

BFS Technical Report # 26
AQUATIC MACROPHYTE
MANAGEMENT PLAN FACILITATION
LAKE MORaine, MADISON COUNTY, NY
2008

- 1. MACROPHYTE BIOMASS MONITORING**
- 2. MONITORING EFFECTS OF SELECTIVE HERBICIDE SONAR[®]**
- 3. COMPARING DRY WEIGHT BIOMASS EVALUATION WITH RAKE TOSS METHOD**
- 3. WATER QUALITY ANALYSIS**

WILLARD N. HARMAN
MATTHEW F. ALBRIGHT
LISA ZACH

SUNY ONEONTA
BIOLOGICAL FIELD STATION
5838 ST HWY 80
COOPERSTOWN, NY 13326

BACKGROUND (Harman et al. 1997)

Moraine Lake (42°50' 47'' N, 75°31'39''W) is located in Madison County, NY. It was formed by deposited glacial moraine that dammed a valley and since then has been artificially raised. The lake has been divided into two basins due to a causeway and is connected by a submerged culvert. The north basin is 79 acres, with a mean depth of 1.1m, and a maximum depth of 3.7m. The south basin is used more for recreational purposes such as fishing, boating, and swimming. It consists of 182 acres, has a mean depth of 5.4m, and a maximum depth of 13.7m.

Moraine Lake is considered a meso-eutrophic lake due to low transparency, high algal and macrophytic plant growth, and depleting dissolved oxygen levels in the hypolimnion during summer stratification. With the increase of residential sprawl along the lakeside and agricultural methods nearby, the productivity of the lake has increased (Anon., 1991). Harman et al. (1998) indicated that increased nutrient loading might be due to faulty septic systems lining the lake. With the close proximity of residents, poor percolation rates, steep slopes, and other factors, the lake is susceptible to nutrient loading (Anon., 1991).

INTRODUCTION (Harman et al. 2007)

The aquatic macrophyte communities of Moraine Lake have been monitored by the SUNY Biological Field Station (BFS) since 1997. The purpose of monitoring these plant communities has specifically been directed towards controlling Eurasian water-milfoil (*Myriophyllum spicatum*). Other species of aquatic macrophytes are abundant in Moraine Lake, but Eurasian water-milfoil has disrupted the ecology of the lake since it was introduced prior to 1990 (Harman et al. 1997). *Myriophyllum spicatum* is an invasive species that grows rapidly and its extensive canopies cause problems for recreation and other species growth (Borman et al. 1999). Numerous methods of control have been applied to reduce the abundance of Eurasian water-milfoil (Harman et al. 2006). The goal in the past of managing the *Myriophyllum spicatum* is to achieve a balance of species (Lembi, 2000).

In response to understanding the abundance of Eurasian water-milfoil and numerous other aquatic macrophytes, two methods of obtaining macrophyte samples has been used. As in previous years, plant samples were collected monthly at 5 sites, separated by species, and dried, allowing for the calculation of mg/m² dry weight. This year, the Point Intercept Rake Toss Relative Abundance Method (PIRTRAM- rake toss) (Anonymous, 2005) was used as well. This streamlined method allows for intense sampling with minimal effort. By comparing the dry weight method and the Point Intercept Rake Toss Relative Abundance Method (PIRTRAM- rake toss) (Anonymous, 2005), it allowed for the BFS to assess which method might be more efficient in the collection of aquatic macrophytes at certain locations in each basin. With the comparison of the two methods, the abundance of different species would allow a better understanding of the distribution of aquatic macrophytes within designated areas of the lake and areas where method of control may be necessary for specific species.

MATERIALS AND METHODS

Sampling took place 3 June, 1 and 22 July, 5 August and 23 September. Five collection sites were sampled from, two in the north basin and three from the south basin (Figure 1). Prior to sampling, 25 plastic garbage bags were labeled with a corresponding number based on the five collection sites and a letter was placed on each bag indicating replication at every site. At each site, a weighted line was thrown randomly from the boat into the lake creating a transect where the five samples were taken. A diver swam along the weighted line with a collection net having a diameter of 0.32 meters (surface area = 0.08m^2). Along the weighted line at five locations, the diver descended from the surface to the bottom collecting all aquatic macrophytes within the area of the net. The net was brought into the boat; plants were placed in corresponding plastic bags and put into a cooler of ice.

The samples were brought back to the lab and the aquatic macrophytes were sorted by species using Crow and Hellquist (2000a, 2000b) and Borman et al. (1999). Each species was placed in a labeled container according to sites and dried to a constant weight in a drying oven at 105°C . After the plants were dried, the samples were weighed. The mass was converted to mass per square meter dividing by 0.08 (collection net surface area). This is known as the dry weight method.

The second sampling method used was the Point Intercept Rake Toss Relative Abundance Method (PIRTRAM) (Anonymous 2005). Two heads of garden rakes were welded together and connected to a 10m nylon chord. At each of the 5 sites, the rake was thrown out randomly 3 times. The rake was allowed to settle to the bottom of the lake and slowly pulled into the boat. Once in the boat, species were separated and measured by abundance categories. The 5 abundance categories are “no plants” (denoted by “Z”), “fingerful” (“T”= trace), “handful” (“S” = sparse), rakeful (“M” =medium), and “can’t bring into the boat” (“D” = dense). (Dry weight ranges for each category are given in Table 26). To compare the methods, each rake toss triplicate sample’s category was converted to its corresponding mid point which were then averaged. The abundance range that corresponded to the mean mid-point value was applied and compared to the dry weight method.

In each basin at the deepest location, water quality was measured with a Hydrolab Scout 2 ®. From surface to substrate, dissolved oxygen, conductivity, pH, and temperature were measured. A water sample was taken from each basin and returned to the lab to be analyzed using the Lachat QuickChem FIA+Water Analyzer ®. The ascorbic acid method following persulfate digestion (Liao and Marten 2001) was used to determine total phosphorus. For total nitrogen, the cadmium reduction method (Pritzlaff 2003) was used following peroxodisulfate digestion as described by Ebina et. al (1983). The phenolate method (Liao 2001) was used to measure ammonia and the cadmium reduction method (Pritzlaff 2003) for nitrate+nitrate-nitrogen.

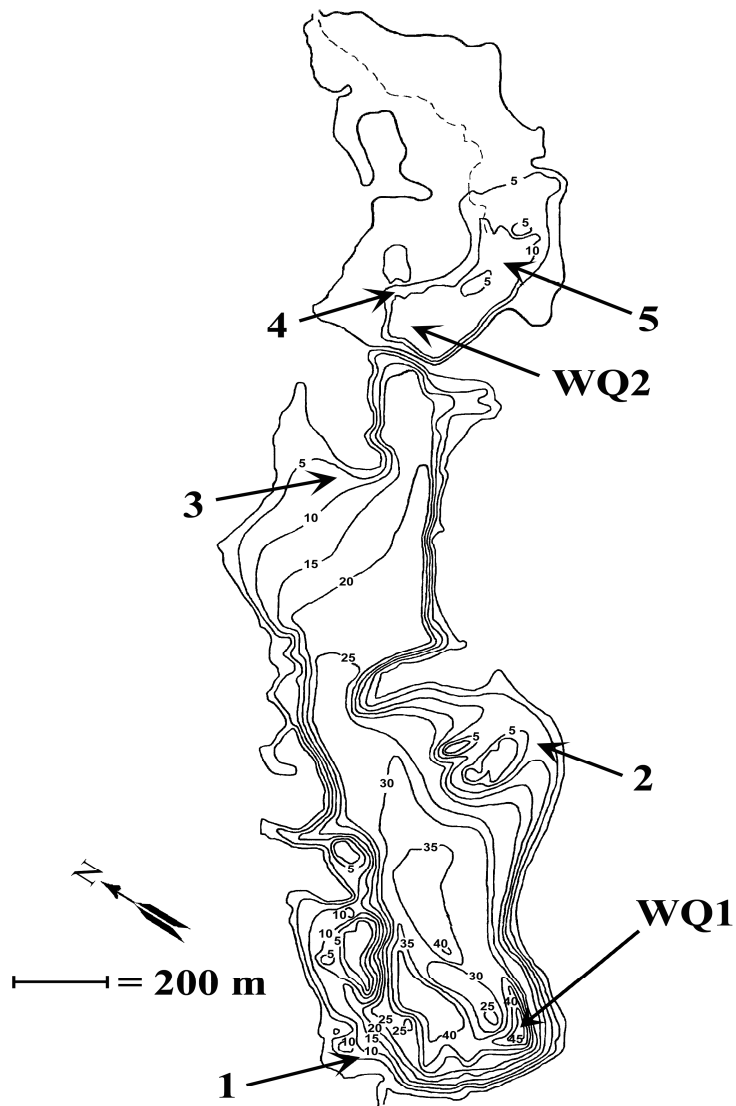


Figure 1. Bathymetric map of Moraine Lake, Madison County, NY. Contours in feet. WQ1 and WQ2 represent where water quality data were collected, sites 1-5 represent where plant biomass and rake toss methods were performed.

RESULTS

Plant Biomass

The 2008 aquatic macrophyte biomass by site and species is shown in Tables 1-15. This year's data is portrayed graphically as well as data from 1996 (Fuller 1997), 1997 (Harman and Albright 1998), 1998 (Harman et al. 1999), 1999 (Harman et al. 2000), 2000 (Harman et al. 2001), 2001 (Harman et al. 2002), 2002 (Harman et al. 2003),

2004 (Harman et al. 2005), 2005 (Harman et al. 2006), 2006 (Harman et al. 2007), and 2007 (Harman et al. 2008) in Figures 2-6 for sites 1-5, respectively. Figures 7-8 show the relationship between the abundance of Eurasian water-milfoil to all the other aquatic macrophytes in each basin since 1996. Since Eurasian water-milfoil (*Myriophyllum spicatum*) is the objective of past management efforts in Moraine Lake, all other aquatic macrophyte biomass are compared to it.

Eurasian water-milfoil was collected from the south basin, though was not abundant, nor was it at site 4 in the north basin. It did comprise about half the biomass at site 5 in the north basin. During the 3 June sampling, *Potamogeton crispus* was the most abundant species within both basins. As discussed in previous reports with the application of Sonar[®] (Harman et al. 2007), *Elodea* is becoming more predominant in many of the sites. Starry stonewort (*Nitellopsis obtusa*), first noted in 2007 at site 1 (Harman et al. 2008), became dominant in sites 1 and 3 by 5 August 2008.

	A	B	C	D	E	Avg
Site 1: 6/3/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>						0.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>	3.00					0.60
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>	3.38					0.68
<i>Chara vulgaris</i>		12.38	5.13		295.00	62.50
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>			12.25		0.11	2.47
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>	72.50	142.50	1.63			43.33
<i>Potamogeton crispus</i>	55.00	82.50		3.63		28.23
<i>Potamogeton zosteriformis</i>	50.00	116.25	56.25	25.00		49.50
<i>Potamogeton pusillus</i>				2.75		0.55
<i>Nitellopsis obtusa</i>				10.25		2.05
					Total	189.90

Table 1. Macrophyte biomass, site #1, 3 June 2008.

	A	B	C	D	E	Avg
Site 2: 6/3/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>						0.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>					2.38	0.48
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>						0.00
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	21.25	12.50	0.25	14.25	12.50	12.15
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>	58.75	41.25	20.00	71.25	13.38	40.93
<i>Potamogeton crispus</i>		0.93	0.01	2.63	26.25	5.96
<i>Potamogeton zosteriformis</i>						0.00
<i>Potamogeton pusillus</i>			2.63			0.53
<i>Nitellopsis obtusa</i>						0.00
					Total	60.04

Table 2. Macrophyte biomass, site #2, 3 June 2008.

	A	B	C	D	E	Avg
Site 3: 6/3/08	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)
<i>Myriophyllum spicatum</i>	5.88	15.25	13.00	687.50	68.75	158.08
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>	103.75	17.75	0.19	0.40		24.42
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>			113.75		2.00	23.15
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	335.00	28.75	6.00	217.50	116.25	140.70
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>		1.25				0.25
<i>Stuckenia pectinata</i>	6.00	7.75	2.75	0.45		3.39
<i>Potamogeton crispus</i>	11.25	478.75	15.88	0.25	361.25	173.48
<i>Potamogeton zosteriformis</i>	0.10					0.02
<i>Potamogeton pusillus</i>		0.03				0.01
<i>Nitellopsis obtusa</i>		2.25	60.00		1.88	12.83
					Total	536.31

Table 3. Macrophyte biomass, site #3, 3 June 2008.

	A	B	C	D	E	Avg
Site 4: 6/3/08	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)
<i>Myriophyllum spicatum</i>	422.50	1.75	268.75	115.00	22.50	166.10
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>	0.01		0.03			0.01
<i>Ceratophyllum demersum</i>	593.75	2.88	60.00	21.50		135.63
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>	237.50	150.00	60.00	717.50	183.75	269.75
<i>Potamogeton zosteriformis</i>	7.88	15.38	5.50		41.25	14.00
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	585.48

Table 4. Macrophyte biomass, site #4, 3 June 2008.

	A	B	C	D	E	Avg
Site 5: 6/3/08	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)	Dry Wt. (g/m2)
<i>Myriophyllum spicatum</i>	0.88		7.38		0.75	1.80
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>	5.25					1.05
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>	0.21					0.04
<i>Potamogeton crispus</i>	163.75	142.50	141.25	215.00	755.00	283.50
<i>Potamogeton zosteriformis</i>						0.00
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>	0.03					0.01
					Total	286.40

Table 5. Macrophyte biomass, site #5, 3 June 2008.

	A	B	C	D	E	Avg
Site 1: 7/1/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>						0.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>	55.63					11.13
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>						0.00
<i>Chara vulgaris</i>	21.88	52.50	301.25	565.00		188.13
<i>Vallisneria americana</i>	1.25					0.25
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>	419.38	1461.25	201.25	120.00	4.38	441.25
<i>Potamogeton crispus</i>	6.25		35.00		32.50	14.75
<i>Potamogeton zosteriformis</i>	266.88	740.63	540.00	70.63	244.38	372.50
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	1028.00

Table 6. Macrophyte biomass, site #1, 1 July 2008.

	A	B	C	D	E	Avg
Site 2: 7/1/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>			821.88			164.38
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>			12.50			2.50
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>					1.25	0.25
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	335.63	1670.63	220.63	443.13		534.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>			8.75		1.25	2.00
<i>Stuckenia pectinata</i>	828.13	225.00	305.00	839.38	407.50	521.00
<i>Potamogeton crispus</i>			46.88		12.50	11.88
<i>Potamogeton zosteriformis</i>		8.75	11.88			4.13
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	1240.13

Table 7. Macrophyte biomass, site # 2, 1 July 2008.

	A	B	C	D	E	Avg
Site 3: 7/1/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>		17.50		5.00	678.13	140.13
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>		370.63		45.00	23.13	87.75
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>				13.13		2.63
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	1340.63	580.00		290.00	832.50	608.63
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>		11.88		28.75		8.13
<i>Potamogeton crispus</i>		6.88				1.38
<i>Potamogeton zosteriformis</i>						0.00
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	848.63

Table 8. Macrophyte biomass, site #3, 1 July 2008.

	A	B	C	D	E	Avg
Site 4: 7/1/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>		2016.25		76.25	798.75	578.25
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>			9.38		3.75	2.63
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>			105.00			21.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>				8.13		1.63
<i>Potamogeton crispus</i>	1.25		0.63	26.25		5.63
<i>Potamogeton zosteriformis</i>	125.00	256.25	183.13	143.75		141.63
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	750.75

Table 9. Macrophyte biomass, site #4, 1 July 2008.

	A	B	C	D	E	Avg
Site 5: 7/1/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>	15.63		51.25		17.50	16.88
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>						0.00
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>		451.25				90.25
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>			4.38	6.25		2.13
<i>Potamogeton crispus</i>				9.38		1.88
<i>Potamogeton zosteriformis</i>	21.88			47.50	3.75	14.63
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	125.75

Table 10. Macrophyte biomass, site #5, 1 July 2008.

	A	B	C	D	E	Avg
Site 1: 7/22/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>						0.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>				3.75		0.75
<i>Chara vulgaris</i>				225.00		45.00
<i>Vallisneria americana</i>				3.75		0.75
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>				0.63		0.13
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>	130.00			634.38	11.25	155.13
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>	850.00	862.50	830.63		1041.25	716.88
					Total	918.63

Table 11. Macrophyte biomass, site #1, 22 July 2008.

	A	B	C	D	E	Avg
Site 2: 7/22/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>		109.38				21.88
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>			603.13	63.75	385.63	210.50
<i>Ceratophyllum demersum</i>						0.00
<i>Chara vulgaris</i>					1.88	0.38
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	66.25	405.63	3.13	13.13	47.50	107.13
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>	112.50					22.50
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>						0.00
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	362.38

Table 12. Macrophyte biomass, site #2, 22 July 2008.

	A	B	C	D	E	Avg
Site 3: 7/22/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>	35.00	13.75		1.25		10.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>	725.00	553.75	568.13	15.00	4.38	373.25
<i>Najas spp.</i>	375.00	11.88				77.38
<i>Ceratophyllum demersum</i>	32.50					6.50
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	43.75	925.00	718.75	776.88	34.38	499.75
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>				1.88	5.00	1.38
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>				59.38		11.88
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>		3.75			1873.75	375.50
					Total	1355.63

Table 13. Macrophyte biomass, site #3, 22 July 2008.

	A	B	C	D	E	Avg
Site 4: 7/22/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>	81.88	1631.88	1158.75	1093.13	41.88	801.50
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>			37.50		706.88	148.88
<i>Najas spp.</i>	449.38					89.88
<i>Ceratophyllum demersum</i>			140.00	473.75		122.75
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>	1.25	30.00	36.25	230.00	11.25	61.75
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	1224.75

Table 14. Macrophyte biomass, site #4, 22 July 2008.

	A	B	C	D	E	Avg
Site 5: 7/22/08	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)	Dry Wt. (g/m ²)
<i>Myriophyllum spicatum</i>		26.25	36.25		1.88	12.88
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>		13.13				2.63
<i>Ceratophyllum demersum</i>				58.75		11.75
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>	9.38					1.88
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>						0.00
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	29.13

Table 15. Macrophyte biomass, site #5, 22 July 2008.

	A	B	C	D	E	Avg
Site 1: 8/5/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>						0.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>	9.38	40.63				10.00
<i>Ceratophyllum demersum</i>				10.38		2.08
<i>Chara vulgaris</i>	186.00	35.63		66.75	2035.00	464.68
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>		15.75		4.13		3.98
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>	0.13	0.13				0.05
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>	1530.63			896.50	62.50	497.93
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>			1478.13	13.00		298.23
					Total	1276.93

Table 16. Macrophyte biomass, site #1, 5 August 2008.

	A	B	C	D	E	Avg
Site 2: 8/5/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>		1.38				0.28
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>		1.38				0.28
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	511.38	668.63		484.25	836.88	500.23
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>				0.13		0.03
<i>Potamogeton crispus</i>	0.25			1.38		0.33
<i>Potamogeton zosteriformis</i>	1.25					0.25
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	501.38

Table 17. Macrophyte biomass, site #2, 5 August 2008.

	A	B	C	D	E	Avg
Site 3: 8/5/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>	19.50	5.63	121.75	0.13		29.40
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>		1.13	85.25	1586.00	734.00	481.28
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	739.00		533.75	189.38	430.00	378.43
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>	47.75	0.63				9.68
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>	3202.13		917.13	8.50	792.63	984.08
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>	853.50	3086.75	2.38			788.53
					Total	2671.38

Table 18. Macrophyte biomass, site #3, 5 August 2008.

	A	B	C	D	E	Avg
Site 4: 8/5/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>	40.63	17.13	20.88	117.13	276.88	94.53
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>		157.63	280.13	135.88	126.13	139.95
<i>Ceratophyllum demersum</i>	333.00	75.75	45.25	258.88	550.63	252.70
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>					0.50	0.10
<i>Potamogeton crispus</i>					1.00	0.20
<i>Potamogeton zosteriformis</i>	0.75			41.13	101.75	28.73
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	516.20

Table 19. Macrophyte biomass, site #4, 5 August 2008.

	A	B	C	D	E	Avg
Site 5: 8/5/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>	384.13	220.13	373.00	298.50	52.75	265.70
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>	32.88					6.58
<i>Ceratophyllum demersum</i>	1660.75	534.75	71.38	4.75		454.33
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>			92.50			18.50
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>			431.75			86.35
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>	4.50	19.88	19.75		532.00	115.23
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>			0.63			0.13
					Total	946.80

Table 20. Macrophyte biomass, site #5, 5 August 2008.

	A	B	C	D	E	Avg
Site1: 9/23/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>						0.00
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>			86.63			17.33
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>					1.33	0.27
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>	2.38	0.91	59.24			12.51
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>	1455.63	1386.63	528.00	1995.63	2676.13	1608.40
					Total	1638.50

Table 21. Macrophyte biomass, site #1, 12 September 2008.

	A	B	C	D	E	Avg
Site 2: 9/23/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>			29.63		32.38	12.40
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>				0.85	99.63	20.10
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>			4.10			0.82
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>	2340.63	1632.50	2019.63	174.75	133.50	1260.20
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>					12.25	2.45
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>	2.09	10.00	9.26			4.27
<i>Potamogeton zosteriformis</i>		3.08		2.81		1.18
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	1301.41

Table 22. Macrophyte biomass, site #2, 12 September 2008.

	A	B	C	D	E	Avg
Site 3: 9/23/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>		0.80		1124.50	25.38	230.14
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>				0.74	7.21	1.59
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>	26.23	0.03	2224.38	130.75	1.51	476.58
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>				323.38	1956.00	455.88
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>					7.89	1.58
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>			1.64		1.04	0.54
<i>Potamogeton zosteriformis</i>			0.36			0.07
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>	5291.63	1541.63			139.50	1394.55
					Total	2560.91

Table 23. Macrophyte biomass, site #3, 12 September 2008.

	A	B	C	D	E	Avg
Site 4: 9/23/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>	121.00	611.38	741.00	857.75	434.63	553.15
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>	164.13			15.50	17.04	39.33
<i>Najas spp.</i>	51.80	14.63	346.38	2.38		83.04
<i>Ceratophyllum demersum</i>	1020.75	544.38	138.63	628.38	350.13	536.45
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>				0.05		0.01
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>	6.56	1.78			1.06	1.88
<i>Potamogeton zosteriformis</i>	5.94	6.29				2.45
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>						0.00
					Total	1216.30

Table 24. Macrophyte biomass, site #4, 12 September 2008.

	A	B	C	D	E	Avg
Site 5: 9/23/08	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.	Dry Wt.
<i>Myriophyllum spicatum</i>	13.83	649.25		2.93	45.74	142.35
<i>Megalodonta beckii</i>						0.00
<i>Zosterella dubia</i>						0.00
<i>Najas spp.</i>						0.00
<i>Ceratophyllum demersum</i>	3649.25	334.00	2027.25	307.13	2120.88	1687.70
<i>Chara vulgaris</i>						0.00
<i>Vallisneria americana</i>						0.00
<i>Elodea canadensis</i>						0.00
<i>Ranunculus aquatilis</i>						0.00
<i>Ranunculus trichophyllus</i>						0.00
<i>Stuckenia pectinata</i>						0.00
<i>Potamogeton crispus</i>						0.00
<i>Potamogeton zosteriformis</i>		10.50				2.10
<i>Potamogeton pusillus</i>						0.00
<i>Nitellopsis obtusa</i>				0.91		0.18
					Total	1832.33

Table 25. Macrophyte biomass, site #5, 12 September 2008.

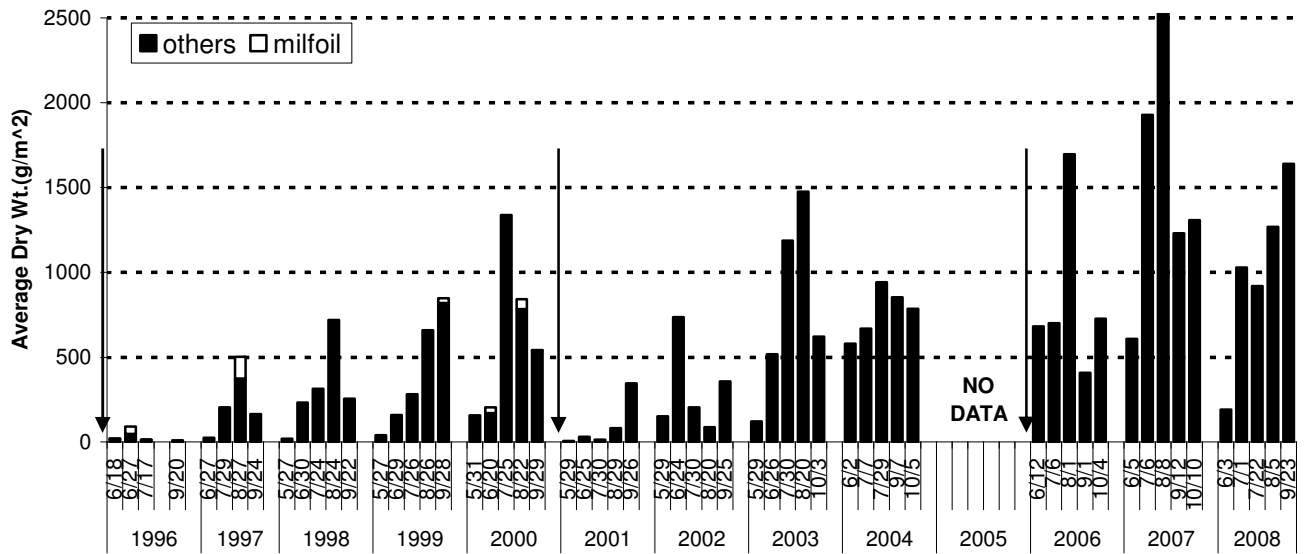


Figure 2. Comparison of dry weight (g/m²) of Eurasian water-milfoil (EWM) and other plants combined, site #1, 1996- 2008. Each bar represents the mean of five replicate samples. Arrows represent Sonar[®] application.

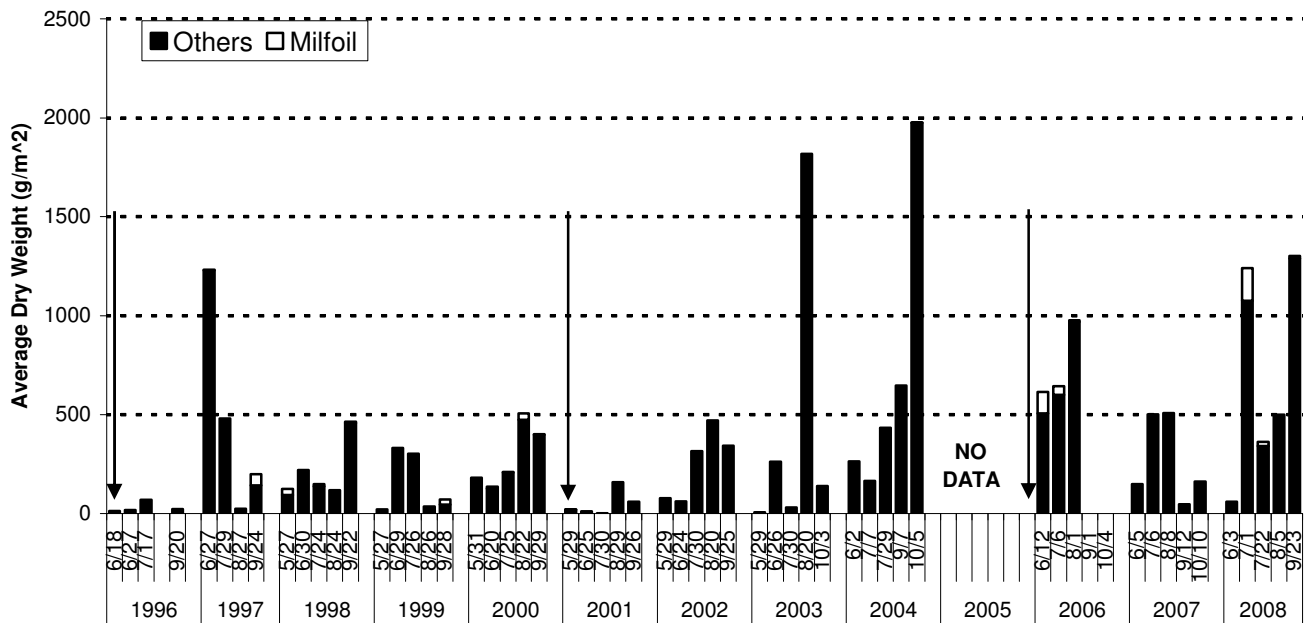


Figure 3. Comparison of dry weight (g/m²) of EWM and other plants combined, site #2, 1996- 2008. Each bar represents the mean of five replicate samples. Arrows represent Sonar[®] application.

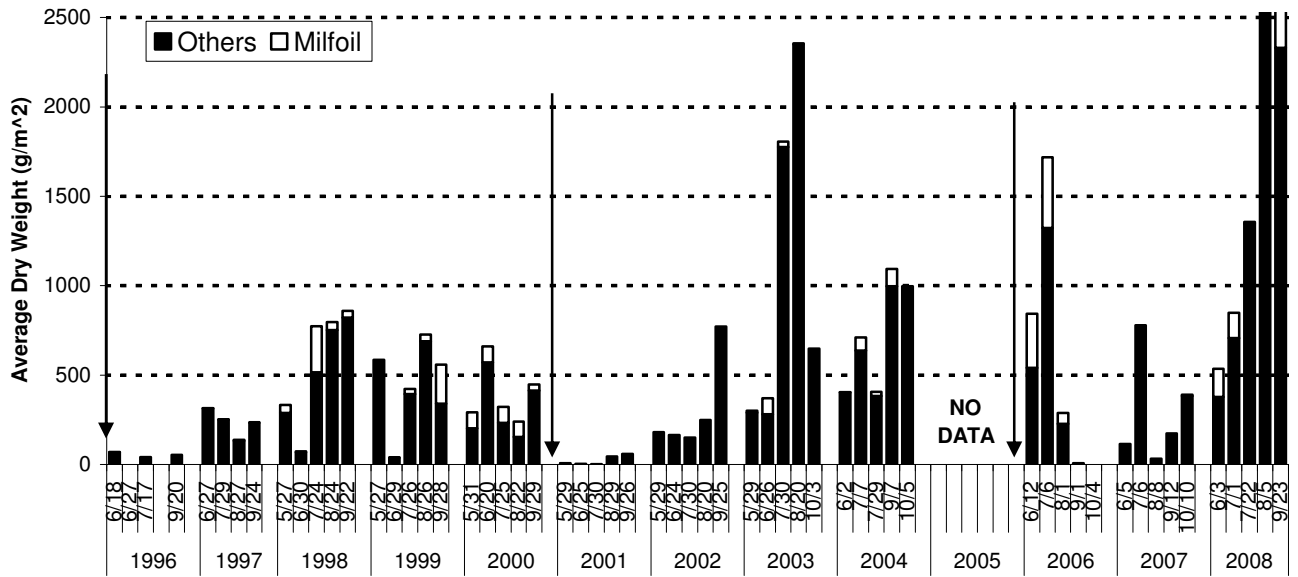


Figure 4. Comparison of dry weight (g/m²) of EWM and other plants combined, site #3, 1996-2008. Each bar represents the mean of five replicate samples. Arrows represent Sonar[®] application.

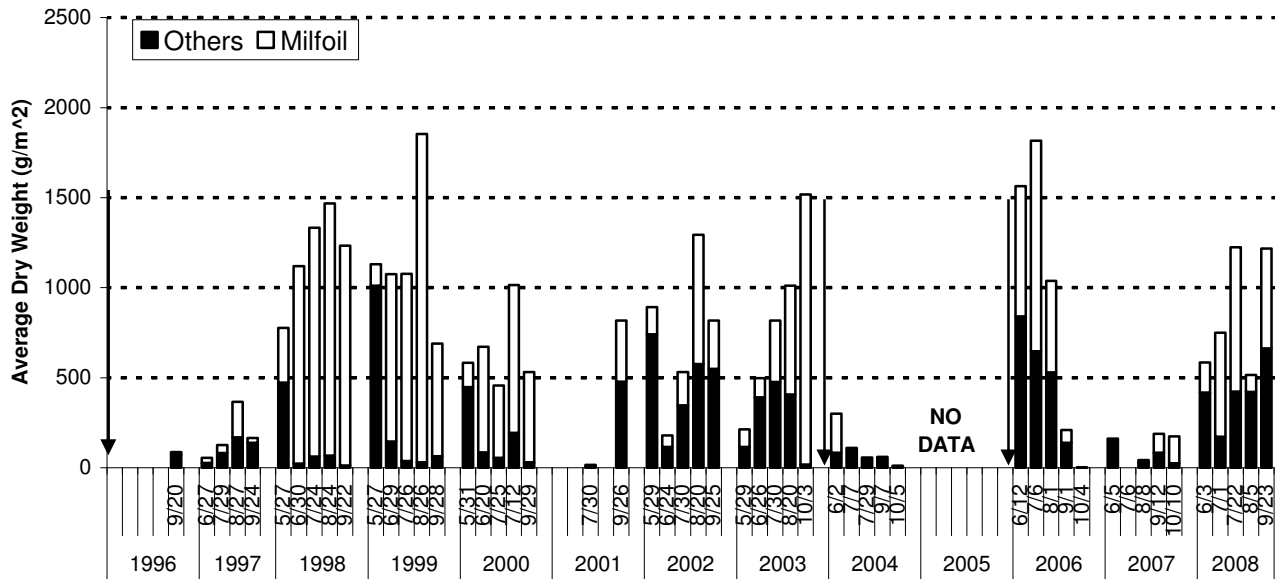


Figure 5. Comparison of dry weight (g/m²) of EWM and other plants combined, site #4, 1996-2008. Each bar represents the mean of five replicate samples. Arrows represent Sonar[®] application.

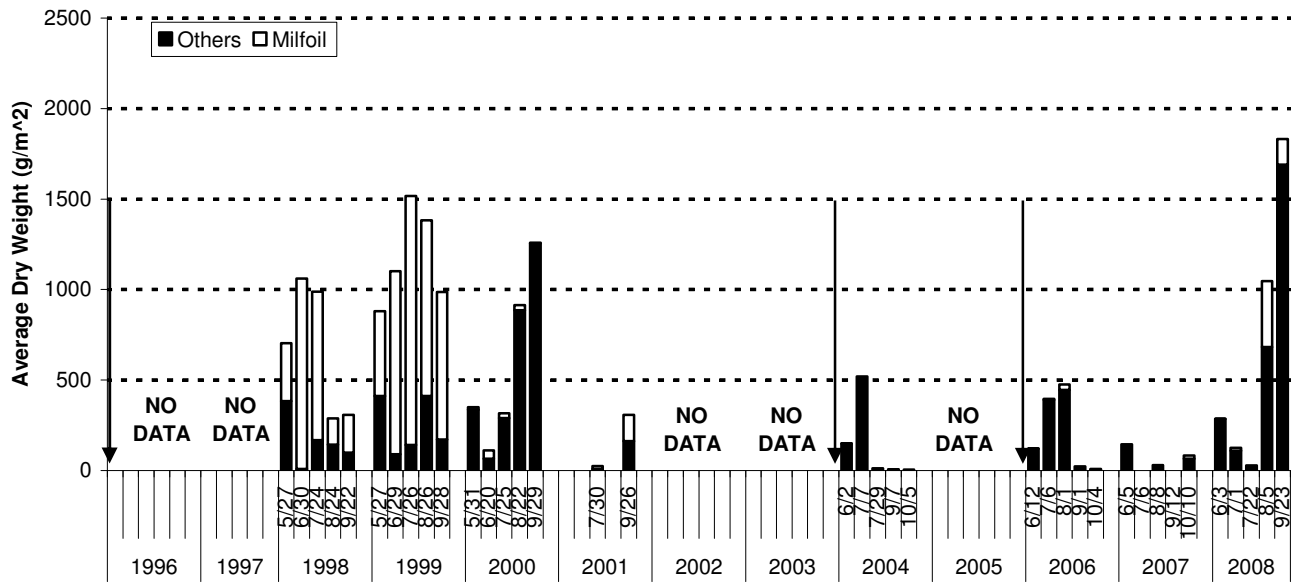


Figure 6. Comparison of dry weight (g/m²) of EWM and other plants combined, site #5, 1996-2008. Each bar represents the mean of five replicate samples. Arrows represent Sonar[®] application.

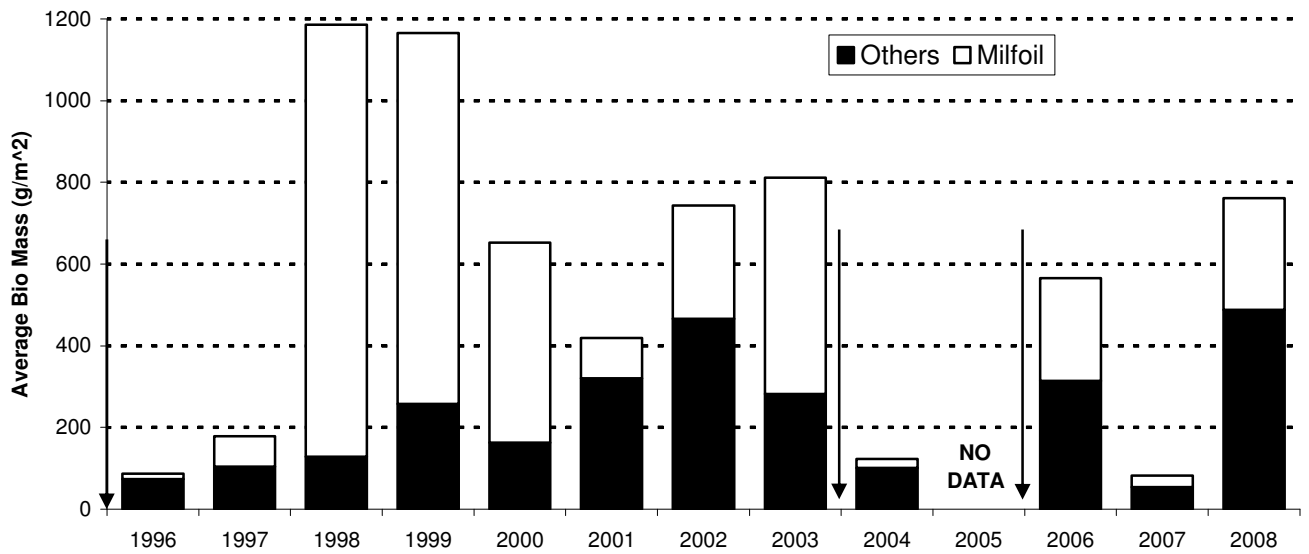


Figure 7. Comparison of mean annual biomass of EWM and other aquatic plants, 1996-2008, in the north basin. Arrows represent Sonar[®] application.

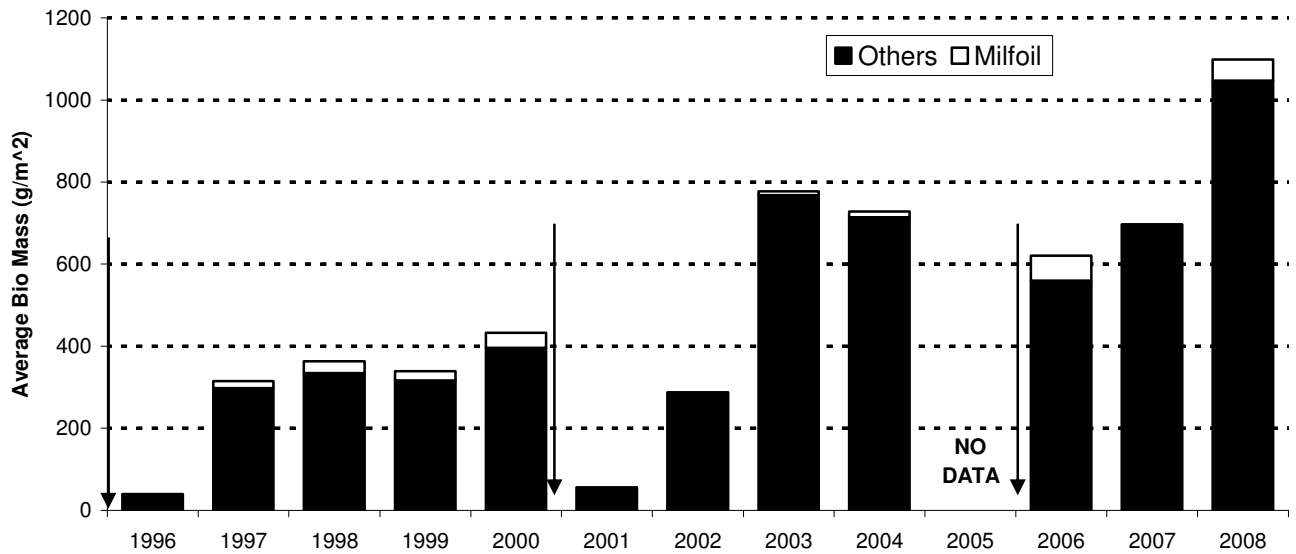


Figure 8. Comparison of mean annual biomass of EWM and other aquatic plants, 1996-2008, in the south basin. Arrows represent Sonar[®] application.

Rake Toss

Table 26 provides the abundance categories employed by the rake toss method (mid point, low and high biomass as g/m²). The data collected using the rake toss method is shown in Tables 27 – 51.

Abundance Categories	Field Measure	Total Dry Weight (g/m ²)	mid	low	high
"Z" = no plants	Nothing	0	0	0	0
"T" = trace plants	Fingerful	.0001 - 2.000	1.00005	0.0001	2
"S" = sparse plants	Handful	2.001 - 140.000	71.0005	2.001	140
"M" = medium plants	Rakeful	140.001 - 230.000	185.0005	140.001	230
"D" = dense plants	Can't bring in boat	230.001 - 450.000+	340.0005	230.001	450

Table 26. Categories, field measurements, midpoint of each category (g/m²) and dry weight ranges applied for the rake toss method and used to generate Tables 27-51.

Site 1: 6/3/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>	1.00	71.00	71.00	2.00	140.00	47.67
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	71.00	1.00	1.00	2.00	140.00	24.33
<i>Potamogeton crispus</i>	71.00	0.00	0.00	2.00	140.00	23.67
<i>Potamogeton zosteriformis</i>	1.00	1.00	1.00	0.00	2.00	1.00
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	97.00

Table 27. Rake toss, site #1, 3 June 2008.

Site 2: 6/3/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	71.00	71.00	71.00	2.00	140.00	71.00
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	71.00	71.00	1.00	2.00	140.00	47.67
<i>Potamogeton crispus</i>	1.00	71.00	185.00	2.00	140.00	85.67
<i>Potamogeton zosteriformis</i>	0.00	0.00	1.00	0.00	2.00	0.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	205.00

Table 28. Rake toss, site #2, 3 June 2008.

Site 3: 6/3/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	0.00	1.00	1.00	0.00	2.00	0.67
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	1.00	185.00	1.00	2.00	140.00	62.33
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	0.00	1.00	1.00	0.00	2.00	0.67
<i>Potamogeton crispus</i>	340.00	185.00	340.00	230.00	450.00	288.33
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	352.00

Table 29. Rake toss, site #3, 3 June 2008.

Site 2: 7/1/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	0.00	1.00	0.00	0.00	2.00	0.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	71.00	1.00	1.00	2.00	140.00	24.33
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	71.00	1.00	71.00	2.00	140.00	47.67
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
Total						72.33

Table 33. Rake toss, site #2, 1 July 2008.

Site 3: 7/1/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	71.00	1.00	71.00	2.00	140.00	47.67
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	0.00	71.00	0.00	2.00	140.00	23.67
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	0.00	71.00	71.00	2.00	140.00	47.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	185.00	1.00	1.00	2.00	140.00	62.33
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>	0.00	71.00	0.00			23.67
Total						204.67

Table 34. Rake toss, site #3, 1 July 2008.

Site 4: 7/1/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	1.00	185.00	1.00	2.00	140.00	62.33
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	71.00	0.00	71.00	2.00	140.00	47.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Potamogeton crispus</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Potamogeton zosteriformis</i>	1.00	0.00	185.00	2.00	140.00	62.00
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
Total						172.33

Table 35. Rake toss, site #4, 1 July 2008.

Site 5: 7/1/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	0.00	1.00	0.00	0.00	2.00	0.33
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	0.00	0.00	1.00	0.00	2.00	0.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	185.00	185.00	71.00	140.00	230.00	147.00
<i>Potamogeton crispus</i>	0.00	1.00	0.00	0.00	2.00	0.33
<i>Potamogeton zosteriformis</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	148.33

Table 36. Rake toss, site #5, 1 July 2008.

Site 1: 7/22/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>	1.00	0.00	1.00	0.00	2.00	0.67
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>	0.00	0.00	71.00	2.00	140.00	23.67
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	1.00	1.00	71.00	2.00	140.00	24.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>	185.00	185.00	0.00	2.00	140.00	123.33
					Total	172.00

Table 37. Rake toss, site #1, 22 July 2008.

Site 2: 7/22/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Najas spp.</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	71.00	71.00	1.00	2.00	140.00	47.67
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	48.67

Table 38. Rake toss, site #2, 22 July 2008.

Site 3: 7/22/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	1.00	1.00	0.00	0.00	2.00	0.67
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Ceratophyllum demersum</i>	1.00	1.00	0.00	0.00	2.00	0.67
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	71.00	340.00	185.00	140.00	230.00	198.67
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	71.00	0.00	71.00	2.00	140.00	47.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>	0.00	1.00	0.00	0.00	2.00	0.33
					Total	248.00

Table 39. Rake toss, site #3, 22 July 2008.

Site 4: 7/22/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	71.00	71.00	71.00	2.00	140.00	71.00
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>	1.00	1.00	0.00	0.00	2.00	0.67
<i>Ceratophyllum demersum</i>	185.00	71.00	71.00	2.00	140.00	109.00
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	1.00	71.00	1.00	2.00	140.00	24.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	205.00

Table 40. Rake toss, site #4, 22 July 2008.

Site 5: 7/22/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	1.00	1.00	0.00	0.00	2.00	0.67
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>	1.00	0.00	1.00	0.00	2.00	0.67
<i>Ceratophyllum demersum</i>	1.00	0.00	71.00	2.00	140.00	24.00
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>	0.00	71.00	1.00	2.00	140.00	24.00
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	1.00	1.00	71.00	2.00	140.00	24.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	73.67

Table 41. Rake toss, site #5, 22 July 2008.

Site 1: 8/5/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	0.00	71.00	1.00	2.00	140.00	24.00
<i>Najas spp.</i>	0.00	1.00	0.00	0.00	2.00	0.33
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>	185.00	0.00	0.00	2.00	140.00	61.67
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>	0.00	71.00	185.00	2.00	140.00	85.33
					Total	171.67

Table 42. Rake toss, site #1, 5 August 2008.

Site 2:8/5/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	0.00	0.00	1.00	0.00	2.00	0.33
<i>Megalodonta beckii</i>	1.00	1.00	0.00	0.00	2.00	0.67
<i>Zosterella dubia</i>	0.00	0.00	1.00	0.00	2.00	0.33
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	71.00	71.00	71.00	2.00	140.00	71.00
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	72.67

Table 43. Rake toss, site #2, 5 August 2008.

Site 3: 8/5/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	185.00	185.00	1.00	2.00	140.00	102.60
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	71.00	0.00	71.00	2.00	140.00	47.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	1.00	1.00	185.00	2.00	140.00	62.33
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	1.00	0.00	0.00	0.00	2.00	0.33
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>	71.00	0.00	1.00	2.00	140.00	24.00
					Total	236.93

Table 44. Rake toss, site #3, 5 August 2008.

Site 2: 9/23/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>						
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	0.00	1.00	0.00	0.00	2.00	0.33
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>						
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	185.00	185.00	185.00	140.00	230.00	185.00
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	185.33

Table 48. Rake toss, site #2, 23 September 2008.

Site 3: 9/23/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	71.00	0.00	0.00	2.00	140.00	23.67
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	71.00	185.00	0.00	2.00	140.00	85.33
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	71.00	71.00	0.00	2.00	140.00	47.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>	71.00	185.00	1.00	2.00	140.00	85.67
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>	0.00	1.00	340.00	2.00	140.00	113.67
					Total	355.67

Table 49. Rake toss, site #3, 23 September 2008.

Site 4: 9/23/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	71.00	71.00	71.00	2.00	140.00	71.00
<i>Megalodonta beckii</i>						
<i>Zosterella dubia</i>	185.00	0.00	0.00	2.00	140.00	61.67
<i>Najas spp.</i>						
<i>Ceratophyllum demersum</i>	71.00	71.00	71.00	2.00	140.00	71.00
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>	1.00	1.00	0.00	0.00	2.00	0.67
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	204.33

Table 50. Rake toss, site #4, 23 September 2008.

Site 5: 9/23/08	Toss 1	Toss 2	Toss 3	low	high	Mean mid-point
<i>Myriophyllum spicatum</i>	71.00	1.00	0.00	2.00	140.00	24.00
<i>Megalodonia beckii</i>						
<i>Zosterella dubia</i>						
<i>Najas spp.</i>	0.00	71.00	0.00	2.00	140.00	23.67
<i>Ceratophyllum demersum</i>	1.00	185.00	340.00	140.00	230.00	175.33
<i>Chara vulgaris</i>						
<i>Vallisneria americana</i>						
<i>Elodea canadensis</i>						
<i>Ranunculus aquatilis</i>						
<i>Ranunculus trichophyllus</i>						
<i>Stuckenia pectinata</i>						
<i>Potamogeton crispus</i>						
<i>Potamogeton zosteriformis</i>						
<i>Potamogeton pusillus</i>						
<i>Nitellopsis obtusa</i>						
					Total	223.00

Table 51. Rake toss, site #5, 23 September 2008.

Dry weight vs. rake toss evaluation

Table 16 provides the midpoint values and ranges of each abundance category, as well as the subjective field description. For the purposes of the evaluation of the two methods, it was assumed that the dry weight method conventionally used yielded a more accurate estimation of the true biomass of each species present (though this assumption might not be entirely accurate). A comparison of the abundance estimates for the two methods are summarized in Table 17. Given are the numbers (and percents) of the following, both as an overall summary and for each species encountered: 1) species collected across dates and sites over the summer, by either (or both) the “dry weight” (DW) or the “rake toss” (RT) method; 2) species collected by both the DW and RT methods at concurrent sampling efforts; 3) species collected by the DW method but not the RT method; 4) species collected by the RT method but not the DW method; 5) the count of samples that the RT method yielded an abundance estimate that was less than that by the corresponding DW method, and; 6) the count of samples that the RT method yielded an abundance range into which the DW method fit. For example, over the course of the study (five dates, five sites), 172 discrete samples were collected by either the dry weight method or by the corresponding rake toss method (All, in Table 52). Of those, 91 (53%) were collected by both DW and RT concurrent efforts. Sixty four (37%) were collected by only the DW method and 17 (10%) were collected only by the RT method. In 137 of the cases (80%), the RT method provided a lower abundance estimate than did the DW method, and 30 of the cases (17%), fell within the biomass range provided by the RT method.

Figure 9 graphically compares the Dry Weight method with the Rake Toss method, providing range values of each category for the latter. Values graphed are means across sites and dates for each species. Those species appearing infrequently and/or at very low abundances were not included, as they couldn't be differentiated from the x axis.

	either/both	RT & DW	DW, not RT	RT, not DW	RT<DW	in RT range
All	172 (100)	91 (53)	64 (37)	17 (10)	137 (80)	30 (17)
<i>Myriophyllum spicatum</i> *	19 (100)	16 (84)	3 (16)	0 (0)	18 (95)	3 (16)
<i>Megalodonta beckii</i>	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)
<i>Zosterella dubia</i>	17 (100)	4 (24)	7 (41)	6 (35)	9 (53)	2 (12)
<i>Najas spp.</i>	11 (100)	8 (73)	1 (9)	2 (18)	8 (73)	2 (18)
<i>Ceratophyllum demersum</i>	22 (100)	13 (59)	8 (36)	1 (5)	17 (77)	6 (27)
<i>Chara vulgaris</i>	5 (100)	3 (60)	2 (40)	0 (0)	5 (100)	2 (40)
<i>Vallisneria americana</i>	2 (100)	0 (0)	2 (100)	0 (0)	2 (100)	0 (0)
<i>Elodea canadensis</i>	17 (100)	11 (65)	6 (35)	0 (0)	16 (94)	2 (12)
<i>Ranunculus trichophyllus</i>	7 (100)	0 (0)	7 (100)	0 (0)	7 (100)	0 (0)
<i>Stuckenia pectinata</i>	17 (100)	8 (47)	7 (41)	2 (12)	13 (76)	3 (18)
<i>Potamogeton crispus</i> *	16 (100)	8 (50)	7 (44)	1 (6)	13 (81)	3 (19)
<i>Potamogeton zosteriformis</i>	22 (100)	14 (64)	6 (27)	2 (9)	15 (68)	7 (32)
<i>Potamogeton pusillus</i>	3 (100)	0 (0)	3 (100)	0 (0)	3 (100)	0 (0)
<i>Nitellopsis obtusa</i> *	13 (100)	6 (46)	5 (38)	2 (15)	11 (85)	0 (0)

Table 52. The numbers (and percents) of the following, both as an overall summary and for each species encountered: 1) species collected across dates and sites over the summer, by either (or both) the “dry weight” (DW) or the “rake toss” (RT) method; 2) species collected by both the DW and RT methods at concurrent sampling efforts; 3) species collected by the DW method but not the RT method; 4) species collected by the RT method but not the DW method; 5) the count of samples that the RT method yielded an abundance estimate that was less than that by the corresponding DW method, and; 6) the count of samples that the RT method yielded an abundance range into which the DW method fit. * indicates exotic species.

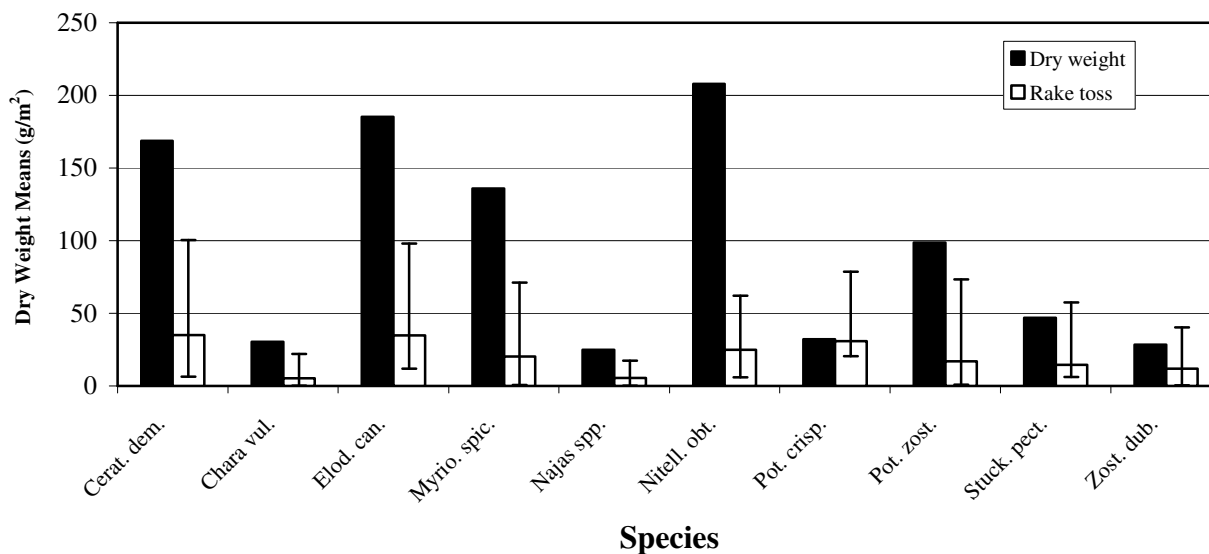


Figure 9. Comparison of the Dry Weight method to the Rake Toss method, showing high and low ranges for each category for the latter, for *Ceratophyllum demersum*, *Chara vulgaris*, *Elodea Canadensis*, *Myriophyllum spicatum*, *Najas spp.*, *Nitellopsis obtusa*, *Potamogeton crispus*, *Potamogeton zosteriformis*, *Stuckenia pectinata* and *Zosterella dubia*. Species collected at such low abundances that they would not appear in the graphic were not included.

Water Quality Analysis

The shallower north basin mixed frequently over the course of the summer, though temporary stratification was evident on 1 July and 5 August in that near-bottom waters were anoxic. pH values ranged from 7.80 to 9.11. The maximum temperature recorded was 23.73 C⁰ at the surface on 1 July. Secchi readings averaged 2.4 m. Ammonia was below detection (< .02 mg/l) on all sampling dates. Nitrite+nitrate concentrations were 0.09 mg/l in early June and below detection (<0.02 mg/l) on subsequent dates. Total nitrogen averaged 0.43 mg/l and total phosphorus averaged 21.0 ug/l.

In the south basin, stratification was evident at the onset of sampling (3 June). Then, waters were near anoxic from depths of 10 m to the bottom (13 m). By the last sampling date (23 September), waters were anoxic from 7 m to the bottom. pH ranged from 7.12 at the bottom (23 September) to 8.79 at 1 m on 1 July. The surface temperature reached 24.53 C⁰ on 5 August. Secchi readings averaged 2.9 m. Ammonia was below detection (< .02 mg/l) on all sampling dates. Nitrite+nitrate concentrations were 0.374 mg/l in early June and below detection (<0.02 mg/l) on subsequent dates. Total nitrogen averaged 0.394 mg/l and total phosphorus averaged 11.3 ug/l.

DISCUSSION

Eurasian milfoil was a minor component of the plant biomass over the summer of 2008 in the south basin sites, as it was at site 4 in the south basin. At site 5 it comprised about half of the biomass. Curly leaf pondweed (*P. crispus*), flat-stem pondweed (*P. zosteriformis*) and sago pondweed (*S. pectinatus*) were common throughout the south basin, and common waterweed (*E. canadensis*) seemed to continue its rebound since the 2006 Sonar[®] application (Harman et al. 2008). The most obvious shift in the plant community involved the irruption of starry stonewort (*N. obtusa*). It was likely confused with *Chara* when first encountered in Moraine Lake, but was identified with confidence, in small quantities, in 2007 when fruiting bodies were observed. Over the course of 2008, it became dominant at sites 1 and 3, giving the highest biomass densities collected to date in Moraine.

A comparison of biomass estimates collected by the conventional dry weight method and by the rake toss method implies that the latter, as used in this study, has its shortcomings. Overall, 37% of the time that species were collected by the dry weight method, they were missed using the rake toss. 80% of the time, the rake toss method provided an abundance estimate that was less than that provided using the dry method, and in only 17% of the instances did the range suggested by the rake toss results encompass the biomass determined by the dry weight method.

Species commonly missed by the rake toss were those which were non-branching (*V. americana*), those with collapsible forms (*P. crispus*, *P. pusillus*), those commonly growing at low densities relative to other species (*Najas* spp.) and those growing lower in the canopy relative to other species (*C. vulgaris*). Species exhibiting the opposite characteristics (*M. spicatum*, *N. obtusa*) were collected regularly, but the estimated biomass was largely underestimated.

Despite the above shortcomings, the rake toss method could prove useful if not too much value is placed on actual abundance estimates. It is quick and easy to use, and an adequate number

of replicate samples could provide insight into species dominance and extent related to exotic nuisance species as well as efforts to control them.

REFERENCES

- Anon. 1988. Madison County septic system survey. Madison County Planning Department, Wampsville, NY 13163.0
- Anon. 2005. reputedly by Lord, P.H. & R. L. Johnson.
- Borman, S., R. Korth, and J. Tempte. 1999. Through the Looking Glass. A Field Guide to Aquatic Plants. Wisconsin Lakes Partnership.
- Crow, G. E. and C. B. Hellquist. 2000a. Aquatic and wetland plants of Northeastern North America. V.1. Pteridophytes, gymnosperms, and angiosperms: dicotyledons. The University of Wisconsin Press.
- Crow, G. E. and C. B. Hellquist. 2000b. Aquatic and wetland plants of Northeastern North America. V.2. Angiosperms: monocotyledons. The University of Wisconsin Press.
- Fuller, R. 1997. Unpublished data. Colgate University, Hamilton, NY 13346.
- Harman, W. N. and M. F. Albright. 1997. Aquatic macrophyte survey of Lake Moraine, Madison County, summer 1997, as related to management efforts by Sonar ® application. SUNY Oneonta Bio. Fld. Sta., Oneonta NY.
- Harman, W. N. and M. F. Albright, P.H. Lord and D. King. 1998. Aquatic macrophyte management plan facilitation of Lake Moraine, Madison County. Tech. Rept. #5. SUNY Oneonta Bio. Fld. Sta., Oneonta NY.
- Harman, W. N. and M. F. Albright, P.H. Lord and M. Miller. 2000. Aquatic macrophyte management plan facilitation of Lake Moraine, Madison County. Tech. Rept. #9. SUNY Oneonta Bio. Fld. Sta., Oneonta NY.
- Harman, W. N. and M. F. Albright, P.H. Lord and M. E. Miller. 2002. Aquatic macrophyte management plan facilitation of Lake Moraine, Madison County. Tech. Rept. #13. SUNY Oneonta Bio. Fld. Sta., Oneonta NY.
- Harman, W. N. and M. F. Albright, and A. Scorzafava. 2006. Aquatic macrophyte management plan facilitation, Lake Moraine, Madison County, NY. Tech. Rept. #23. SUNY Oneonta Bio. Fld. Sta., Oneonta NY.
- Harman, W. N. and M. F. Albright, and C. M. Snyder. 2007. Aquatic macrophyte management plan facilitation, Lake Moraine, Madison County, NY. Tech. Rept.

#25. SUNY Oneonta Bio. Fld. Sta., Oneonta NY.

Lembi, C. A. 2000. Aquatic Plant Management. Purdue University, Cooperative Extension Service. West Lafayette, IN 47907.