Population Studies of Eurasian Watermilfoil (*Myriophyllum spicatum*) and Zebra Mussels (*Dreissena polymorpha*) in Conesus Lake, N.Y. (Summer 2000)

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EXECUTIVE SUMMARY

1. We studied the distribution and density of macrophyte beds dominated by Eurasian watermilfoil and of populations of zebra mussels in Conesus Lake to better understand the impact of these species on the lake ecosystem and to provide a scientific foundation for possible management strategies. Two sites, sampled by Herman Forest since 1967 and by our group in 1999, were revisited and sampled in 2000 to provide a comparable data base for evaluating long-term trends in macrophyte biomass.
2. Twelve dense macrophyte beds consisting of more than 95% Eurasian watermilfoil were found in shallow coves and off points in the north basin and in the upper south basin. Owing to more narrow slopes and greater depths, the far southern areas of the lake were relatively free of milfoil beds.
3. The largest watermilfoil bed, located off Sand Point in the north end, covered an area of 0.34 km^2 (the equivalent of 84 acres) and contained an estimated biomass of 87 thousand kg dry weight. Average bed size was 0.05 km^2 or approximately 12.4 acres.
4. Without exception, watermilfoil beds were located in the proximity of streams and drainage pipes, including several which have been shown to deliver high loads of nutrients from the watershed into the lake. We suggest that these sources have caused significant local enrichment of macrophyte growth and therefore warrant special attention in any management considerations.
5. At the long term study sites near Wilkins Creek and Sand Point, macrophyte biomass was relatively low compared to 1999 and 9 other years. In contrast, blooms of filamentous green algae in Conesus Lake reached nuisance levels, particularly near streams and runoff pipes. The

balance between macrophyte growth and filamentous algal growth near streams and runoff pipes could be a fruitful area for future investigations.

6. Surveys in seven widely distributed locations revealed that adult zebra mussels were abundant in nearly every available substrate from the shoreline to a depth of about 10 m.
7. Population densities at a depth of 8 m ranged from an average low of 12,139 individuals per m^2 off Eagle Point to an average high of 50,133 individuals per m^2 off Grayshores. These densities are slightly higher than those reported for established populations in 32 European lakes, but moderate in comparison to reports of maximum numbers reaching 250 thousand individuals per m^2 in newly invaded North American lakes.
8. Continued monitoring is necessary to better understand the population dynamics of zebra mussels in Conesus Lake.

TABLE LEGENDS

FIGURE LEGENDS

INTRODUCTION

The transport of species across natural barriers by human activities (i.e. shipping, agriculture, fishery stocking) poses a great threat to the uniqueness of native biological communities and to the integrity of ecosystem processes. In the United States alone, according to Mills and his colleagues (1993), at least 4500 nonindigenous species have established free living populations, and approximately 15% of these have caused severe harm to agriculture, human health and the environment. Recognizing the potential threat to native ecosystems, Carlton and Geller (1993) referred to the problem of species introductions as "ecological roulette".

The Great Lakes have been subject to nonindigenous species invasions since the arrival of Europeans, and their history offers one of the most profound examples of the ecological impact of species introductions (Mills et al. 1993). Since the 1800's, 139 aquatic organisms have become established in the Great Lakes watershed, and of these nearly one third have arrived in the last 30 years. Some of the more notorious invaders that have significantly altered the ecosystem include animals such as the sea lamprey, the alewife, the Asiatic clam, and more recently the zebra and quagga mussels, the spiny waterflea and the fishhook waterflea; and plants such as the purple loosestrife, the waterchestnut and the Eurasian watermilfoil (Mills et al. 1993).

As with the Great Lakes, the character of our own Conesus Lake has been altered significantly by the establishment of nonindigenous species. The alewife (*Alosa pseudoharengus)*, Eurasian watermilfoil (*Myriophyllum spicatum*) and zebra mussels (*Dreissena polymorpha)* are three nonindigenous species which have become dominant in Conesus Lake. The impact of the alewife on the lake ecosystem and on lake water quality has been documented by Makarewicz and his students (Makarewicz, 1986; Puckett, 1989; Makarewicz, 2000). The extent to which watermilfoil and zebra mussel populations have expanded in the lake and their potential impact on the ecosystem have not been studied.

The primary goal of our research during the summer 2000 was to examine the distribution and density Eurasian watermilfoil beds and of populations of zebra mussels in Conesus Lake. The results of this study improve our knowledge of these populations and contribute to the scientific foundation required for consideration of possible management strategies. A secondary goal of this project was to extend our long term database on macrophyte growth at two sites first studied by Herman Forest and his colleagues in 1967.

Background on Zebra Mussels and Watermilfoil

Zebra mussel (*Dreissena polymorpha*) larvae were first identified in Conesus lake during the summer of 1992, approximately 6 years after they had been accidentally brought from Eurasia to the Great Lakes watershed in the ballast water of a transatlantic cargo ship. By the fall of 1994 large populations of zebra mussels occupied the whole south basin of Conesus Lake. From there they spread with the prevailing currents northward into the north basin and by the fall of 1998 occupied every suitable benthic habitat.

To date there are no quantitative studies of adult zebra mussel populations in Conesus lake. Students from SUNY Geneseo documented the summer production of veliger larvae from 1995-97 and again in 1999 (Bosch, unpublished) and found that summer larval densities had declined from an average of 10,000 $\cdot m^{-3}$ in 1995 to less than 3,000 $\cdot m^{-3}$ in 1997 and 1999. Whether this decline in larval supply is indicative of changes in the adult population remains uncertain.

Evidence from studies in the Great Lakes and elsewhere indicate that zebra mussels have a profound impact on native ecosystems. Large populations clear the water of suspended material, alter the nutrient balance (e.g. carbon, phosphorus) between the water column and the benthic compartments of the ecosystem, and outcompete native species for food and space. The specific consequences of these changes are currently under investigation in other lakes. A well known indirect outcome of zebra mussel feeding is an increase in the amount of light penetrating the water and reaching the bottom of the lake. This trend has been correlated with the increased growth of attached algae and macrophytes in the nearshore environment (Skubinna et al. 1995).

The first verified record of Eurasian watermilfoil (*Myriophyllum spicatum*) in North America was from the Potomac River, Virginia in 1881. When and how this species spread from Virginia to its nearly ubiquitous present range was not well known until the work of C.F. Reed in 1977. Some of this uncertainty was the result of the strong morphological and ecological similarities between *M. spicatum* and the native North American watermilfoil, *M. exalbescens.* A debate over the taxonomy of the two forms persisted well into the 1970's. In time, Nichols (1975), Aiken and his colleagues (1979, 1980) and others were able to reliably distinguish the two forms as species on the basis of morphological and ecological criteria that were consistent in the field as well as in the laboratory under different growth conditions.

The first comprehensive study of the macrophyte community in Conesus Lake was by Muenschner (1927). According to Forest (1978), Muenschner judged several species to be "predominant" and included among these was *Myriophyllum*, which Muenschner identified as *M. exalbescens.* Forest (1971, 1978) recognized the uncertainty of the taxonomic distinction between the two types of watermilfoil and cautiously resisted making definitive species designations in any of his collections. Consequently the approximate time of arrival of the Eurasian species in Conesus Lake can not be ascertained.

Eurasian watermilfoil is a vigorous plant that favors eutrophic waters and by shading effectively excludes other species from its habitat. Its branches regularly reach the surface, covering as much as 80% of the surface in some lakes. Forest (1978) remarked that *Myriophyllum* in Conesus Lake" is important and at times greatest in bulk". This trend is reflected in Forest's unpublished quantitative data from the late 60's and 70's. Whether his records encompass one or both types of watermilfoil is of interest but of no great consequence to present concerns about the lake. Many of Forest's original research sites were surveyed by our group in 1999 (Bosch et al, 1999) and were found to be dominated by dense stands that were almost monocultures of Eurasian watermilfoil. The proliferation of this species is one of the greatest environmental problems in Conesus Lake today.

PROCEDURES AND MATERIALS

Our study was carried out between July and November 2000 in Conesus Lake, NY (Lat 42ß 47' N; Long 77ß 43' W). The main objectives of our work were to (1) map the distribution and surface area coverage of the principal watermilfoil beds in the lake; (2) determine the density and standing crops of plants within each bed; and (3) characterize the population size of adult zebra mussels in the lake. Collections of zebra mussels were made in late July. Mapping and quantitative collections in macrophyte beds were carried out from early to mid August. Qualitative observations of some of the beds were made in September and October.

Macrophyte Collections

A variety of sources including the herbarium collection at SUNY Geneseo were used to identify species (Hotchkiss, 1967, Prescott 1980). The field guide by Borman and colleagues (1998) proved to be the most useful for field identifications.

The principal beds that extended to the water's surface were identified initially by visually surveying the perimeter of the lake. Subsequently a Trimble Model TSC1 global positioning system (Trimble Navigation Ltd.) was used to map the beds. The surface area of each bed was delineated by having a swimmer in snorkeling gear track its perimeter visually while an operator on board a trailing boat recorded georeferenced positions with the GPS (latitudelongitude or UTM points) every few seconds on a continuos track. Since our interest was primarily on the distribution of watermilfoil, the swimmer essentially followed the margin of the watermilfoil growth. The outer margin of watermilfoil beds were abrupt and well defined, typically at a depth 3-3.5 m. The inner margins were less defined and often difficult to track. Accordingly, we defined our inner boundary as the position where watermilfoil represented about 50% of the total plant number. While this procedure introduced a margin of error in our estimates of bed surface area and standing crop, we believe the error to be relatively small due to the small size of watermilfoil plants and the low biomass in the shallows.

ArcView software (Esri Inc.) was used to superimpose the graphical data on a high-resolution topographic map of Conesus Lake and the surrounding watershed and to estimate the surface area of each bed.

Th procedures followed for quadrat sampling are described in a previous report (Bosch et al., 1999). Briefly, 3 or 4 replicate quadrats were taken by S.C.U.B.A. divers at depths ranging from 2 - 3.5 m within each bed (Fig. 1). The quadrat was a PVC square with sides of 0.5 m which were held together by PVC elbows. Within a few hours of collection the samples were processed in our laboratory. Hundreds of zebra mussels had to be removed manually from each plant before they could be weighed. Bulk plant samples were blotted dry, sorted by species and weighed to the nearest 0.1 g. To be consistent with the procedures used by Forest and colleagues in previous studies we converted blotted wet weights to dry weights using an average wet weight to dry weight conversion of 0.10 (Forest et al. 1971; 1978). Our own estimates of blotted wet weight to dry weight conversions for watermilfoil are approximately 12%.

Zebra Mussel Collections

Adult zebra mussels were collected at seven representative locations distributed throughout the lake (Figure 1). Replicate quadrat samples (3-4) were taken by divers using a PVC square with a total sample surface area of 0.125 m^2 (0.25 m per side). Mussels were collected by hand and loaded into a 1 L wide-mouth jar that was covered on one side with 1mm plastic mesh. Individuals were separated from empty shells in the laboratory and counted. For each quadrat, a representative subsample of more than 100 individuals was weighed to obtain an average weight per animal. The remainder of the bulk sample was weighed and the total number of individuals in a quadrat was estimated by dividing the bulk sample weight by the average weight per individual. The height and length of 100-200 animals from each sampling site were measured under a stereomicroscope to the nearest mm.

Our first collections were made off Grayshores, which proved to be an excellent location from a standpoint of safety and accessibility. At the Grayshores site multiple samples were taken from 2, 4 and 8 m depth, in part to determine the optimal depth for the remaining collections. The 2 m collection depth fell within the marginal band of milfoil. Milfoil plants seem to be a preferred substrate for thousands of very small zebra mussels which were not considered in our bottom sampling scheme. Plants were sparse or absent at the 4 m sites but a steep slope at these depths tended to make sampling more difficult. At depths of about 8 m, zebra mussels of all sizes formed a dense carpet over the gradually sloping bottom. Below 10 m the populations were always sparse or absent. Taking these patterns into consideration it was decided to base our survey on populations in the 8 m depth range.

RESULTS AND DISCUSSION

Distribution and Standing Crops of Eurasian Watermilfoil

The survey of macrophyte bed distribution using global positioning systems (GPS) provided some valuable insights into the environmental factors that foster plant growth. We emphasize that the beds mapped in this study were ones dominated by Eurasian watermifoil. Milfoil beds are visible from the surface, sometimes at a distance of more than one hundred meters. They form a very dense growth with thick tangles of branches near the surface and consequently pose considerable hindrance to recreational use of the lake. Several other macrophyte species form expansive beds in Conesus Lake (ex. eelgrass), but these plants rarely grow to the surface and their impact on public aesthetic perception and recreational use of the lake is limited.

The distribution of the Eurasian milfoil beds in the lake is shown in **Figure 2A-D**. Starting from the north end the beds were distributed as follows: as shown in **Figure 2A**, a bed south of Sand Point over a broad shallow shelf southeast nearly to Wilkins Creek and southwest past Pebble Beach cove; one from Graywood to Gray Center continuing south past "Gray Gully"; as shown in **Figure 2B**, a large bed extending from Eagle Point well into Sacketts Harbor to the south; one off Sand Point north of Sand Point Gully; off Long Point and into Long Point Cove; on the east shore, off Orchard Point extending into north and central McPhersons Cove; and off McPhersons Point extending south to the state boat launch; as shown in **Figure 2C** a small bed south of Harston Point near an unnamed rivulet; across to the west two small beds located near large runoff pipes; a small narrow bed off Booher Hill; and a larger, discrete bed north of Cottonwood Gully; as shown in **Figure 2D**, a small bed off North Sutton Point. There was very little milfoil in the large bed that covers most of the south end of the lake, near the inlet.

Without exception the watermilfoil beds described in this study were associated with a stream or large drainage pipes . A good example is the bed near Sand Point (west shore, **Figure 2B**). This dense, well defined bed grows in a shallow shelf immediately to the north of Sand Point Gully , where it would be bathed directly by runoff from the stream under the prevailing southwesterly winds. As is true of many of the major streams and rivulets in the lake, Sand Point Gully, is known to contribute significant loading of sediment and nutrients to the lake (Makarerwicz et al. 1991; Makarewicz in preparation). In addition to the direct fertilizing effect of stream runoff, a wide shallow shelf and a southern exposure are factors that possibly contribute to the distribution pattern of milfoil beds in Conesus Lake.

The biomass of macrophytes in the large beds dominated by Eurasian watermilfoil ranged from a high of 389 $g \cdot m^{-2}$ off Booher Hill to a low of 92 $g \cdot m^{-2}$ in McPhersons Cove (**Table 2**) . Typically, these samples consisted of more than >95% watermilfoil by weight. Overall, the biomass densities for the summer 2000 in the milfoil beds were 29-66 % lower than values recorded in 1999 for some of the same sites.

We used the average August biomass obtained from our quadrat samples and multiplied them by the calculated surface areas of the respective beds to generate estimates of watermilfoil standing crops (**Table 3**). The largest standing crop, representing more than 87 thousand kg dry weight was in the north end bed. Standing crops in the other beds ranged from a low of 345 kg dry wt. for a small bed near Harston Point (So. Gully) to a high of 10,298 kg in Eagle Point/Sacketts Harbor bed.

Interannual Patterns of Macrophyte Density

In addition to quadrat collections taken within the beds dominated by Eurasian watermilfoil, quadrat samples were collected at various depths along two transects, one just north of Wilkins Creek and one south of Sand Point. These transects correspond to the approximate locations sampled by Herman Forest and his colleagues over the years (Forest et al. 1971; Forest et al. 1978; Makarewicz et al 1991; Forest unpublished data) and by our group in 1999 (Bosch et al. 2000). As in our previous studies the collections were made during a time which we estimated to be the height of the growing season for Conesus Lake. Because there are no previous estimates of the size of the macrophyte beds it is not possible to determine how surface area and total biomass have changed over the years. Our analysis of long term trends is based on the average macrophyte biomass observed in a square meter of water surface at selected sites within a macrophytes bed.

In the Wilkins Creek site collections were made at depths of 1.5, 3 and 4 m. The highest average biomass along the transect was 419 $g \cdot m^{-2}$ at depths of 1-1.5 m. Eelgrass was the dominant species at these depths. At a depth of 4 m coontail (*Ceratophyllum demersum*) was the dominant species and the biomass was relatively low (95 $g \cdot m^{-2}$). Eurasian watermilfoil was present in the 3-4 m depth range, but the Wilkins Creek sampling site was one of the few in which the native species are dominant at these depths. Collections made at a depth of 1.5 m directly south of Sand Point also yielded a high biomass (513 $g \cdot m^{-2}$) and eelgrass was once again the dominant. At depths of 3 m and below, the Sand Point transect was dominated by Eurasian watermilfoil, but the average biomass was relatively low (94 $g \cdot m^{-2}$).

The average macrophyte biomass per square meter in the summer 2000 was generally low to moderate compared to 1999 and previous years (**Table 4-5, Figs 3-4**). Differences between the last two years are particularly interesting and warrant further consideration. As we discussed in the previous section, typical biomass in the Eurasian milfoil beds in August 2000 was 24-66% lower than in August 1999. At our Wilkins Creek study site, which is more representative of the native flora, the biomass in the eelgrass dominated shallows (1-2 m) was similar in the two years (**Table 4**). However at a depth of 3 m the average biomass was nearly 3 times higher in 1999; and at 4 m the biomass was nearly 5 times higher. A similar contrast between the two years is evident in the Sand Point data **(Table 5).**

The growth of aquatic plants can be influenced by a number of physical and chemical forces which include light, water transparency, site exposure, hydrostatic pressure and nutrient availability (Aiken and Piccard 1980; Middleboe and Markager 1997; Hudon et al. 2000). There is no direct evidence that indicates which of these factors, if any, can account for the lower macrophyte biomass in Conesus Lake during the summer 2000. One plausible explanation is that growth might have been light-limited during the cloudy and rainy summer. This hypothesis is consistent with the observations that growth of eelgrass and of filamentous algae was extensive in the shallows of the lake (unpublished data) while at greater depths macrophyte biomass was relatively low.

Abundance and Population Structure of Zebra Mussels

Zebra mussels were abundant from nearshore to a depth of approximately 10 m at all 7 sites sampled quantitatively. According to our qualitative observations over the last two years, they are present throughout the lake above a depth of 10 m, which is approximately the upper layer of the hypolimnion during the period of stratification in the Conesus Lake. The numerical density of mussels and their corresponding mass per unit area for our 7 sampling sites are shown in **Table 6** and **Figure 5.** At our Grayshores station, the number of adults at 2 m was relatively low. These samples were collected from the bottom within a stand of watermilfoil. Large numbers of smaller zebra mussels also lived along the stem of milfoil plants, but these populations were not accounted for in our quadrat sampling protocol. The 4 m and 8 m samples yielded much higher densities of adult mussels, averaging 45 thousand and 50 thousand individuals· m^{-2}, respectively. These were among the highest values found at any of our collection sites. A similar pattern of distribution has been noted by researchers in European lakes (Stanczykowka, 1977).

The biomass (kg· m^{-2}) recorded for the 4 m depth in the Grayshores site was considerably lower than the biomass at 8 m . We can attribute this difference to the uniformly smaller mussels inhabiting the shallower site (data not shown). Why such differences exist between proximate sites remains a mystery. Similar contrasts could be made among several of our other sampling sites on the basis of the length distributions of the subpopulations (**Figure 6**). In our Sutton Point and McPherson Point sites, for example, the average zebra mussel length was approximately 0.9 cm. In Eagle Point and Grayshores the average length was between 1.3 and 1.5 cm, or 30-40% higher.

Adult zebra mussel densities as high as 250 thousand individuals· m^{-2} have been found in Lake Ontario and other North American lakes, but numbers more established populations seem to be consistently lower. Stanczykowka (1977) compiled information for 32 European lakes where the species has more established populations and reported average densities of 100 -14,000 individuals· m^{-2}.

With only one year's study of adult densities, the dynamics of the Conesus Lake populations cannot be determined. Our unpublished studies of zebra mussel veliger densities show that larval numbers averaged for the summer were approximately 10,000 per cubic meter (· m^{-3}), a relatively low density. Larval numbers were lower in '96 and continued to decline to less than 3,000 · m^{-3} in '97, and '99. These trends in larval numbers suggest that recruitment may be on the decline, but only continued monitoring of adult populations can provide unequivocal evidence of the fate of the zebra mussel in Conesus Lake.

SUMMARY AND CONCLUSIONS

Macrophyte Studies

1. Submersed macrophytes form a dense band along the perimeter of Conesus Lake, extending from a nearshore depth of about 0.5 m to a relatively shallow maximum depth of 4 m. As in our 1999 survey, the dominant species during the summer 2000 were eelgrass and water stargrass at depths of 0.5-2 m and the Eurasian milfoil at depths of 2-3.5 m; coontail and curly-leaf pondweed were sometimes well represented at depths of 3.5 m and below. The species diversity of macrophytes remains high along the shallow marginal zones of the lake, particularly between Sand Point and Wilkins Creek near the north end, and between the inlet and South McMillan Creek near the south end..

2. The perimeter band of macrophytes is punctuated by a series of expansive and very dense beds that are dominated in coverage and biomass by Eurasian watermilfoil. These beds are particularly common along shallow coves and off points in the north basin and in the upper south basin of the lake. Owing to its narrower slopes and greater depths, the far southern areas of the lake are relatively free of milfoil beds.

3. The distribution of the macrophyte beds and surface area of each bed were determined with a global positioning system which uses satellites and land based transmitters to determine geographic position to a precision of less than one meter. The largest watermilfoil bed, located off Sand Point in the north end of the lake, covered an area of 0.34 km^2 (about 84 acres). Expansive watermilfoil beds were also found on a number of other coves and points throughout the lake.

4. These watermilfoil beds were invariably located very near streams or large runoff pipes. A broad, shallow shelf and some degree of southern exposure seemed to be also necessary for the sustenance of these beds.

5. The average milfoil biomass was low compared to 1999. At our long term study sites near Wilkins Creek and off Sand Point, biomass levels were also low to moderate compared to 9 other years from 1968-1999. However, the standing crops calculated from biomass and area measurements reveal that the lake continues to harbor vast amounts of macrophytes, particularly in the form of Eurasian milfoil beds.

6. The relatively low macrophyte densities in 2000 may be attributable to low light levels during the rainy summer. In contrast, filamentous green algae growing in or on the canopy of milfoil beds and along the shallow shoreline reached nuisance levels, particularly near streams and other sources of runoff. The balance between macrophyte growth and filamentous algal growth near streams could be a fruitful area for future investigations.

7. Streams and other sources of runoff seem to have a fertilizing effect on macrophyte communities, creating conditions that favor the proliferation of Eurasian Watermilfoil and filamentous algae. Significant reduction of nutrient runoff from these sources could mitigate excessive growth on a local scale. Mitigation of the lake-wide problem of excessive macrophyte growth will require more comprehensive and protracted measures.

Zebra Mussel Studies

1. Surveys by S.C.U.B.A. divers in seven widely distributed locations revealed that adult zebra mussels were abundant in nearly every available substrate from the shoreline to a depth of about 10 m.

2. Population densities at a depth of 8 m ranged from an average low of 12,139 individuals per m^2 off Eagle Point to an average high of 50,133 individuals m^{-2} at a site off Grayshores road .

3. Eurasian watermilfoil plants provide a suitable substrate for large numbers of smaller zebra mussels, but a quantitative analysis of this habitat was beyond the scope of our study.

4. The numerical abundance of adult mussels in Conesus Lake was slightly higher than values reported for 32 European Lakes, but lower than in many newly colonized lakes in North America. Whether Conesus Lake populations are stable, increasing or on the decline cannot be ascertained from a single year's data. Research on adult and larval population dynamics should be continued under the auspices of the monitoring program.

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Metric Units	English Unit Equivalent
meter (m)	*3.28 feet*
centimeter(cm)	*0.4 inches*
millimeter(mm)	*0.04 inches*
Square meter (m^2)	*0.093 square ft*
gram(g)	*0.35 ounces;0 .0022 lbs*
Kg per square meter ($kg.m^{-2}$)	*0.205 lb per square ft*
milliliter (ml)	*0.034 fluid ounces*
Liter (L)	*34 fluid ounces*

Table 1. English equivalent of metric units used in this report**.**

Location	Depth (m)	# of Quadrats	Mean Dry Wt. (g/square meter)	Standard Deviation
McPherson Cove	3	3	92	13
Orchard Point	3	3	147	53
Eagle Point	3	4	170	61
Sand Point West	3	3	212	29
McPherson Point	3	3	262	134
Long Point	3	3	252	35
Booher Hill	3	3	389	61
Cottonwood	3	3	193	85
McMillan	3	3	132	33
North Sutton Point	3	3	184	43
Sand Point North	1.5	3	513	12
Sand Point North	3	3	94	44
Wilkins Creek	1.5	3	419	133
Wilkins Creek	3	4	133	30
Wilkins Creek	4	3	95	6

Table 2. Macrophyte biomass at selected beds in Conesus Lake. Collections were made from Aug. 3-10, 2000. All but the Wilkins Creek samples and the 1.5m Sand Point sample represent areas dominated by Eurasian watermilfoil.

Macrophyte Bed Location	Area (m^2)	Biomass /Area (kg. m^{-2})	Total Biomass (kg dry wt)
North End	337,547	0.259	87,425
Eagle Pt./Sacketts Harbor	60,574	0.17	10,298
Old Orchard Point	54,294	0.147	7,981
Long Point Cove 1	37,080	0.252	9,344
"Gray Gully"	23,351	0.238	5,557
McPhersons Point	23,192	0.267	6,192
Cottonwood Gully	15,070	0.193	2,909
Sand Point Gully	9,535	0.212	2,021
Long Point Cove 2	4,852	0.252	1,223
Booher Hill	4,673	0.389	1,818
Harston Point	3,746	0.092	345
North Sutton Point	2,756	0.184	507

Table 3. Macrophyte biomass at selected beds in Conesus Lake. Collections were made from Aug. 3-10, 2000. All but the Wilkins Creek samples and the 1.5 m Sand Point samples represent areas dominated by Eurasian watermilfoil.

Year of Collection	Depth (m)	# of Quadrats	Mean Dry Wt. (g/sq.meter)	Standard Deviation
Summer 1968	0.5	1	562	
	2	1	499	
	2.5	1	332	
	5	1	1410	
September 14, 1969	1	9	513	191
	2.5-3.5	6	1816	
	3	3	973	362
	5.5	1	463	
August 26, 1970	1	5	431	
	2	5	499	
	3	5	1407	
September 20, 1970	1	5	551	225
	1.75	2	2054	205
July 25,1975	2	1	885	
	3.5	1	568	
July 7, 1978	1	3	91	
	2	3	372	
August 15, 1978	0.5	3	256	
	2	4	391	62
September 28, 1978	2	3	482	
October 27, 1978	2	3	244	303
August 31, 1979	3	3	170	
July 22, 1984	3	1	417	
August 28, 1984	Average	1	318	
August 20, 1985	1	1	120	
	2	1	350	
	3	1	525	
	4	1	1400	
August 8, 1999	1	3	490	0
	2	3	687	267
	3	3	390	275
	4	3	493	39
August 10, 2000	1.5	3	419.23	132
	3	4	133.47	30
	4	3	95.05	6

Table 4. Historical record of standing crops at various depths in the Wilkins Creek site. Data from 1999 and 2000 are from Bosch et. al. 1999, and this study. Previous data are from work by Herman Forest and his colleagues and were extracted from various published and unpublished sources.

Date	Depth (m)	# of Quadrats	Mean Dry Wt. (g/sq.meter)	Standard Deviation
Summer 1968	0.5	1	82	
	1	1	235	
	2	1	256	
	3.5	1	1470	
	5.5	1	214	
	7	1	562	
August 14, 1969	3	6	908	
	5.5	3	454	
August 25, 1975	2.0-3.0	4	521	47
July 7, 1978	2	5	183	
July 13, 1978	2.5	3	184	
	3-3.5	3	88	
August 15, 1978	3	3	101	
	4	6	71	50
September 28, 1978	2	3	1033	
	3	6	289	117
	4	6	160	0
October 27, 1978	2.5	3	782	
July 31, 1979	2.5	4	296	
	2	4	301	
July 7, 1984	2.5	1	687	
	3	1	473	
	3.5	1	478	
August 20, 1985	1	1	120	
	2	1	350	
	3	1	350-700	
	4	1	1400	
August 7, 1999	2	3	690	174
	3	3	827	296
	4	3	395	191
August 10, 2000	1.5	3	513	30
	3	3	153	23

Table 5. Historical record of macrophyte standing crops at Sand Point. Although less comprehensive than the Wilkins Creek record, the 2000 values appear to be low to moderate compared to 1999 and other years. Sources of the data as in Table 4.

Location	Depth (m)	Number of Quadrats	Thousands per sq. meter	Standard Deviation
Grayshores	2	3	4.565	2.029
Grayshores	4	3	44.875	10.016
Grayshores	8	3	50.133	19.119
Eagle Point	7	3	12.139	0.800
McPhersons Pt.	7	3	26.843	14.199
Sand Pt. West	8	4	23.288	3.802
S. McMillan Cove	8	3	38.123	8.796
Booher Hill	8	3	29.168	1.760
North Sutton Pt.	7	3	21.056	2.392

Table 6. Numerical density of zebra mussels in thousands per square meter at our seven sampling locations. At the Grayshores site, replicate samples were taken at 2, 4, and 8 m.

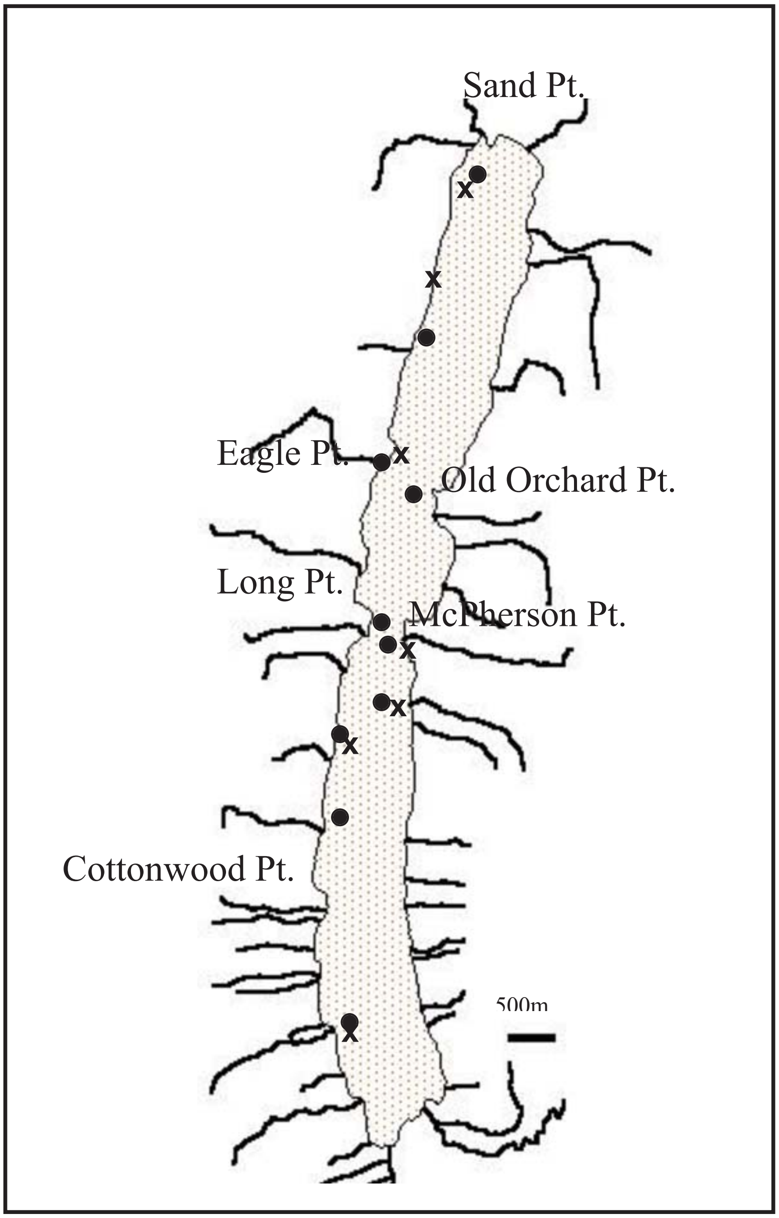

Figure 1. Locations in Conesus Lake where quantitative surveys were carried out. X zebra mussels populations
● macrophyte surveys

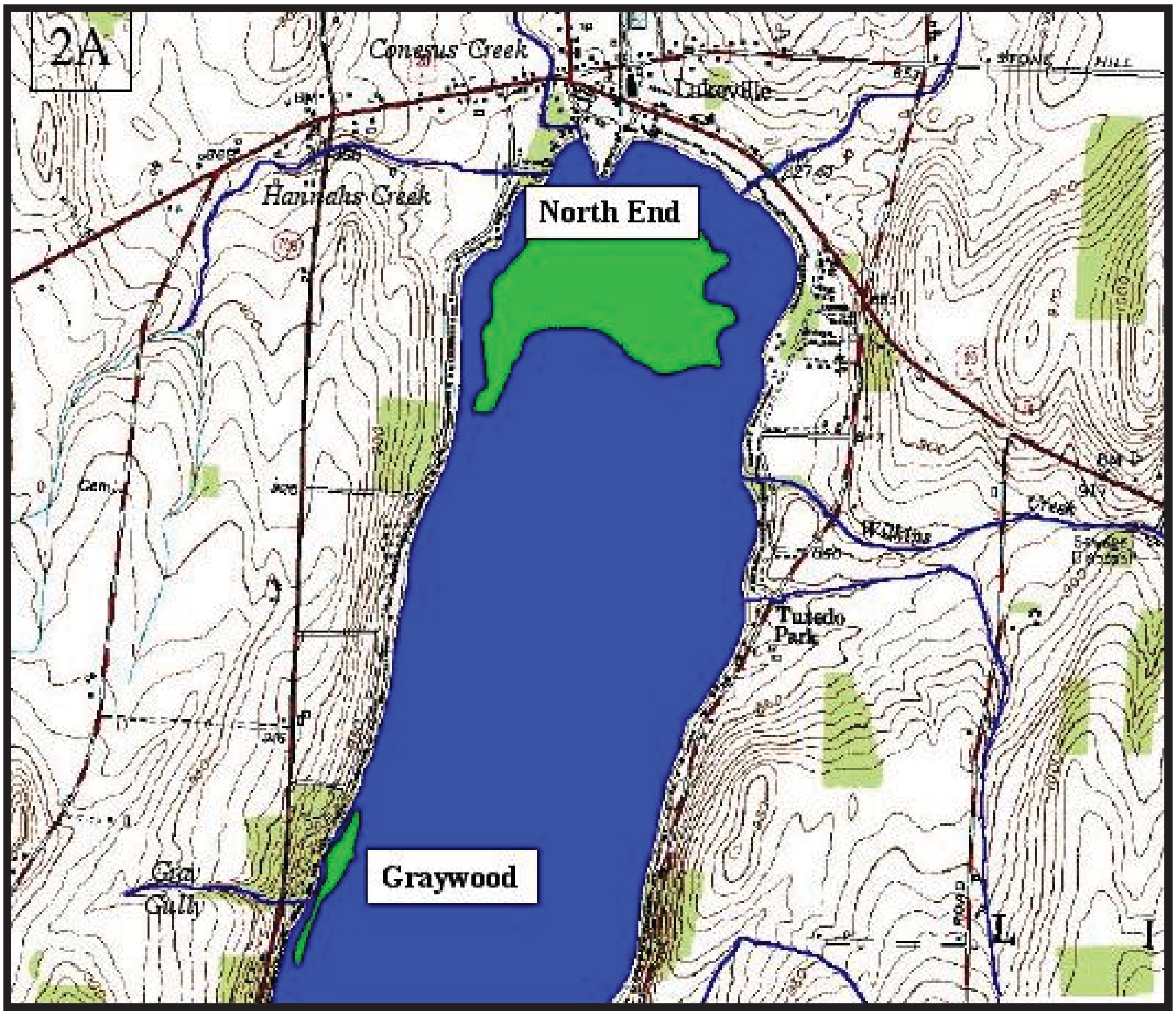

Figure 2A. Location of the watermilfoil beds in Conesus Lake. The coordinates for the outer margin of each bed were mapped as a continous track using a Trimble model TSC1 GPS. Shown in 2A are the beds in the Northern portion of the lake.

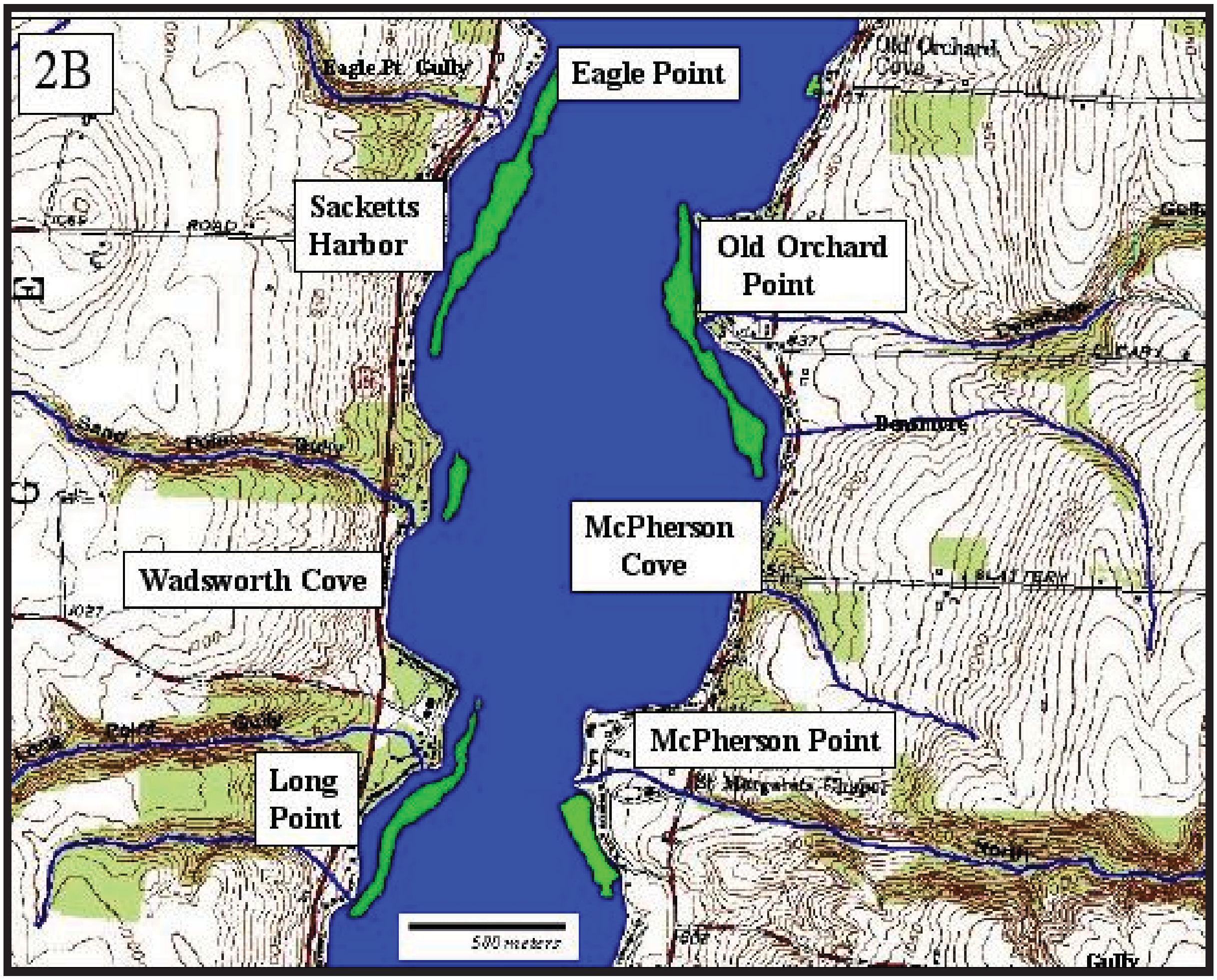

Figure 2B. Watermilfoil beds in the central portion of Conesus Lake, including parts of the North basin and parts of the South basin.

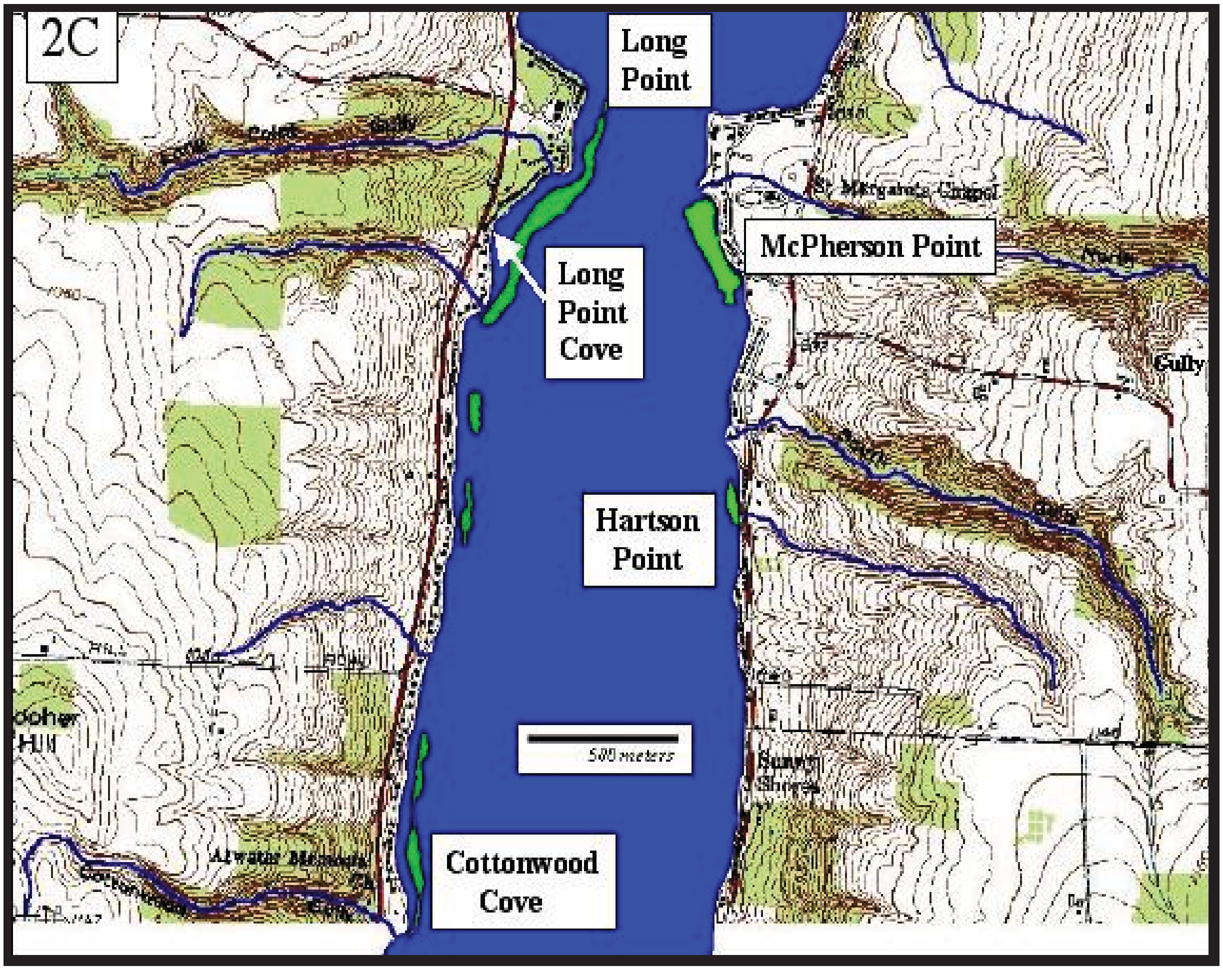

Figure 2C. Larger scale view of the south basin showing the watermilfoil beds down to Cottonwood Gully along the southwest shore.

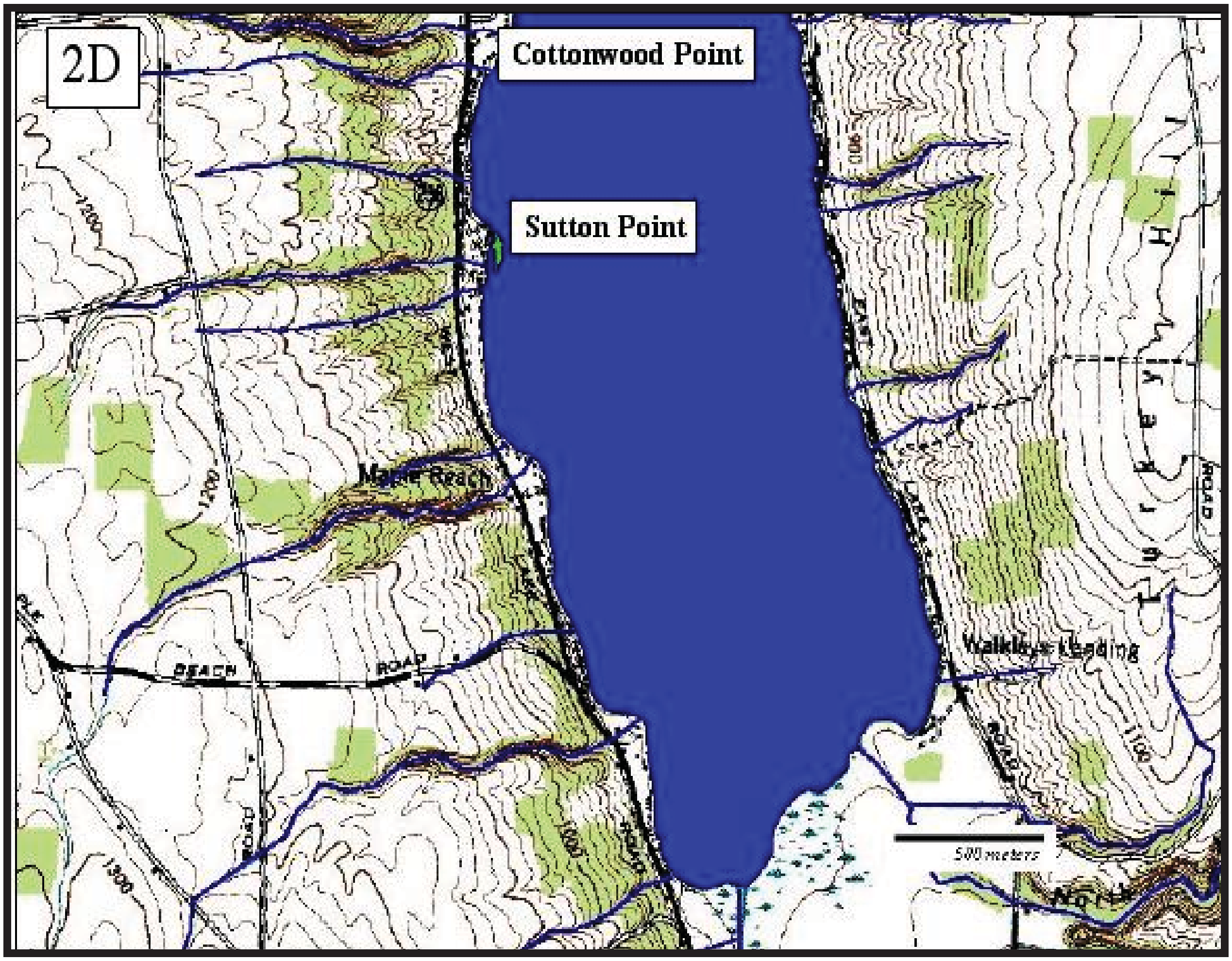

Figure 2D. The South end of the lake showing a small bed off North Sutton Point. Greater depths and narrower slopes limit the growth of watermilfoil in this region. The large macrophyte bed between the Inlet Stream and North McMillan Creek was dominated by eelgrass and other native species.

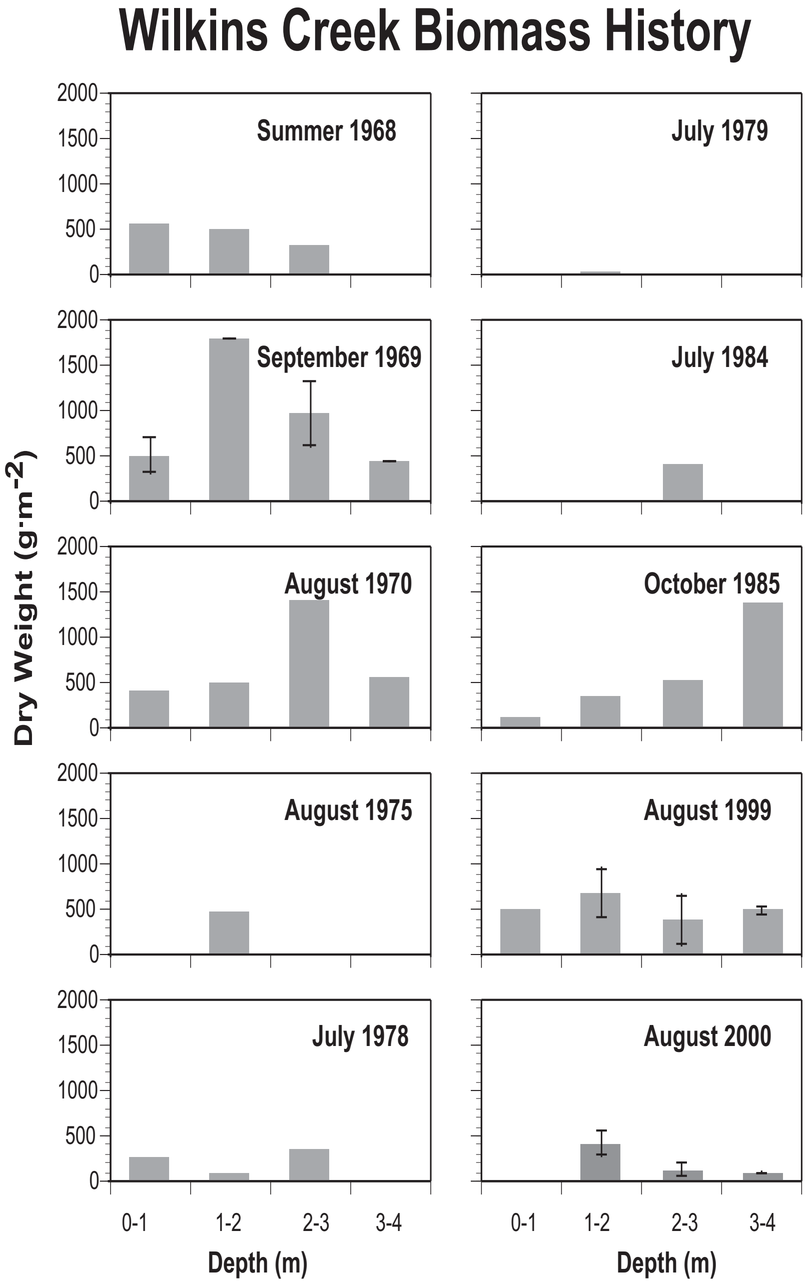

Figure 3. Historical record of macrophyte biomass at Wilkins Creek. The 2000 values were moderate to low compared to 9 other years, and much lower than values obtained during our 1999 study. See Table 4 for numerical data.

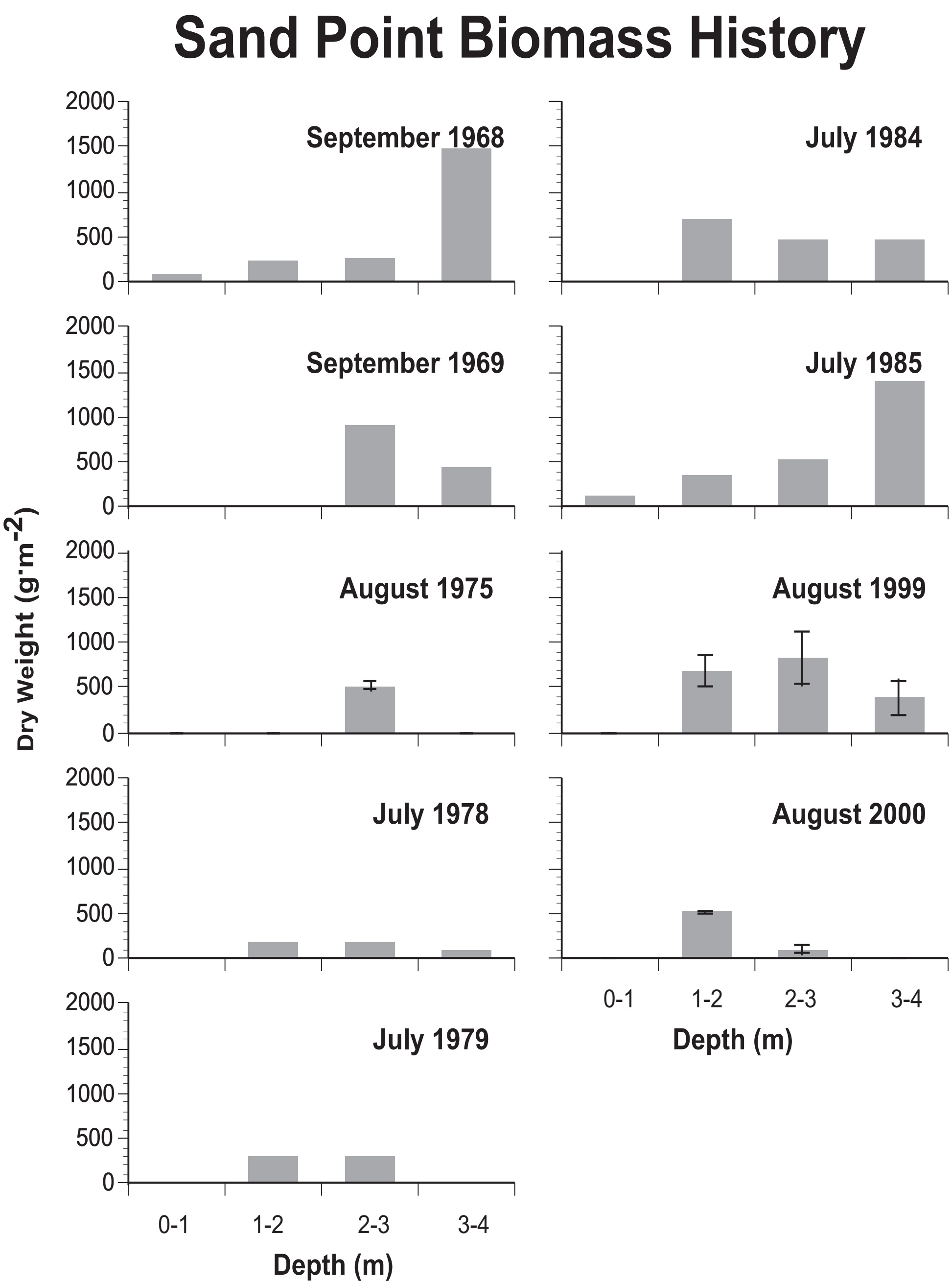

Figure 4. Historical record of macrophyte standing crops at Sand Point. Although less comprehensive than the Wilkins Creek record, the 2000 values appear to be low to moderate compared to 1999 and other years. See Table 5 for numerical data.

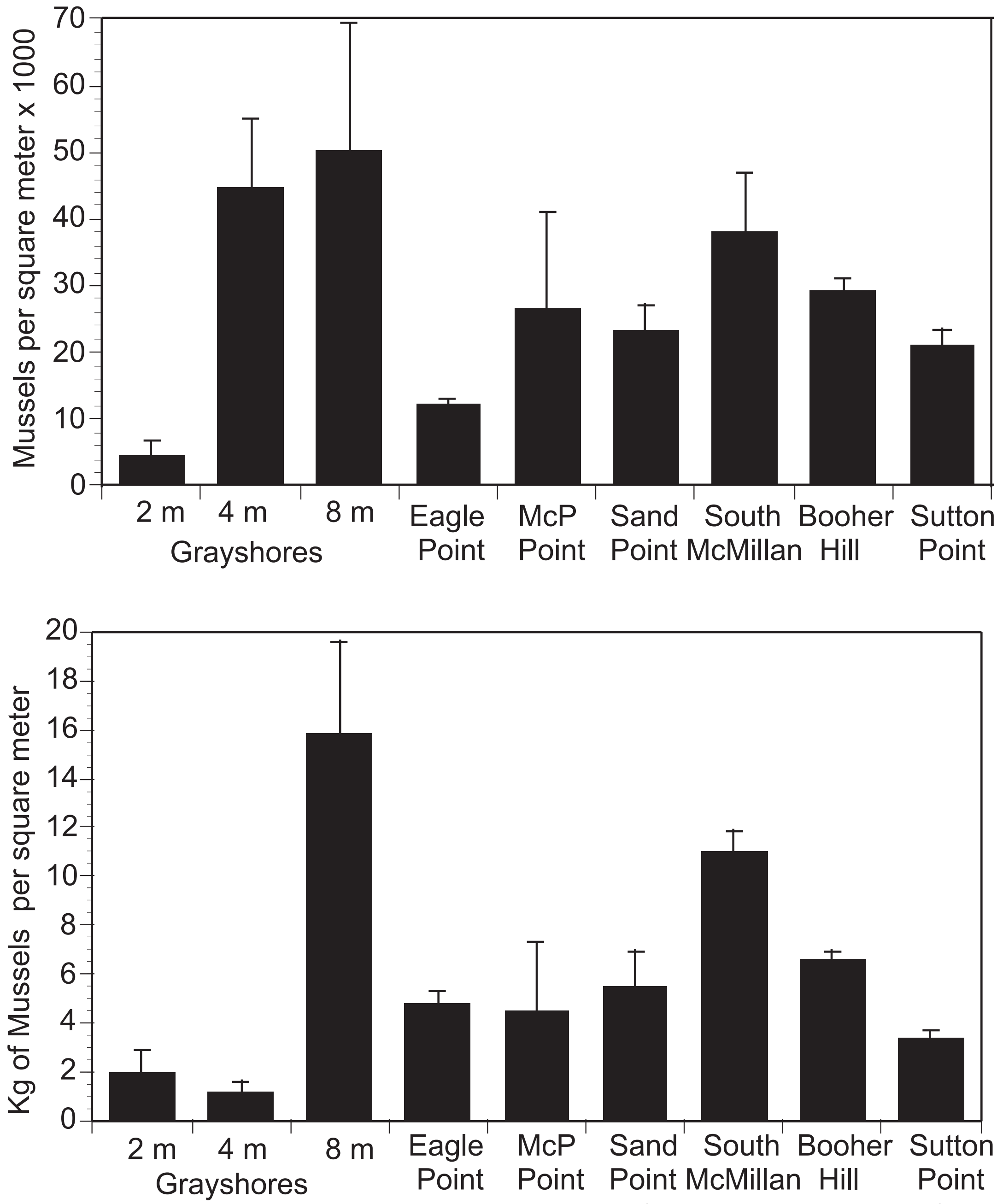

Figure 5. Numerical abundance (individuals · m^{-2})and biomass (kg· m^{-2}) of adult zebra mussels at selected locations. Three depths were sampled off Grayshores road. At all other sites, samples were taken only from a depth of about 8 m.

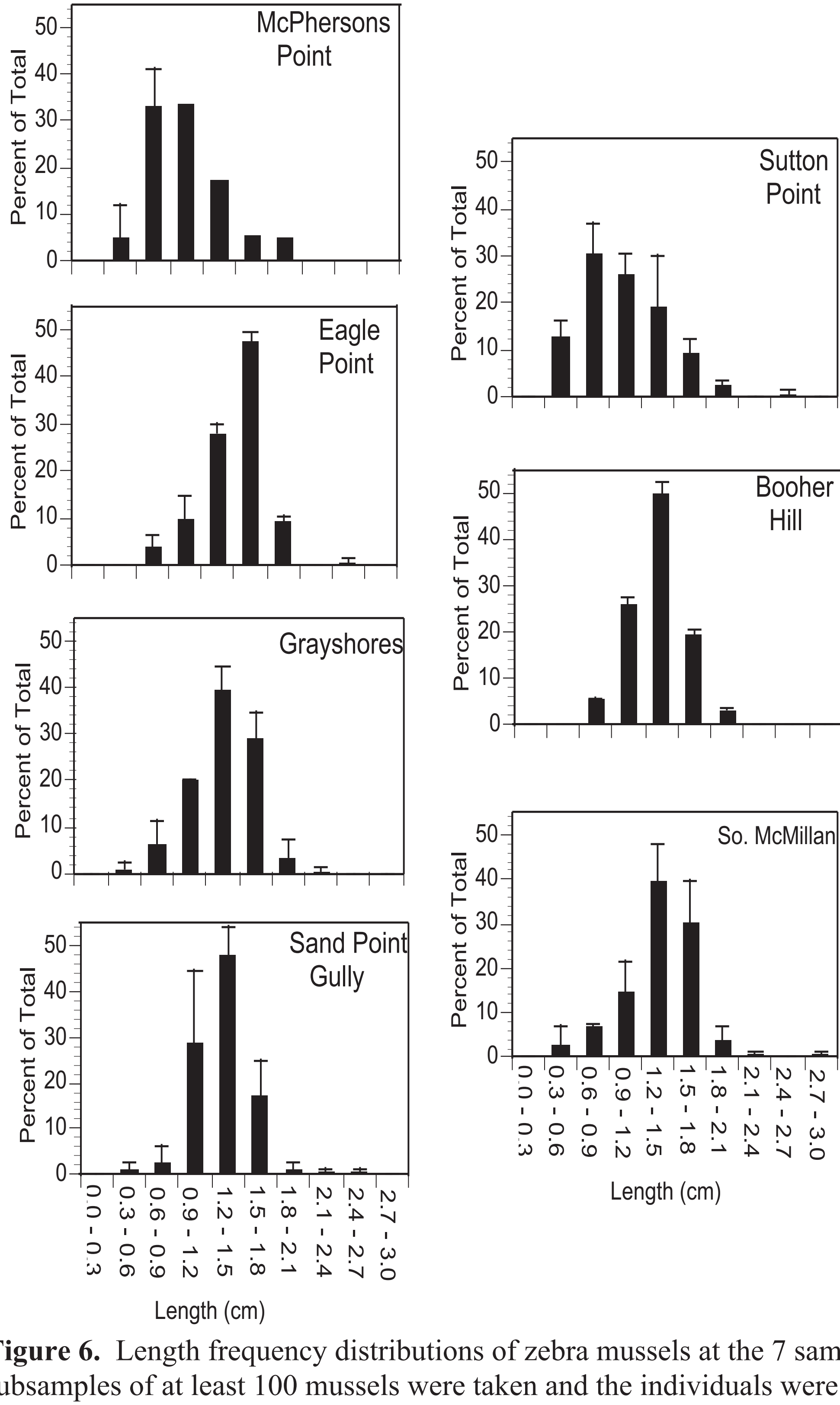

Figure 6. Length frequency distributions of zebra mussels at the 7 sampling sites. Subsamples of at least 100 mussels were taken and the individuals were measured to the nearest mm. Two replicate quadrats were analyzed for each site.