been the main method of macrophyte management in Chautauqua Lake for decades. Harvesting is often cited by some stakeholders as the major cause of floating mats of macrophytes and piles of macrophytes on the shorelines. However, our observations of the last 20 years at Chautauqua Lake, along with our earlier assessments of lakes in the Finger Lakes region, suggest that there are many potential causes of free-floating aquatic plants. A majority of the occurrences are after weather events where high winds have produced waves that pull tall plants from the sediments. In Chautauqua Lake, we often observe wave action pulling *Myriophyllum spicatum* (Eurasian watermilfoil) up by the roots and pushing plants to the shoreline. Another example is the fragile species, *Elodea sp*. (elodea), which breaks off and moves easily due to wind-driven waves, especially in shallow areas of the littoral zone. High winds also affect macrophytes that are at the end of their life cycle and break off as they die. The most notable of these species have been *Potamogeton crispus* (curly-leaf pondweed) and *P. pusillus* (small pondweed), in late June or early July, after they have flowered and produced seeds.

Harvesting is also perceived to be the major cause of macrophyte fragmentation, which would lead to new plant growth from cut stems. Other reasons for floating plants include the increased recreational boating on Chautauqua Lake then results in more plants being cut by propellers. This is most notable on Mondays after the weekend before mechanical harvesting commences for the workweek. Some macrophyte species also reproduce by auto fragmentation where short apical stems naturally break away from the larger rooted plant. Eurasian watermilfoil creates short new stems by auto fragmentation both in the early spring and late fall **(Madsen *et al.* 1988, Smith and Barko 1990)**. This occurs at a time when mechanical harvesting generally is not taking place in northern lakes like Chautauqua.

Mechanical harvesting can affect aquatic ecosystems in diverse ways. Harvesting aquatic macrophytes allow for the removal of nutrients, including phosphorus from the sediment and water, which could provide better water clarity in the long term **(Bartodziej *et al.* 2017, James *et al.* 2002, NYSFOLA 2009, Painter 1988, Wile 1978)**. However, in the short term, the harvesting operation can decrease water quality due to sediment resuspension and increased turbidity in extremely shallow water depths **(Alam *et al.* 1996, Madsen 2000)**. Researchers have recognized that harvesting also removes zooplankton, invertebrates, and small fish as bycatch **(Engel 1990, Mikol 1985, Wile 1978)**. In Chautauqua Lake, the fish most affected from harvesting macrophytes is likely the white perch due to high populations found in plant beds. However, fish capture measurements do not show declines of macrophyte dwelling fish species after years of harvesting **(Lord *et al.* 2003, McKeown 2003)**. Our studies on invertebrate herbivores of 20 years have not shown long-term declines of the five species we study at Chautauqua Lake (**Johnson *et al.* 2021**).

While reviewing the scientific literature on mechanical harvesting, we found limited information on the loss of plant material from the process. Published approximations of the magnitude of losses were wide-ranging and appeared to be greater than we estimated after observing harvesting over several decades. We recognize that the experience and long history of mechanical harvesting by the Chautauqua Lake Association, Inc. (CLA) should result in fewer losses of aquatic plants compared to other harvesting operations. The CLA focuses on retaining a healthy littoral zone requiring a strong-rooted plant community to foster good water clarity and low turbidity. The question of the amount of plant loss from harvesting on Chautauqua prompted this evaluation.

Methods

A mechanical harvesting experiment to determine plant loss from the cutting and collecting of aquatic plants in Whitney Bay, Chautauqua Lake occurred on August 26, 2021. The experimental area chosen to evaluate macrophyte loss had limited management in 2021, and previous years, because it is designated as an important habitat for the lake's fishery. This lake area has a robust growth of aquatic plants with macrophyte species typical to the north basin. Plant species grew to the lake surface with filamentous algae attaching. Two rake-toss drags were collected adjacent to the plot area to be harvested for a determination of species identification and individual species dry weight to calculate the plant community composition along with an estimate of dry weight as g/m^2. The rake-toss drag samples were separated, bagged, and labeled for transport back to the lab. The specific machine used to cut and collect in the evaluation of plant loss was owned by the CLA and named "The Chautauqua."

"The Chautauqua" harvested aquatic plant biomass by proceeding toward shore for the first pass, then back for the second pass within the rectangle area (**Figure 1 and 2**). A range finder was used to determine the experimental plot size allowing calculation of the harvested area. The harvester collected aquatic plant biomass for 24 meters before turning around and returning. The harvester cutting bar had 3.35 meters cutting width, for a total harvested width of 6.7 meters **(Figure 2)**. The total area harvested in Whitney Bay was 160.8 m^2. The bottom cutting bar of the harvester's cutting head was kept slightly above the lake bottom to leave an intact aquatic plant stem stubble. Lake depth in the plot area ranged from 0.75 meters near shore to 1.75 meters with an average of 1.5 meters. This depth is typical of areas within the littoral zone that have the maximum plant biomass and areas mechanically harvested.

Figure 1. "The Chautauqua" harvesting in Whitney Bay, Chautauqua Lake on August 26, 2021. A clear path behind the harvester shows where the collection has taken place.

"The Chautauqua" conveyed all cut and collected plant material onto a transport barge. We collected, bagged, and labeled four subsamples from the transport barge for further analysis in the lab to determine moisture content. All plant material harvested from the experimental plot was transported onto a dump truck to be weighed to determine wet or fresh weight. All macrophytes and algae found suspended or floating in the harvested area were considered as "lost" from the harvesting operation. We collected and stored all "lost" material in a separate labeled bag for transport back to our lab. At the lab, each sample was dried separately in a drying oven. The samples were dried at 105°C for 48 hours then weighed and recorded as grams. All field and lab data were recorded for further analysis.

Figure 2. Area in Whitney Bay, Chautauqua Lake where the mechanical harvesting experiment took place on August 26, 2021.

Results and Discussion

We conducted the mechanical harvester experiment on August 26, 2021, to determine the loss of plant material during and after cutting **(Figure 1)**. The Whitney Bay area, chosen to evaluate plant loss from the process of mechanical harvesting, has a recent history of minimal management which allows for a dense growth of macrophytes in about 1.5 meters of depth. The 1.5 meters of depth at Chautauqua Lake generally reports the maximum growth of macrophytes year after year. We would expect biomass in this area, along with similar locations, to range between 50 to 300 g/m^2 dry weight (DW) with our rake-toss drag values in the Medium and Dense categories.

Table 1 and **Figure 3** show the species and relative abundance present in the plot area harvested during this experiment. The native species, elodea, shows the highest percentage of total plant dry biomass for both rake-toss drags at 83.5% and 88.1% respectively. *Ceratophyllum demersum* (coontail) is a distant second with all other species, including Eurasian watermilfoil, being far less abundant. This is an important distinction that can influence results in this field experiment. Elodea is a very fragile rooted plant that tends to break easily and has the potential to produce a greater loss by mechanical harvesting. Coontail and Eurasian watermilfoil have much tougher stems and do not break easily. We would expect larger losses when elodea is the dominant species in the plant community. Elodea is one of the best test macrophytes in Chautauqua Lake for a "loss" experiment as it has the greatest potential to break up or produce fragments and grow throughout the littoral zone in the lake.

Tables 2 – 6 show calculations and values defining the loss from the mechanical harvesting experiment. The four sub-samples, collected from the transport barge after harvesting all plant material, determined a mean of 7.8% dry weight **(Table 2)**. We use the 7.8% dry weight mean from **Table 2** to calculate the total plant mass dry weight collected from the harvester. The total dry weight of all collected plants from the harvester was 48,824.6 grams **(Table 3)**. In the lab, all collected lost material from the harvester **(Figure 3)** was dried and weighed **(Table 4)**. A total of 295.8 grams DW plant mass or 0.6% was lost during the harvesting operation of the plot **(Table 5)**. Another way we can express a 0.6% loss from the 303.6 g/m^2 DW calculated macrophyte bed in Whitney Bay is 1.8 g/m^2 **(Table 6)**.

This loss of 0.6% is small but probable. Our experience and observations at Chautauqua Lake for the last 20 years, along with our earlier experience with harvesting operations in the Finger Lakes Region, would suggest that losses attributed to harvesting operations were much less when investigated. Often the reported floating mats of plants in the waterbody and wave-driven piles along the shoreline in these lakes were blamed on harvesting operations that had not occurred.

The following likely reasons for free-floating macrophytes observed on the lake surface or in piles along the shoreline should be considered. Curly-leaf pondweed and small pondweed are early seasons maturing species that die, break off at the base, and decay rapidly in late spring/early summer. This mass floats in "rafts" to shoreline beaches without any mechanical harvesting taking place. Cutting by recreational boat props can result in floating macrophytes on numerous lakes. This is easily confirmed and observed on Monday mornings after a summer weekend well before any harvesting operation is underway for the week. Furthermore, the prevailing winds from the west, north-west in Chautauqua Lake, and the Finger Lakes Region have historically pulled and pushed aquatic plants, sometimes a long distance, to the east, south-east end of the lakes. Our observations over decades suggest strong wind-induced wave action, as a major cause of macrophyte removal from the lake bottom, macrophyte drift to the shoreline, and sediment turbidity that we investigated and observed yearly. In Chautauqua Lake, one only has to observe the lack of water clarity in the south basin at Burtis Bay on a windy day.

Two scientific papers that describe harvesting similar macrophyte species in the northern tier of the United States suggest that harvesting losses are in the range of 2 to 15 % **(Engel 1990, Mikol 1985)**. Another paper **Sperry *et al.* 2021**, suggests up to a 20% loss, however, this is their estimate of loss when harvesting water hyacinth, a floating plant, in Florida that they cite as having 15-fold greater biomass than submersed plants like Eurasian watermilfoil. A loss of 20% therefore would seem extremely high and difficult to achieve when harvesting submerged plants. Additionally, it is difficult to put a level of confidence on reported individual % loss estimates as few have documented measurements. The reports that had data appear to have measured plant mass as fresh or wet weight, a defensible measurement although subject to possible large errors.

Table 1. Two rake-toss drag samples, collected from the harvested area in Whitney Bay, show plant community composition as species presence, wet weight, dry weight, species percentage of sample, and the dry weight percentage of each species. ND = non-detectable.

Scientific Name	Common Name	Plant Mass Wet Weight (g)	Plant Mass Dry Weight (g)	% of Total Sample	% Dry Weight
Ceratophyllum demersum	coontail	209.1	10.7	9.1	5.1
Elodea sp.	elodea	850.0	98.4	83.5	11.6
Heteranthera dubia	water stargrass	5.6	0.3	0.3	5.4
Myriophyllum spicatum	Eurasian watermilfoil	19.7	1.9	1.6	9.7
Potamogeton praelongus	white stem pondweed	12.3	1.3	1.1	10.6
Potamogeton robbinsii	Robbin's pondweed	1.1	0.1	0.1	8.2
Potamogeton zosteriformis	flat-stem pondweed	32.9	5.1	4.3	15.5

Scientific Name	Common Name	Plant Mass Wet Weight (g)	Plant Mass Dry Weight (g)	% of Total Sample	% Dry Weight
Ceratophyllum demersum	coontail	109.3	6.8	6.1	6.2
Elodea sp.	elodea	875.5	97.5	88.1	11.1
Heteranthera dubia	water stargrass	25.9	2.1	1.9	7.9
Myriophyllum spicatum	Eurasian watermilfoil	5.5	0.5	0.5	9.1
Najas guadalupensis	common water nymph	0.1	0.1	0.1	ND
Potamogeton praelongus	white stem pondweed	13.8	1.2	1.1	8.7
Potamogeton zosteriformis	flat-stem pondweed	15.9	2.6	2.3	16.4

Table 2. Four plant subsamples were collected from the harvester to determine the mean percentage of the dry weight of harvested plants from the plot.

Samples from Harvester	Plant Mass Wet Weight (g)	Plant Mass Dry Weight (g)	% Dry Weight
Sample 1	600	52.2	8.7
Sample 2	950	64.1	6.7
Sample 3	1250	100.6	8.0
Sample 4	1340	103.5	7.7
		Mean	7.8

Table 3. Harvested plants, showing the weight conversion from pounds to grams, minus the dump truck empty weight. The total plant mass dry weight was determined by using the mean percentage of plant mass dry weight from **Table 2**.

	Weight (lbs)	Weight (g)
Dump Truck Weight with Plant Mass	8960	4064184
Dump Truck Weight without Plant Mass	7580	3438227
Total Plant Mass Wet Weight	1380	625957
Total Plant Mass Dry Weight		48825

Table 4. Total plant mass wet weight was found and recovered as harvester "loss" then separated into piles of macrophytes or filamentous algae in the lab. All material from the piles was dried at 105°C for 48 hours then weighed and recorded.

Loss from Harvester	Plant Mass Wet Weight (g)	Plant Mass Dry Weight (g)
Plant	3000	273
Algae	300	22
Total	3300	296

Table 5. Percentage loss of aquatic plants to Chautauqua Lake during the operation of mechanical harvesting by the CLA while harvesting a robust macrophyte bed typical to Chautauqua Lake. The total dry mass harvested from the experimental plot of 48,825 grams was calculated from the wet mass multiplied by 7.8%. The 296 grams is the actual weight loss of plants to the lake from the harvested plot.

Total Plant Mass Dry Weight (g)	Total Loss from Harvester Plant Mass Dry Weight (g)	% Loss
48825	296	0.6

Table 6. The 0.6% loss is shown below as a loss of 1.8 g/m^2 to the lake.

Total Plant Mass Dry Weight (g)	Total Harvested Area (m^2)	Total Plant Mass Dry Weight (g/m^2)	% Loss	Total Loss from Harvester Plant Mass Dry Weight (g/m^2)
48825	160.8	303.6	0.6	1.8

Figure 3. The top left picture shows biologists processing macrophyte samples from dual-headed rakes by separating individual species for an estimate of each species' percentage of the whole mass. The bottom left picture shows the harvester and transport barge after harvesting in Whitney Bay, Chautauqua Lake. The right picture shows the total loss of plants and algae collected after harvesting from the experimental plot.

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