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Continued Monitoring of Macrophyte Biomass and Filamentous Algal Cover in Conesus Lake (Summer 2009)

Report Submitted to
The Livingston County Planning Department

by

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I. Summary

- During the summer 2009 we measured macrophyte biomass, macrophyte bed surface area, total standing crop, and the % cover of filamentous algae in North Gully Cove and three other study sites in Conesus Lake that were originally part of the U.S.D.A. watershed project (Makarewicz *et al.* 2009). North Gully Cove was the experimental site in testing the hypothesis that diversion of the North Gully effluent (completed in February 2008) would bring about reductions in plant growth in North Gully Cove. The three other study sites (Sutton Point, Sand Point and Cottonwood Gully) were reference sites studied to account for lake-wide changes in plant growth that might influence trends at North Gully Cove.

- The biomass density, surface area, and total standing crop of the macrophyte bed in North Gully Cove were 12%, 6% and 17% higher than the 2000-2007 average (before stream rechanneling). At Sand Point and at Sutton Point, these same metrics for macrophyte growth were near or slightly below the long-term average. Only at Cottonwood Gully was the macrophyte bed appreciably smaller and less dense than the long-term average for the site. This is part of a continuing trend of reduced plant growth which begun after management practices were implemented in the Cottonwood Gully watershed as part of the U.S.D.A. project.

- Overall in 2009, the biomass of macrophytes in North Gully Cove seemed to follow or exceed historical trends for the same bed and for the three reference study sites. These results confirm the conclusion of last year's monitoring report (Bosch *et al.* 2008) in which low macrophyte biomass at North Gully Cove was attributed to lake-wide trends rather than local declines due to stream rechanneling.

- In contrast to the trends in macrophyte biomass, filamentous algal cover at North Gully Cove In July and August was relatively low, despite the fact that filamentous algae bloomed in many areas of the lake throughout the summer. Median cover was 3.2% compared to 38.6%, 31.2% and 13.7% at Sand Point, Sutton Point, and Cottonwood Gully.

- A second survey of algal cover on September 3-10, which also included study sites at Eagle Point and Graywood Gully, revealed a similarly low cover of 3.2% at North Gully Cove, while blooms had abated at Sutton Point and Cottonwood Gully (4% and 0% cover), but not at Sand Point (37.8%) or Eagle Point (19.4%). In seeking an explanation for the disparity in algal cover between sites we surveyed land use in the associated watersheds, However, the differences observed in land use and crop types in the various watersheds were not consistent with respect to the differences in algal cover along the lake shore.

- In 2009, filamentous algal cover at North Gully Cove was low relative to previous years and in comparison to reference sites in Conesus Lake. SUNY Brockport's study of stream runoff indicated that nutrient concentrations were extremely high at North Gully and other streams around the lake. Thus the most plausible explanation for the low algal cover at North Gully Cove is that the rechanneling of North Gully tributary is having the intended outcome of reducing plant growth in North Gully Cove. Additional monitoring will be necessary to fully establish this trend and to determine if there might be a similar but slower response by the macrophyte assemblage.

II. Introduction

This study continues a long-term program designed to monitor trends in growth of macrophyte beds and filamentous algae along the shoreline of Conesus Lake. The program was initiated as part of the U.S.D.A. watershed project and is now sustained with the support of Livingston County. We now have an extensive and valuable ten-year record of plant biomass and distribution that can be used to assess natural changes in the Conesus Lake ecosystem and to evaluate the efficacy of management practices that target nuisance plant growth.

One such management project is the diversion of North Gully creek at McPhersons Point. Until 2008, North Gully creek drained directly into North Gully Cove, delivering large amounts of dissolved and particulate nutrients to the shoreline. North gully is a 735 ha sub-watershed that is approximately 45% in dairy and row crop agriculture (Makarewicz et al., 2001, 2002). In February 2008, the North Gully creek channel was diverted northward along the McPhersons Point shoreline, presumably allowing much of the stream effluent to drain into the open waters of Conesus Lake away from the macrophyte bed to the south. Observations of runoff plumes before and after the project indicate that the stream diversion may have been effective in reducing the amount of sediment and nutrient runoff entering North Gully Cove (Bosch *et al.* 2008). However the hydrodynamics of the North Gully plume and its dispersal under different environmental conditions (discharge, winds, currents) have not been studied. At this time there is no certainty that rechanneling of the stream has altered the delivery of nutrients to North Gully Cove.

During the summer 2008 we conducted the first post-rechanneling study of plant growth and distribution in the macrophyte bed dominated by Eurasian watermilfoil at North Gully Cove (Bosch *et al.*, 2008). The results indicated that the biomass and standing crop of macrophytes (primarily milfoil) were very low when compared to previous years for this site. However, because a similar decrease in biomass had been found in two reference sites, the trends were believed to be lake-wide rather than specific to North Gully Cove. The cover of filamentous algae reported in the 2008 report was extremely high. However, the measurements were taken on the bottom after the collapse of the bloom because a plant canopy never developed at North Gully Cove and for that reason these data are not readily comparable to previous studies of percent surface cover.

The results of the 2009 monitoring study reported here provide more evidence on the potential changes in plant growth at North Gully Cove brought about by the rechanneling of North Gully creek. Because our study sites are a subset of those included in the U.S.D.A. project, the present study also contributes to the long-term database of macrophyte and filamentous algal growth along the shoreline in Conesus Lake.

III. Methods

Macrophyte species composition and biomass, macrophyte bed area and filamentous algal coverage, were determined for the North Gully Cove, Sutton Point, Sand Point and Cottonwood Gully macrophyte beds **(Figure 1)** during the peak of the growing season in July and August 2009. North Gully Cove **(Figures 2 and 3)** was the experimental site in testing the hypothesis that diversion of the North Gully effluent will lead to reductions in plant growth. The other macrophyte beds were monitored as reference sites to account for lake-wide changes that might influence trends at North Gully Cove. The four sites have been studied since 2000 as part of the U.S.D.A. watershed study. Consequently there is an extensive published record of nutrient delivery, plant growth, and distribution for these sites (see Makarewicz *et al*., 2009, Bosch *et al*. 2009a and 2009b).

A second major survey of algal cover was conducted on September 3-10, after declining lake water levels had exposed much of the algae growing in the macrophyte canopy. Two additional study sites at Eagle Point and Graywood Gully were sampled as part of the September survey **(Figure 1)**.

The methods used to quantify macrophyte biomass and filamentous algal cover are described in a previous technical report (e.g. Bosch *et al*., 2008). A more detailed account can be found in the published studies from the U.S.D.A. project (Bosch *et al*. 2009a and 2009b).

To determine aquatic plant biomass, replicate quadrat samples (3 per depth) were collected at depths of 2, 3 and 4 m along three transect lines at each site. Transect locations at all three sites were the same as those used in previous studies of Eurasian milfoil in Conesus Lake (Bosch *et al.* 2009a). A 0.5m x 0.5m quadrat constructed from PVC pipe is placed on the bottom and all shoot biomass is harvested by hand. Each sample was placed in a numbered plastic collection bag and taken to the laboratory for species sorting and zebra mussel removal. Plant species within each sample were blotted dry with paper towels and weighed separately to the nearest 0.1g with an electronic scale. These wet weights were converted to dry weights using species-specific dry weight conversion factors determined by Bosch *et al.* (2009a).

The surface area of the macrophyte beds and the milfoil-dominated area of the beds were mapped at each site using global positioning systems (GPS). To record points, a Trimble Model TSC1 global positioning unit (Trimble Navigation Ltd.) was used by a research assistant aboard a boat while a swimmer indicated points to be mapped as he swam around the perimeter of milfoil dominated areas in each bed. Pathfinder software was used to analyze these maps for surface area and to compare these surface areas to years past.

Filamentous algal cover was determined on canopied macrophyte beds by taking digital photographs of a quadrat at the surface (Bosch *et al.* (2009b). Because the peak surface growth depends on macrophyte canopy formation as well as algal growth, all of the beds in this study were monitored throughout the summer until peak biomass development was apparent. Monitoring of algal biomass is continued through the season in order to document declines and in some cases secondary blooms of filamentous algae. In 2009 for example, a secondary bloom that appeared in late August was document by sampling in multiple sites in early September.

Photographs were taken from the surface over depths of 1 m and 2 m along the same transect lines used for macrophyte sampling. In cases where the canopy did not form, S.C.U.B.A. divers used an underwater digital camera (Sea Life DC 500) to photographs quadrats at depths of 1 m and 2 m. Surface and underwater photographs were analyzed for percent algal cover using Image J computer software.

In seeking an explanation for the disparity in algal cover between sites sampled in early September, we conducted a one-time survey land use in the associated watersheds. To complete this survey we drove along the boundaries of each watershed and identified individual fields from watershed maps and areal photographs. We distinguished between active agricultural fields, residential areas, and fields not currently in agriculture (i.e. woodlots, vacant fields). Within the agricultural field category we identified the existing crop or current use of each field. The land use survey was completed in late September.

IV. Results and Discussion

Macrophyte Biomass

In 2009, the macrophyte biomass within the 2-3 m zone at North Gully Cove was high overall with an average of 283 $\pm$ 108 g dry wt./m^2 (**Table 1, Figure 4**). This was higher by a small percent than all but the years 2001 and 2003 when the quadrat biomass was 459 and 304 g dry wt./m^2, respectively. The dominant species in this bed continues to be Eurasian watermilfoil, which made up approximately 87% of the biomass in the 2-4 m zone. A species known as coontail (*Ceratophyllum demersum*) and a variety of pondweeds (*Potamogeton* sp.) made up the bulk of the remaining biomass.

The macrophyte bed at North Gully Cove is one of the largest in Conesus Lake, extending south from McPhersons Point until an artificial cutoff at the State Boat launch. South of the boat launch the bed narrows gradually into a fringing band along the shoreline. Our maps of this bed do not extend south of the State Boat Launch. Thus the southern cutoff of the bed is precise from year to year.

In 2009 the North Gully Cove macrophyte bed was expansive compared to the historical record, with the milfoil dominated area covering 24,267 m^2 or nearly 2.43 ha of lake bottom (**Table 1**). This is in sharp contrast to 2008 when the milfoil area of the bed was 11, 855 m^2 and 55% smaller than the long-term average. Because the reference macrophyte beds at Sutton Point and Sand Point were also considerably smaller than the respective long-term averages for the sites, we concluded in our 2008 report that the changes in North Gully Cove were part of a lake-wide trend rather than a unique condition might have been caused by the diversion of the stream. The fact that in 2009 the bed regained its more typical dimensions supports our 2008 conclusions.

Total bed standing crop is calculated by multiplying average quadrat biomass times bed surface area. Thus it is not surprising that in 2009 the standing crop of the North Gully Cove macrophyte bed was slightly above (6874 Kg Dry Wt.) the long-term average for the site (**Figures 5, 6**).

Overall, all three metrics used to monitor macrophyte bed development indicate that 2009 was a year of extensive growth in North Gully cove. The 2009 values for quadrat biomass, bed surface area, and total standing crop were 12%, 6% and 17% higher than the combined averages for the 2000-2007 seasons. (**Table 1, Figure 6**) Thus the result of the 2009 monitoring provide no indication that the diversion of North Gully had an effect on the macrophyte flora of the adjacent cove.

This conclusion is also supported by comparisons with trends in other beds. At Sand Point Gully and Cottonwood Gully, two of the U.S.D.A. experimental sites, quadrat biomass was 8% and 40% lower than the corresponding long-term average (**Table 1, Figure 4**). Similar trends were evident in terms of surface area and standing crops at these sites (**Figure 5, 6**). The changes in Cottonwood Gully are notable because this bed has shown a continuing decrease in standing crop after management practices were implemented in the associated watershed (see Makarewicz *et al.* 2009) in summer and fall 2003 (**Figures 4,5,6**; Note: the 2003 data is an outlier because in the previous winter there was an unusual die-off of the macrophyte bed and this was followed by slow recovery in the following summer). The average milfoil-zone standing crop in the Cottonwood bed from 2005-2009 was 1,344 Kg whereas the 2001-2002 pre-management average was 2914 kg.

In contrast to the declining trends in Cottonwood Gully and below average growth at Sand Point, the Sutton Point macrophyte bed showed more extensive biomass particularly in terms of bed surface area and total standing crops, which were 40% and 21% higher than the long-term average (**Table 1, Figure 6**). Overall, Sutton Point followed the same trend as North Gully.

Cover of Filamentous Algae

Unlike rooted macrophytes which can draw nourishment from vast stores of nutrients in the sediment, filamentous algae absorb nutrients directly from the water column and proliferate rapidly in response to increasing supplies. Thus, filamentous algae may be the more reliable indicator of changes in stream nutrient loading into Conesus Lake (D'Aiuto *et. al.* 2006, Makarewicz *et al*. 2007, Bosch *et al*. 2009b).

During the summer 2009, the Conesus Lake watershed received considerable rainfall. The weather station at Rochester Airport (www.wunderground.com) recorded heavy rains in late May (2.26 inches from the 26th -31st), throughout most of June (5.3 inches total) and in late July (2.5 in. from the 21st-30th). The rainfall was followed by high discharge of nutrient rich waters into Conesus Lake, according to SUNY Brockport's 2009 monitoring report (Makarewicz *et al.* 2009), which included all of the sites that are part of our study. The combination of high runoff and increasing water temperatures contributed to a lake-wide bloom of filamentous algae in early June that was especially vigorous in the southwest section of the lake that includes the Sutton Point and Cottonwood Gully sampling sites. At Sutton Point, the median cover of filamentous algae was 31.2% (range 7.0 - 72.4) in quadrat samples taken on July 9 and 15. At the Cottonwood Gully site, where in recent years there has been very low algal biomass, the median cover was 13.7% on July 15 (range 0.0 -50.5%; **Figure 7**). Because a macrophyte canopy had not developed in the North Gully Cove site by mid July we were unable to quantitatively sample for filamentous algal cover in the designated transects. However, our observations indicated that the area was free of extensive algal growth, the one exception being a small patch in the southern portion of the bed where we estimated that algal cover was approximately 18.9%.

On August 10-11 a more comprehensive survey of filamentous algal cover was conducted using S.C.U.B.A. divers to photograph bottom quadrats in areas where a macrophyte canopy had not developed (**Figure 7**). At North Point Cove during this sampling period the median cover was still high along the southern transect, but the central and northern transects showed very low cover. For the entire bed the median cover was 3.2% (**Figure 8**; range 0.0 -65.4%). By contrast over the same period filamentous cover at the Sand Point macrophyte bed was high in all transects reaching a maximum of 73.8% and a median of 38.7% **(Figure 9A)**

An additional survey was conducted on September 3 -10 when lower water levels had exposed the macrophyte canopies and algal mats in most areas of the lake. Macrophyte beds at Graywood Gully and Eagle Point Gully were also sampled. The results of the survey are shown in **Figure 7** along with the results of July-August. Algal cover was not measurable (i.e. low or no cover) in Cottonwood Gully and Sutton Point, low in Graywood Gully (median 2.6, maximum 28.2) and relatively high in Eagle Point (19.4, 97.1) and Sand Point (12.9, 79.3). In North Gully Cove, the median cover was 4.7% and the maximum was 72.2% in one outlier. Overall, the North Gully Cove values are relatively moderate and similar to values recorded in August. Thus it appears that in 2009 North Gully Cove never developed the extensive growth of algae observed in all the other macrophyte beds sampled (i.e. Sutton Point and Cottonwood Gully in July, Sand Point in August/September, and Graywood Gully and Eagle Point at least in September).

In seeking an explanation for the disparity in algal cover among the five macrophyte beds studied in September, we surveyed land use in the associated watersheds. The results of the land use survey are presented in Table 2, along with data on % cover for the downstream shoreline areas. A brief analysis of trends indicates that the two sub-watersheds with significant amount of acreage in soybeans (i.e. Sand Pt.

Gully 46 ha, Eagle Point Gully 43 ha) were associated with the highest algal growth down stream. Soybeans were also the primary crop in Cottonwood Gully (23.6 ha, with corn a close second at 21.5 ha), but the median algal cover downstream was very low in September (**Table 2**). It is also possible that the algal cove was simply a function of the size of the sub-watershed upstream; Sand Point Gully and Eagle Point gully were far and away the largest watersheds studied and the highest percent cover values were found downstream. We caution that the survey is preliminary and our interpretation of the data is highly speculative. Information on tillage, use of fertilizer, and other farming practices would be necessary for a complete analysis. Moreover, other factors in addition to nutrient may influence biomass accumulation of the algae. Short-term growth experiments with filamentous algae (e.g. D'Aiuto *et al*., 2007) rather than biomass accumulation may provide a more effective way to test how different crop rotations and other specific farming practices drive plant growth in downstream habitats.

Figure 10 shows historical trends in the percent cover of filamentous algae over the last nine growing seasons in North Gully Cove and in the three U.S.D.A. sites used as reference macrophyte beds for this study. The trends indicate that algal cover has remained relatively high at Sand Point and Sutton Point, whereas cover in Cottonwood Gully has continued to decrease gradually since 2004. For North Gully, algal cover over the 2009 growing season was the lowest recorded since 2000 monitoring was initiated in 2000, and it was statistically lower than six of seven other summer seasons sampled ($p < 0.05$, Kruskall-Wallis One Way Analysis of Variance on Ranks; Dunn's Method Pairwise Comparisons). This may be the first indication that the rechanneling of North Gully tributary is having the intended outcome of reducing plant growth in North Gully Cove. However, additional monitoring will be necessary to fully establish this trend.

V. Conclusions

In this 2009 monitoring study we tested the hypothesis that the northward diversion of North Gully had brought about decreases in the biomass of macrophytes and filamentous algae in North Gully Cove. The hypothesis is founded on the assumption that most of the runoff from North Gully is now discharged offshore rather than over the macrophyte bed in North Gully Cove. A similar study conducted in 2008, six months after the diversion project, found no concrete evidence that plant growth had decreased. The conclusion was based on comparisons with historical trends for the site and with trends in reference macrophyte beds.

In 2009 macrophyte density and standing crop in North Gully cove were higher than the average for the years 2000-2007. Thus, as in 2008, we found no indication that macrophyte biomass was impacted by the stream diversion. Similarly high macrophyte s seen in the Sand Point Gully and Sutton Point Gully reference sites, but not in Cottonwood Gully, where macrophyte growth has declined considerably since agricultural management practices were implemented in the Cottonwood Gully watershed by the U.S.D.A. watershed project.

In contrast to the lack of significant change in macrophyte biomass, the percent surface cover of filamentous algae at North Gully Cove was moderate to low relative to algal cover in four reference sites and to the historical record (2001-2007) for North Gully Cove. Although information on total nutrient loading by the North Gully tributary was not available, nutrient concentrations in stream water were very high from May to August 2009 (Makarewicz *et al*. 2009). For example, the seasonal averages for total phosphorus and soluble reactive phosphorus concentrations were the highest reported for the stream. Total suspended solids were approximately 3x higher than normal (Makarewicz *et al*. 2009). Therefore the most plausible explanation for the reduced cover of filamentous algae at North Gully Cove in 2009 is the diversion of the tributary runoff into open water and the accompanying reduction in nutrient delivery into the cove. We recommend that additional monitoring be conducted in order to establish with some certainty whether this is indeed the case, and to determine if there might be a similar response by the macrophyte assemblage.

VI. Acknowledgements

The work of Todd Shuskey,and Brad Cohen in sample collection and S.C.U.B.A. operations is gratefully acknowledged. We are indebted to the Conesus Lake Association and especially President George Coolbaugh and Director Gene Bolster for their continued logistic, financial and moral support of SUNY Geneseo's work in Conesus Lake. This research project was funded by the Livingston County Planning Department.

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VIII. Tables and Figures

Table 1. Long-term record of dry weight biomass, bed surface area and total biomass (i.e. standing crop) in the milfoil dominated zone for the Sutton Point, North Gully, Sand Point and Cottonwood Gully macrophyte beds. Data was collected during the peak of the growing season, typically in the first two weeks of August.

Location	Year	Average Biomass grams . m^2	Surface Area m^2	Standing Crop Kg Dry Wt
Sutton Point Gully	2000	184 ± 43	---	---
	2001	467 ± 183	8,592	4,017
	2002	71 ± 40	3,688	262
	2003	138 ± 92	11,819	1631
	2004	227 ± 77	11,909	2,703
	2005	197 ± 90	11,995	2,349
	2006	364 ± 208	7,438	2,707
	2007	295 ± 94	10,973	3,232
	2008	190 ± 106	5,985	1,201
	2009	224 ± 112	13,802	3,099
North Gully	2000	262 ± 134	23,192	6,192
	2001	459 ± 202	25,783	11,834
	2002	151 ± 74	12,004	1,813
	2003	304 ± 176	19,760	6,007
	2004	186 ± 57	30,099	5,598
	2005	188 ± 105	21,798	4,098
	2006	230 ± 100	22,560	5,178
	2007	225 ± 70	27,850	6,266
	2008	266 ± 167	11,855	3,149
	2009	283 ± 108	24,267	6,874
Sand Point Gully	2000	212 ± 29	9,535	2,021
	2001	484 ± 300	9,781	4,730
	2002	325 ± 82	7,354	2,390
	2003	290 ± 126	5,310	1,540
	2004	131 ± 34	8,474	1,110
	2005	191 ± 96	8,349	1,595
	2006	230 ± 92	9,775	2,246
	2007	112 ± 111	9,684	1,084
	2008	201 ± 71	6,022	1,147
	2009	222 ± 111	6,564	1,457
Cottonwood Gully	2000	193 ± 85	---	
	2001	373 ± 168	9,387	3,501
	2002	316 ± 134	7,360	2,326
	2003	146 ± 43	3,750	548
	2004	234 ± 41	9,205	2,154
	2005	273 ± 81	6,880	1,878
	2006	283 ± 61	5,605	1,589
	2007	155 ± 140	8,100	1,253
	2008	-	-	-
	2009	135 ± 78	4,860	657

Table 2. Data showing agricultural land use for five sub-watersheds on the west side of Conesus Lake that were surveyed in September 2009. The crop data are compared to the % cover of filamentous algae along the lake shoreline in September (far right column).

Watershed	Crop Type	Cover (ha)	Cover (%)	Total Ag. (Active ha)	Total % Ag (active)	September Median % Cover by Algae
Cottonwood Gully	Corn	21.5	21.6	59.6	59.9	0.0
	Groundcover	14.5	14.6			
	Soybeans	23.6	23.7			
	Residential	11.1	11.2			
	Woodlots	28.5	28.6			
Graywood Gully	Corn	4.7	12.3	24.2	63.2	2.6
	Groundcover	12.2	31.9			
	Alfalfa	6.5	16.9			
	Pasture	0.8	2.1			
	Residential	3.6	9.4			
	Woodlots	10.1	26.4			
Sand Point Gully	Corn	56.7	30.1	120.5	64.0	12.9
	Groundcover	12.2	6.4			
	Soybeans	48.0	25.5			
	Alfalfa	3.6	1.9			
	Residential	31.9	16.9			
	Woodlots	35.2	18.7			
Sutton Point Gully	Corn	6.5	9.7	28.3	42.0	0.0
	Groundcover	17.4	25.8			
	Alfalfa	1.3	1.8			
	Unidentified Ag[1]	3.1	4.6			
	Woodlots	39.1	58.1			
Eagle Pt. Gully	Corn	3.9	2.0	106.2	54.1	19.4
	Groundcover	4.7	2.4			
	Soybeans	59.8	30.5			
	Alfalfa	18.1	9.2			
	Residential	43.0	21.9			
	Woodlots	46.6	23.7			
	Unidentified Ag[2]	19.7	10.0			

[1] fields not visible from roadside

[2] freshly planted unknown crop

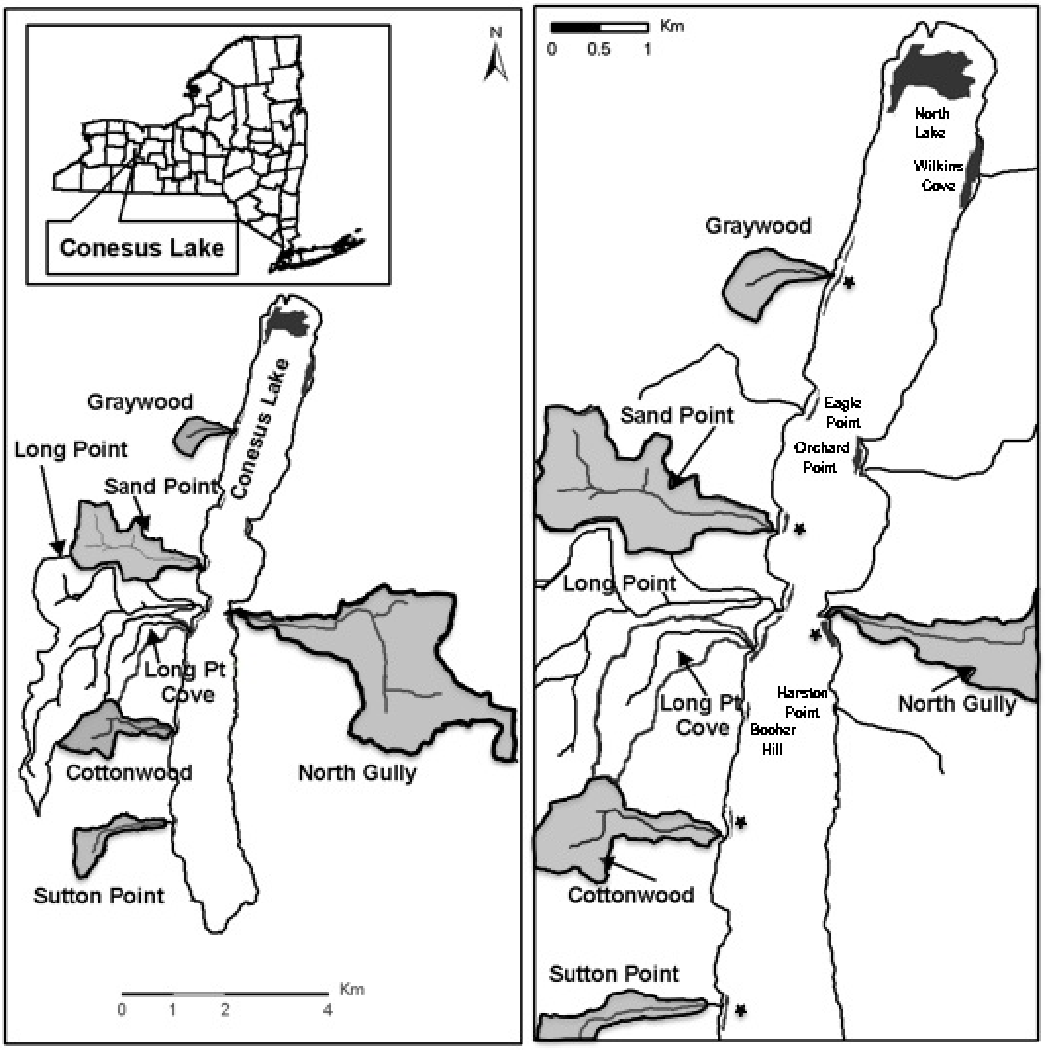


Figure 1. Map showing some of the largest macrophyte beds in Conesus Lake in their geo-referenced positions. Study macrophyte beds are identified by a star symbol and their corresponding watersheds are marked in grey.

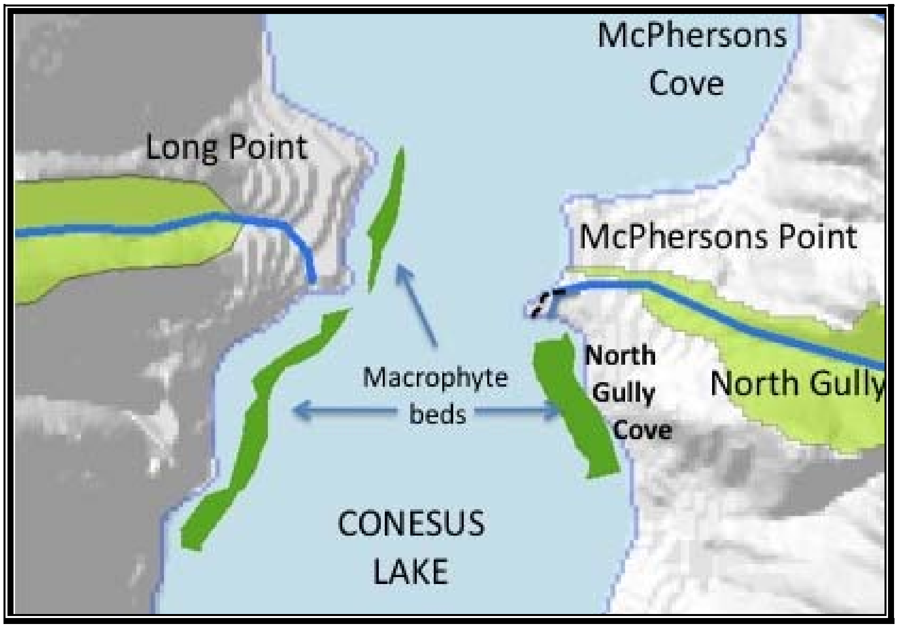


Figure 2. Map of the general area around McPhersons Point showing nearby milfoil dominated areas in geo-referenced positions. The previous (solid line) and current (dashed line) positions of the North Gully stream mouth are drawn in by hand.

Figure 3. Photograph showing heavy cover of filamentous algae the base of North Gully Cove from the shoreline to a depth of nearly 2 m in August 2005.

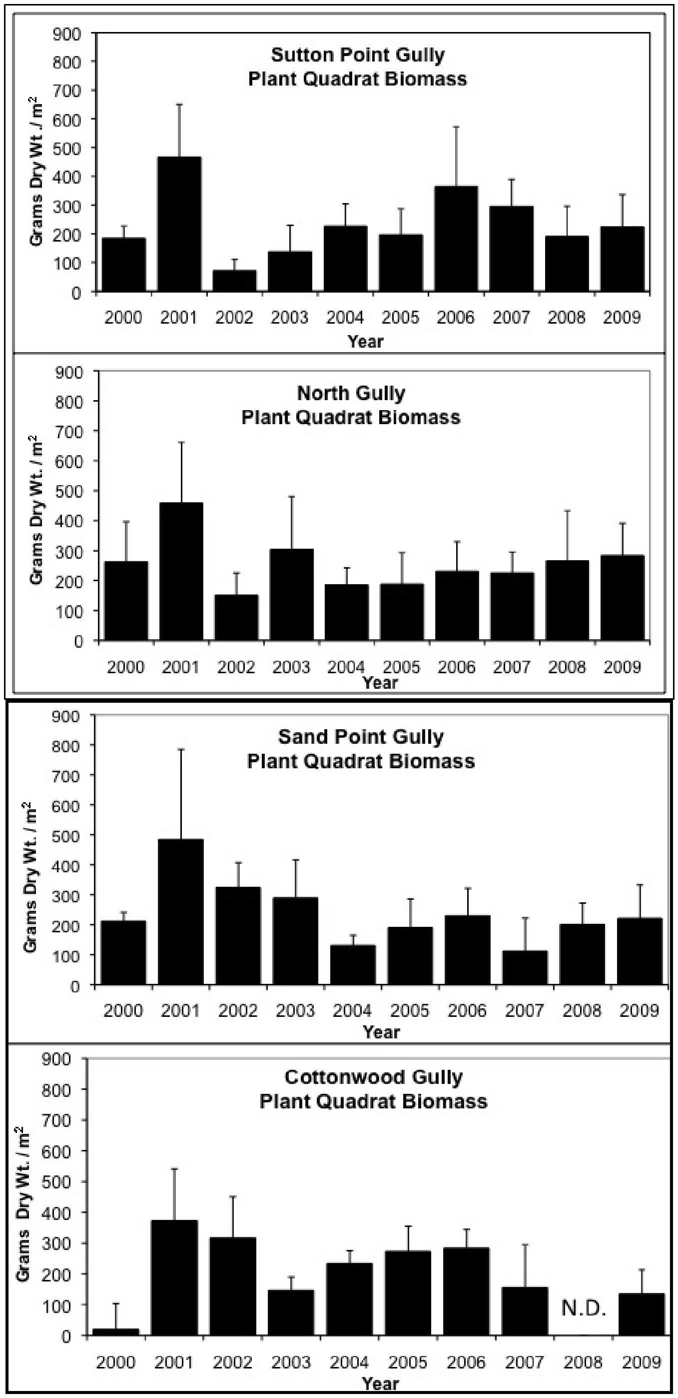


Figure 4. Plots showing annual trends in macrophyte biomass as grams per m^2. Data are for the 2-3 m zone dominated by Eurasian watermilfoil at the Sutton Point, North Gully, Sand Point, and Cottonwood Gully study sites.

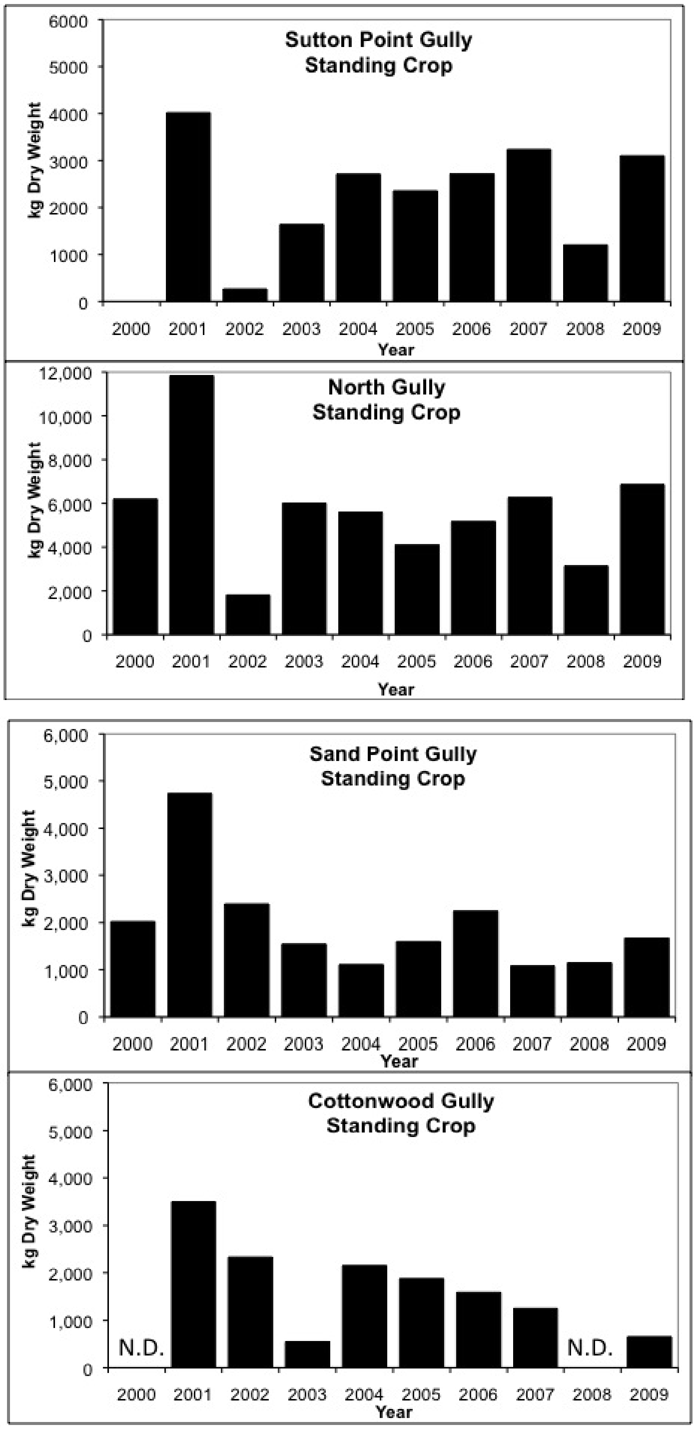


Figure 5. Long-term trends in standing crops for the areas dominated by Eurasian watermilfoil in four macrophyte beds. Standing crops were calculated by multiplying the mean quadrat biomass (see Figure 5) times the surface area covered by milfoil in each bed.

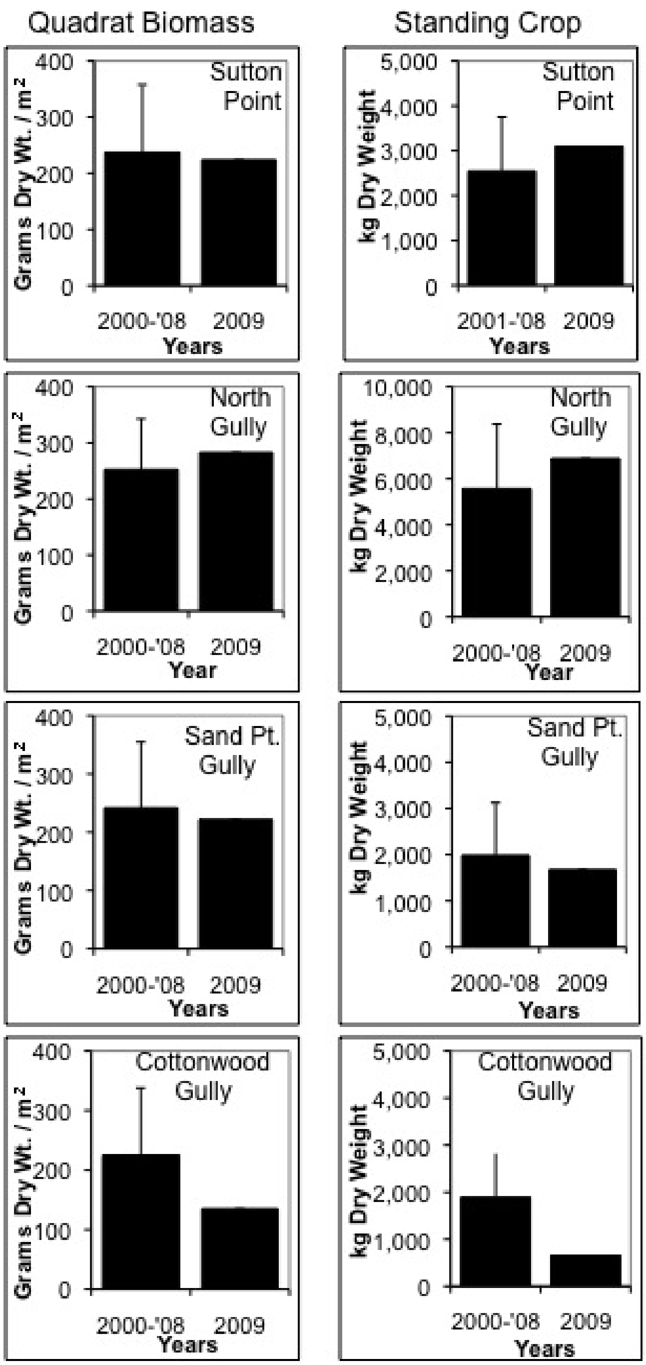


Figure 6. Average trends in quadrat biomass and standing crops for 2000-2008 compared to summer 2009 values. Means and standard deviations are reported for all the historical data (n=9 years) while a single value for each site is reported for 2009. Quadrat biomass density and total standing crop were slightly higher than the long-term average for North Gully Cove. Only in Cottonwood Gully were the 2009 values considerably lower than the long-term averages.

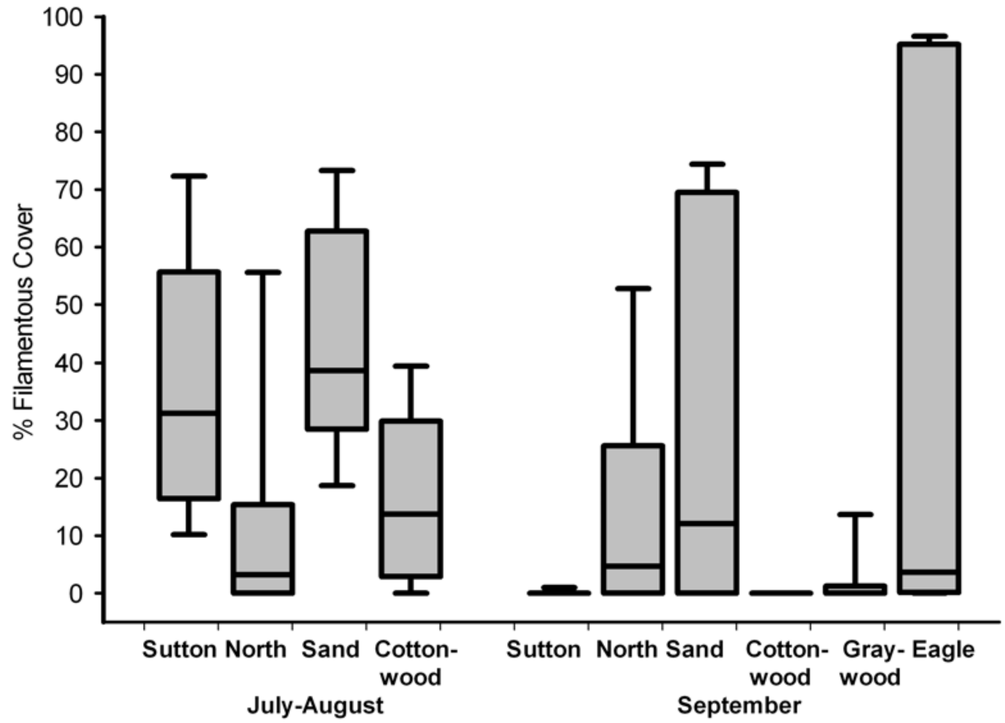
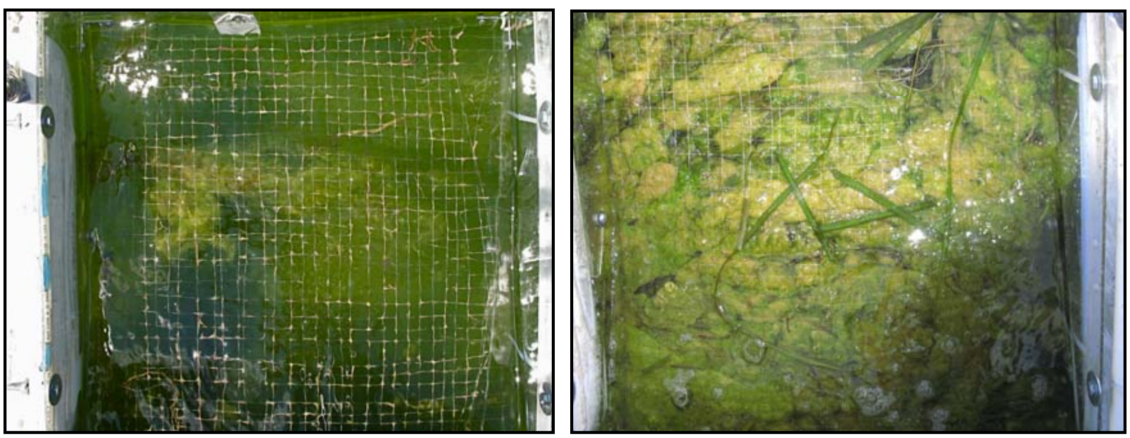


Figure 7. Percent filamentous algal cover on the macrophyte canopy at the Sutton Point, North Gully Cove, Sand Point and Cottonwood Gully sites over the growing season during the summer (July-Aug. combined) and September 3-10 in 2009. The boxes represent the 25-75% data intervals and the bars are the 5 and 95% intervals. The horizontal line within the box is the median.

Figure 8. Photographs taken in North Gully Cove of quadrats held by diver at a depth of 1 m in the same area as in Figure 3. Note the almost complete absence of algal cover on the macrophytes. These images were taken on August 11, 2009.



A **B**

Figure 9. Photographs of the macrophyte canopy taken at Sand Point (**A**) and Eagle Point (**B**). The macrophytes are barely visible at the surface because of the high cover of filamentous algae at these sites (Sand Pt. photo taken in August, Eagle Pt. photo in September)

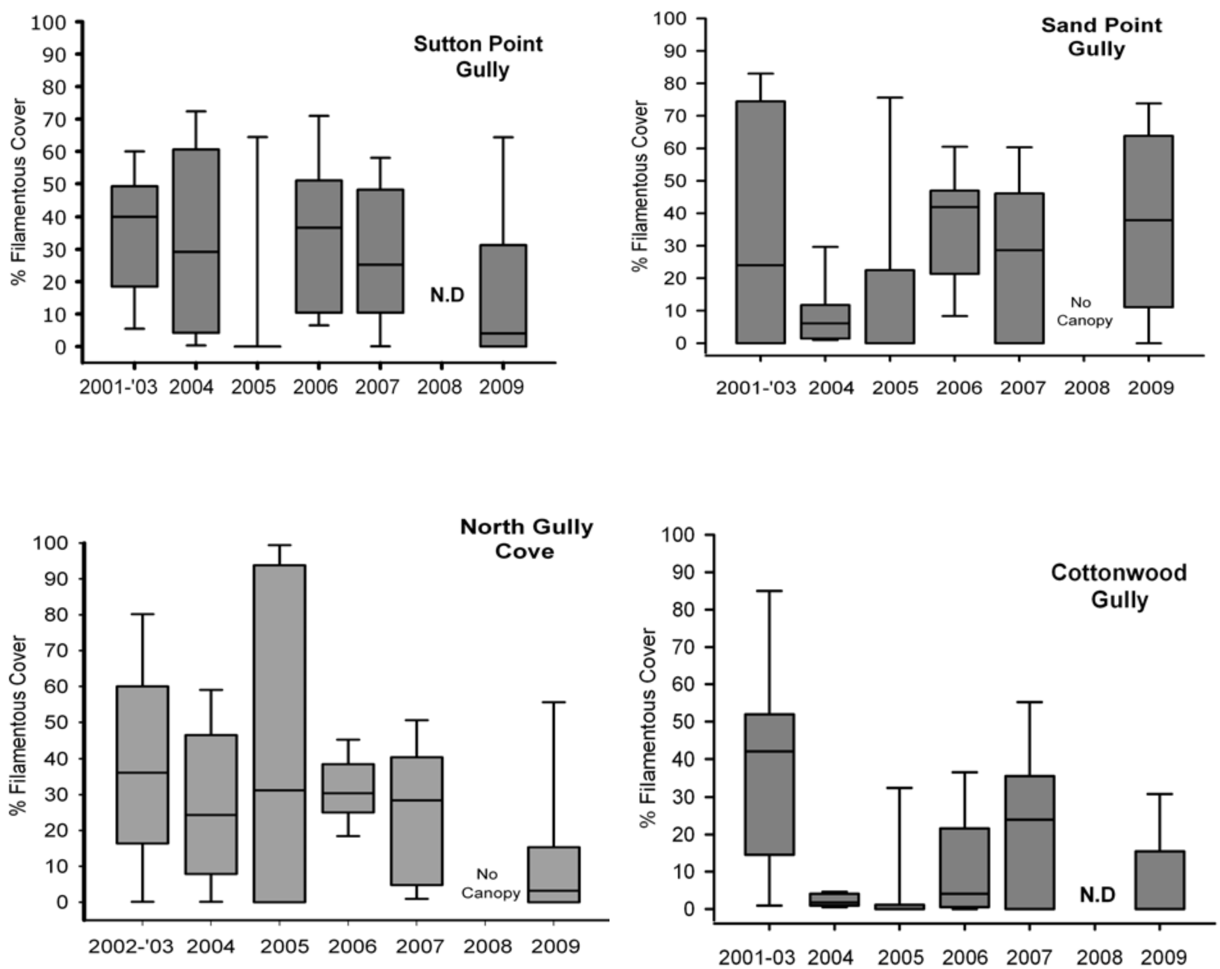


Figure 10. Historical trends in the percent cover of filamentous algae growing on the macrophyte canopy at four study sites. Data for 2009 are compiled for the whole growing season for each site (see Figure 9). The 2009 data for North Gully Cove and for Cottonwood gully were statistically lower than that of any other year in North Gully except 2007 ($p < 0.05$, Kruskall-Wallis One Way Analysis of Variance on Ranks; Dunn's Method Pairwise Comparisons)