BFS Technical Report
AQUATIC MACROPHYTE MANAGEMENT PLAN FACILITATION LAKE MORAINE, MADISON COUNTY, NY 2007

1. **MACROPHYTE BIOMASS MONITORING**
2. **MONITORING EFFECTS OF SELECTIVE HERBICIDE SONAR®**
3. **WATER QUALITY ANALYSIS**

WILLARD N. HARMAN
MATTHEW F. ALBRIGHT
CAITLIN M. SNYDER

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

Background (Harman *et al.*, 1997)

Located in Madison County NY, Moraine Lake (42^0 50’ 47” N, 75^0 31’ 39” W) was formed by a deposited glacial moraine damming a valley. The lake, which has been artificially raised, is divided into two basins separated by a causeway and interconnected by a submerged culvert. The north basin is approximately 79 acres, has a mean depth of 1.1m, and a maximum depth 3.7m. The south basin occupies 182 acres, has a mean depth of 5.4m, and a maximum depth of 13.7m. Most of the recreational activities such as fishing, boating and swimming take place in the south basin.

Moraine Lake has been regarded as meso-eutrophic due to the high productivity of algal and macrophytic plants, low transparency, and depleting levels of dissolved oxygen in the hypolimnion during summer stratification. Developments of lakeside residences and nearby agricultural activities are believed to have contributed to the current productivity status of the upper and lower basins (Anon., 1991). Nutrient loading as a result of faulty septic systems from the residences are believed to be a significant source of the problem in nutrient introduction (Harman et al. 1998). Many of the systems are out of date, undersized, and extremely close to the lake (Brown et al. 1983). Furthermore, soils surrounding the lake have poor percolation rates, steep slopes, shallow depths to bedrock, and fractured bedrock make the lake vulnerable to nutrient loading (Anon., 1991)

INTRODUCTION

Since 1997, the aquatic macrophyte communities at Moraine Lake have been monitored by the SUNY Biological Field Station (BFS). Efforts of the monitoring have been specifically directed towards controlling Eurasian water-milfoil (*Myriophyllum spicatum*). *Myriophyllum spicatum* is an aggressive invasive species that colonizes a variety of habitats include lakes, ponds, streams, rivers, and estuaries (AERF 2005). With the ability to propagate through fragmentation, milfoil can easily disperse and rapidly grow into thick stands (AERF 2005). Stems branch near the water’s surface and create a dense canopy of foliage that can shade out surrounding vegetation (Borman et al.1999). Despite the fact that most of the aquatic plants such as *Ceratophyllum dermersum*, *Vallsinaria Americana*, and *Potamogeton pectinatus* are abundant in Moraine, *Myriophyllum spicatum* has become especially problematic since introduced sometime before 1990 (Harman et al. 1997). Due to the popularity of recreational activities on the lake, both the Moraine Lake Association and local residents have expressed concern about the density of milfoil.

Various chemical, mechanical, and biological methods have been experimented with in the past in attempts to control invasive aquatic weeds (Harman et al. 2005). However, the effectiveness of many of these methods has not been fully investigated. Herbicides are currently used for the management of Eurasian water-milfoil (AERF 2005). At Moraine Lake, copper sulfate ($CuSO_4$) has been used as a non-selective herbicide as well as Diquat (1,1’-ethylene-2,2’-bipyridiylium dibromide salt [Cl_2 $H_{12}N_2Br_2$]) to control planktonic algae (Kastens 1974). Later, Sizamine (6-chloro-N_2,N_4-

diethyl-1,3,5-triazine-2,4,diamine [$C_7H_{12}ClN_5$]) was also applied to control macrophyte and algae production (Harman 1978). These methods, along with mechanical harvesting, have all been used with varying success on the lake. Sonar® (fluridone, 1-Methyl-3-phenyl-5-[3(trifluorromethyl)phenyl]-4(1H)-pyridinone)) was added in the littoral zones of both basins in 1996, again in the south basin in 2001 and in the north basin in 2004 (Harman et al. 2005). In 1998 and 2000, the upper basin of the lake was stocked with *Euhrychiopsis lecontei*, a weevil known to feed on the water-milfoil in an attempt to control milfoil growth (Harmen et al. 1997). Since the stocking there have been no signs of a population increase in beetles nor have there been signs of increased damage on the milfoil (Harman et al.1998, 2000, 2001, 2002, 2003).

Sonar®, which is non-toxic to animals, interferes with chlorophyll metabolism in the plant and thus inhibits plant growth (Harman *et al*. 1997). Research by the BFS has substantiated manufacturer's claims that Sonar® can control Eurasian milfoil with a considerable degree of specificity, provided target concentrations are maintained for the appropriate duration, and that milfoil control lasts up to four years (Blanchard 2005). On 19 June 2006, 16.5 gallons of Sonar® were applied to the lake. Due to heavy rains and flooding that occurred in the area around Moraine Lake shortly after the application, another 16.5 gallons were added on 18 July 2006. This was done in order to keep the concentration at a high enough level to affect the milfoil.

MATERIALS AND METHODS

The lake was sampled on 5 June, 6 July, 8 August, 12 September and 10 October 2007. In preparation for five macrophyte collection sites, 25 plastic garbage bags were labeled each with a number (corresponding to the collection site) and a letter (corresponding to the replication at the site). Two of the locations were in the north basin and three were in the south basin (Figure 1). A weighted line that was marked in 1 meter intervals was thrown randomly thrown from the boat at each sampling site on the lake. A diver would then swim along the weighted line with a collection net having a diameter of 0.32 meters (surface area = 0.08 m^2). At five locations along the line the diver would sample from the surface to the bottom and collect all the plants within the area of the net. Once the full net was brought into the boat the contents were placed into a corresponding bag and placed in a cooler with ice.

Water quality data were measured in a profile at the deepest point in each basin using a Hydrolab Scout 2®. Parameters recorded included pH, conductivity, dissolved oxygen, and temperature. A water sample was also taken from each basin and brought back to the lab to be analyzed for total phosphorous using the ascorbic acid method following persulfate digestion (Liao and Marten 2001). Total nitrogen was analyzed using the cadmium reduction method (Pritzlaff 2003) following peroxodisulfate digestion as described by Ebina et. al (1983). Ammonia was analyzed using the phenolate method (Liao 2001), and nitrate+nitrate-nitrogen was tested for using the cadmium reduction method (Pritzlaff 2003). All of these parameters were analyzed using a Lachat QuickChem FIA+ Water Analyzer®.

Macrophyte sample bags were brought back to the lab and separated by species using Crow and Hellquist (2000a, 2000b) and Borman et al. (1999) as guides. The samples were placed in labeled containers and dried to a constant weight using an industrial plant dryer at 105 °C. Once completely dry, the samples were weighed. The mass of the plants converted to mass per square meter by dividing by 0.08 (the surface area of the collection nets).

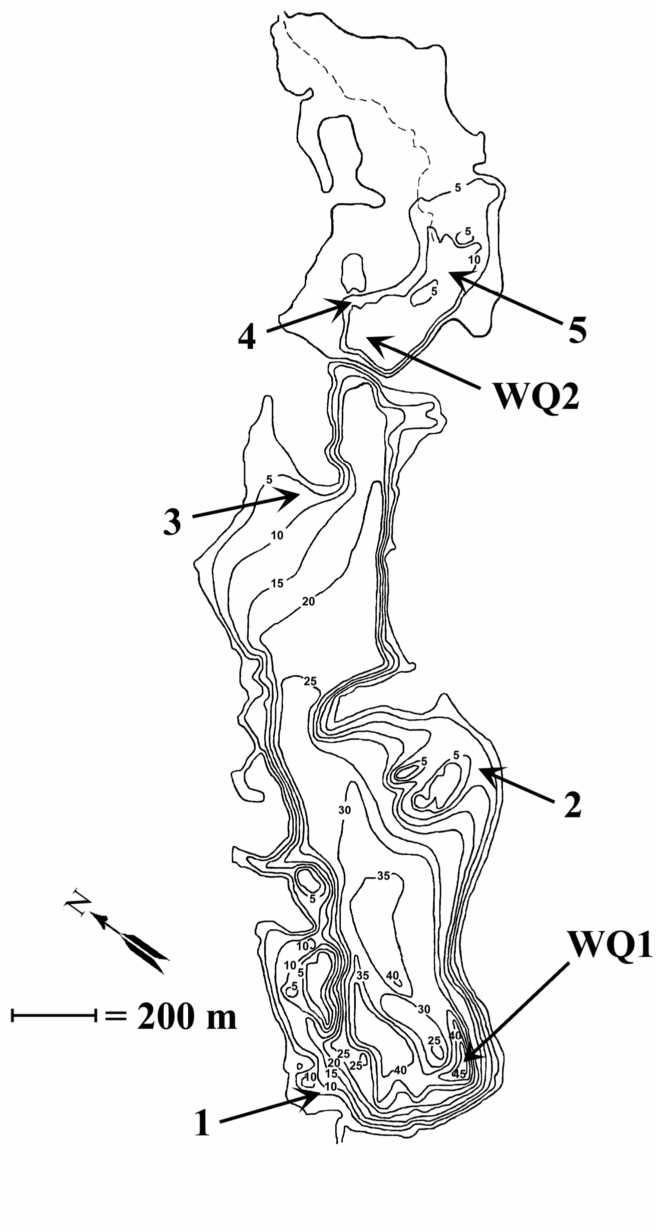

Figure 1. Bathymetric map of Moraine Lake, Madison County, NY. Contours in feet. WQ1 and WQ2 indicate were water quality data were collected, sites 1-5 indicate where plant biomass was sampled.

RESULTS

Water Quality Analysis

Thermal stratification was evident in the lower basin when sampling commenced on 5 June. Initially, waters were oxygenated above 10 m depth; by September, waters below 8 m were anoxic. Conductivity (ranging from 250-370 umho/cm) and pH (ranging from 7.1-8.9) were consistent with earlier BFS findings. The mean transparency was 4.1 m (range = 2.6-5.7). The upper basin was marginally stratified on 12 June, and the bottom waters were anoxic in July and August. Mixing was evident in September into October. Conductivity and pH values were similar to those in the lower basin.

Surface total phosphorus concentrations were somewhat lower than those in past years in the lower basin, ranging from 9.5-16.1 ug/l and somewhat higher in the upper basin, ranging 27.5-54.1ug/l. Ammonia was less than 0.05 mg/l at all samplings and total nitrogen exhibited parallel dynamics in both basins. In early June, nitrite+nitrate was 0.58 mg/l in the lower basin and 0.01 mg/l in the upper basin. Concentrations gradually dropped to below detection in both basins. Total nitrogen was consistent over the summer at both basins (~0.60 mg/l in the lower, 0.30 mg/l in the upper).

Plant Biomass

Macrophyte biomass per species and by site over 2007 is shown in Tables 1-25. These data are graphically represented along with 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) and 2006 (Harman et al. 2007) in Figures 2-6 for sites 1-5, respectively. Figures 7 and 8 show the relationship between the amount of Eurasian water-milfoil to all the other aquatic macrophytes in both the upper basin and lower basin of the lake for years where data are available since 1996. The distinction is given to milfoil because its control is the objective of management.

Plants of all species were growing at lower densities in the upper basin (Figure 7), though Eurasian water-milfoil was encountered at both sites in that basin. Plant diversity was as high, at 6 species, though on three occasions, sites in this basin were devoid of rooted plants.

Eurasian water-milfoil was virtually absent from the lower basin throughout the growing season, only appearing at very low densities on 10 October at sites 2 and 3 (Tables 22 and 23, Figure 8). *Elodea*, which in the past has been negatively impacted by Sonar® treatments (Harman et al. 2005), was found in each of the upper basin sites, sometimes in high densities. Site 1 consistently exhibited the greatest plant diversity, and was always dominated by the macroalgae *Chara vulgaris*. Anecdotal observations indicated this plant at high densities elsewhere, particularly near the northeast shore of this basin.

	A	B	C	D	E	Avg
Site 1: 6/5/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris	823.71	1040.25	491.54	296.68	288.95	588.23
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus		0.64		4.25		0.98
Potamogeton zosteriformis		30.21	48.61	10.60	11.33	20.15
Potamogeton pusillus						0.00
Nitella flexilis	0.00	0.00	0.00	0.00	0.00	0.00
					total	609.35

Table 1. Macrophyte biomass, site #1, 5 June 2007.

	A	B	C	D	E	Avg
Site 2: 6/5/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata	121.66	88.53	24.75	152.33	54.44	88.34
Potamogeton crispus	61.50	95.49	94.18	35.80	13.46	60.09
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	148.43

Table 2. Macrophyte biomass, site #2, 5 June 2007.

	A	B	C	D	E	Avg
Site 3: 6/5/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus	242.26	35.81	197.21	24.54	71.23	114.21
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	114.21

Table 3. Macrophyte biomass, site #3, 5 June 2007.

Site 4: 6/5/07	A Dry Wt. (g/m^2)	B Dry Wt. (g/m^2)	C Dry Wt. (g/m^2)	D Dry Wt. (g/m^2)	E Dry Wt. (g/m^2)	Avg Dry Wt. (g/m^2)
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris				1.78		0.36
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus	296.86	241.76	3.61	81.41	182.40	161.21
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	161.57

Table 4. Macrophyte biomass, site #4, 5 June 2007.

Site 5: 6/5/07	A Dry Wt. (g/m^2)	B Dry Wt. (g/m^2)	C Dry Wt. (g/m^2)	D Dry Wt. (g/m^2)	E Dry Wt. (g/m^2)	Avg Dry Wt. (g/m^2)
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus	114.04	113.75	229.64	193.39	68.91	143.95
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	143.95

Table 5. Macrophyte biomass, site #5, 5 June 2007.

Site 1: 7/6/07	A Dry Wt. (g/m^2)	B Dry Wt. (g/m^2)	C Dry Wt. (g/m^2)	D Dry Wt. (g/m^2)	E Dry Wt. (g/m^2)	Avg Dry Wt. (g/m^2)
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris	1069.75	1365.50	2739.00	1562.25	2258.88	1799.08
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata	78.60		2.05	366.08	33.45	96.04
Potamogeton crispus						0.00
Potamogeton zosteriformis	24.85	83.58	3.09		50.85	32.47
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	1927.58

Table 6. Macrophyte biomass, site #1, 26 June 2007.

	A	B	C	D	E	Avg
Site 2: 7/6/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata	406.58	797.70	263.64		725.50	438.68
Potamogeton crispus	24.05	23.34	27.01	36.93	158.88	54.04
Potamogeton zosteriformis	15.68			18.28	10.29	8.85
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	501.57

Table 7. Macrophyte biomass, site #2, 26 June 2007

	A	B	C	D	E	Avg
Site 3: 7/6/07	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (gm^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis				0.25		0.05
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata				0.38		0.08
Potamogeton crispus	412.00	2725.13	177.44	288.00	293.63	779.24
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	779.36

Table 8. Macrophyte biomass, site #3, 26 June 2007

	A	B	C	D	E	Avg
Site 4: 7/6/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus						0.00
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	0.00

Table 9. Macrophyte biomass, site #4, 26 June 2007

	A	B	C	D	E	Avg
Site 5: 7/6/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus						0.00
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	0.00

Table 10. Macrophyte biomass, site #5, 26 June 2007.

	A	B	C	D	E	Avg
Site 1: 8/8/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis	3.13	7.50	75.00			17.13
Ceratophyllum demersum			3.75			0.75
Chara vulgaris	1488.13	2316.25	2414.38	3988.13	1143.75	2270.13
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata				161.88		32.38
Potamogeton crispus						0.00
Potamogeton zosteriformis	17.50	19.38	23.75	739.38	240.63	208.13
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	2528.50

Table 11. Macrophyte biomass, site #1, 8 August 2007.

	A	B	C	D	E	Avg
Site 2: 8/8/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis	10.63			20.00		6.13
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata	335.63	273.13	473.13		100.63	236.50
Potamogeton crispus	31.25	46.25	51.88	22.50	39.38	38.25
Potamogeton zosteriformis	358.13				778.75	227.38
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	508.25

Table 12. Macrophyte biomass, site #2, 8 August 2007.

Site 3: 8/8/07	A Dry Wt. (g/m^2)	B Dry Wt. (g/m^2)	C Dry Wt. (g/m^2)	D Dry Wt. (g/m^2)	E Dry Wt. (g/m^2)	Avg Dry Wt. (g/m^2)
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis			60.63	35.63		19.25
Ceratophyllum demersum		1.88				0.38
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus		7.50	0.63	0.63	5.00	2.75
Potamogeton zosteriformis	1.25	28.13	0.63		20.63	10.13
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	32.50

Table 13. Macrophyte biomass, site #3, 8 August 2007.

Site 4: 8/8/07	A Dry Wt. (g/m^2)	B Dry Wt. (g/m^2)	C Dry Wt. (g/m^2)	D Dry Wt. (g/m^2)	E Dry Wt. (g/m^2)	Avg Dry Wt. (g/m^2)
Myriophyllum spicatum	25.00		1.88	20.63	23.75	14.25
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis					0.63	0.13
Ceratophyllum demersum					0.63	0.13
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata			0.63			0.13
Potamogeton crispus	7.50		0.63	0.63	0.63	1.88
Potamogeton zosteriformis	3.75		18.75	0.63	105.63	25.75
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	42.25

Table 14. Macrophyte biomass, site #4, 8 August 2007.

Site 5: 8/8/07	A Dry Wt. (g/m^2)	B Dry Wt. (g/m^2)	C Dry Wt. (g/m^2)	D Dry Wt. (g/m^2)	E Dry Wt. (g/m^2)	Avg Dry Wt. (g/m^2)
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum		6.25		0.63		1.38
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata					0.63	0.13
Potamogeton crispus						0.00
Potamogeton zosteriformis					142.50	28.50
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	30.00

Table 15. Macrophyte biomass, site #5, 8 August 2007.

	A	B	C	D	E	Avg
Site 1: 9/12/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia					8.75	1.75
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris	1206.88	993.13	788.38	2570.00	287.38	1169.15
Vallisneria americana					18.50	3.70
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus						0.00
Potamogeton zosteriformis	14.88	3.38	2.50	15.00	237.63	54.68
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	1229.28

Table 16. Macrophyte biomass, site #1, 12 September 2007.

	A	B	C	D	E	Avg
Site 2: 9/12/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia	21.75	6.63			15.50	8.78
Najas flexilis	4.00				2.75	1.35
Ceratophyllum demersum						0.00
Chara vulgaris		3.00	0.50		0.50	0.80
Vallisneria americana						0.00
Elodea canadensis		74.75			0.13	14.98
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata			1.25	1.75		0.60
Potamogeton crispus		1.38	5.38	26.13	7.75	8.13
Potamogeton zosteriformis		7.63	2.13	9.63	45.63	13.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	47.63

Table 17. Macrophyte biomass, site #2, 12 September 2007.

	A	B	C	D	E	Avg
Site 3: 9/12/07	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (gm^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia		122.50	148.75	34.63	94.75	80.13
Najas flexilis	52.00	140.75	65.00	72.38	129.88	92.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus					9.88	1.98
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	174.10

Table 18. Macrophyte biomass, site #3, 12 September 2007.

	A	B	C	D	E	Avg
Site 4: 9/12/07	**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)**
Myriophyllum spicatum	489.00		20.00		11.50	104.10
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis				60.63	285.00	69.13
Ceratophyllum demersum				3.25		0.65
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus		11.50	2.13	3.25		3.38
Potamogeton zosteriformis			50.25			10.05
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	187.30

Table 19. Macrophyte biomass, site #4, 12 Septemebr 2007.

	A	B	C	D	E	Avg
Site 5: 9/12/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus						0.00
Potamogeton zosteriformis						0.00
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	0.00

Table 20. Macrophyte biomass, site #5, 12 September 2007.

	A	B	C	D	E	Avg
Site 1: 10/10/07	**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)**
Myriophyllum spicatum						0.00
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis						0.00
Ceratophyllum demersum						0.00
Chara vulgaris	2235.75	1149.50	399.13	1728.75	977.00	1298.03
Vallisneria americana					0.25	0.05
Elodea canadensis			0.25	0.63		0.18
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus	0.25	4.75	0.34			1.07
Potamogeton zosteriformis		6.00	19.50	11.13	0.75	7.48
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	1306.79

Table 21. Macrophyte biomass, site #1, 10 October 2007.

	A	B	C	D	E	Avg
Site 2: 10/10/07	**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)**
Myriophyllum spicatum				0.13		0.03
Megalodonta beckii						0.00
Zosterella dubia		6.50				1.30
Najas flexilis				0.13		0.03
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana				4.68		0.94
Elodea canadensis	364.88	146.13	0.13		0.38	102.30
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus	17.25	10.50	42.13	2.13	127.88	39.98
Potamogeton zosteriformis	53.13		1.75	24.50	4.25	16.73
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	161.29

Table 22. Macrophyte biomass, site #2, 10 October 2007.

	A	B	C	D	E	Avg
Site 3: 10/10/07	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (gm^2)**	**Dry Wt. (g/m^2)**	**Dry Wt. (g/m^2)**
Myriophyllum spicatum			37.00	2.63	1.75	8.28
Megalodonta beckii						0.00
Zosterella dubia	10.00	385.25	362.50		321.00	215.75
Najas flexilis	0.13	0.13				0.05
Ceratophyllum demersum			7.25			1.45
Chara vulgaris						0.00
Vallisneria americana	0.23					0.05
Elodea canadensis		3.88	77.75	515.13		119.35
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus	2.75	1.75	23.13	11.75		7.88
Potamogeton zosteriformis			0.50			0.10
Potamogeton pusillus						0.00
Nitella flexilis	183.63	3.00	0.88	7.13		38.93
					total	391.82

Table 23. Macrophyte biomass, site #3, 10 October 2007.

	A	B	C	D	E	Avg
Site 4: 10/10/07	**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)**
Myriophyllum spicatum	359.13	146.75	42.00	88.00	110.75	149.33
Megalodonta beckii						0.00
Zosterella dubia						0.00
Najas flexilis	0.15	7.63	3.35	30.25	0.18	8.31
Ceratophyllum demersum		0.63	65.25		4.38	14.05
Chara vulgaris						0.00
Vallisneria americana						0.00
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata						0.00
Potamogeton crispus		1.20	3.38		2.38	1.39
Potamogeton zosteriformis	2.38	2.00	1.38			1.15
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	174.23

Table 24. Macrophyte biomass, site #4, 10 October 2007.

	A	B	C	D	E	Avg
Site 5: 10/10/07	**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)**
Myriophyllum spicatum	85.88	0.88			0.63	17.48
Megalodonta beckii						0.00
Zosterella dubia			8.50	0.28	30.38	7.83
Najas flexilis	0.75	3.38	1.96	4.75	0.15	2.20
Ceratophyllum demersum						0.00
Chara vulgaris						0.00
Vallisneria americana		62.13			94.50	31.33
Elodea canadensis						0.00
Ranunculus aquatilis						0.00
Ranunculus trichophyllus						0.00
Stuckenia pectinata		11.00	11.25			4.45
Potamogeton crispus	10.13	1.08	0.93	7.25	2.88	4.45
Potamogeton zosteriformis	40.50	9.41	27.00	2.38		15.86
Potamogeton pusillus						0.00
Nitella flexilis						0.00
					total	83.59

Table 25. Macrophyte biomass, site #5, 26 June 2007.

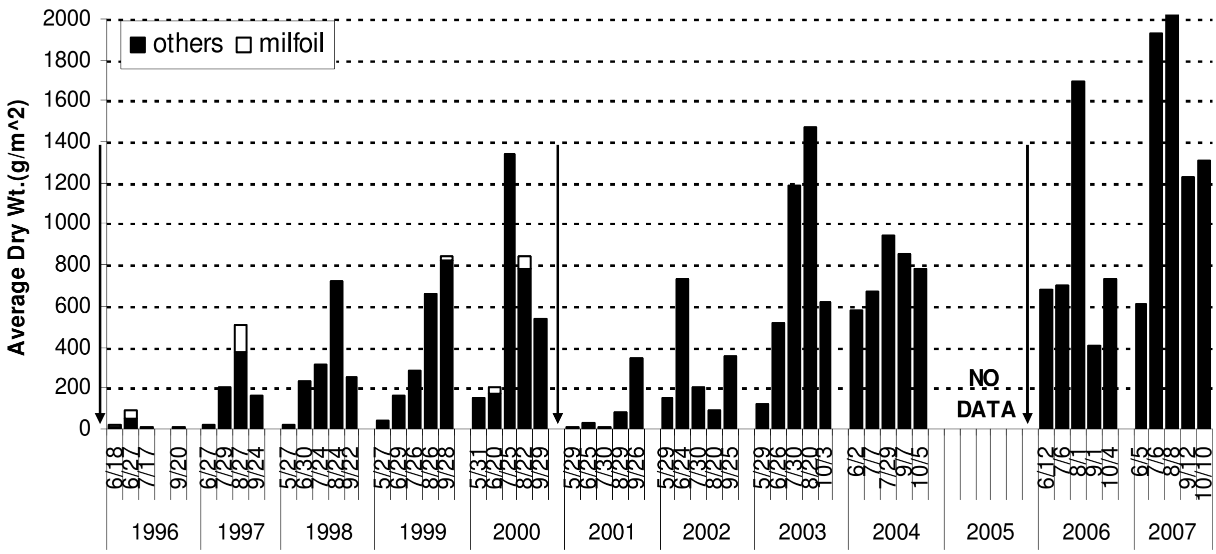

Figure 2. Comparison of dry weight (g/m^2) of EWM and other plants combined, site #1, 1996-2007. Each bar represents the mean of five replicate samples. Arrows represent Sonar application.

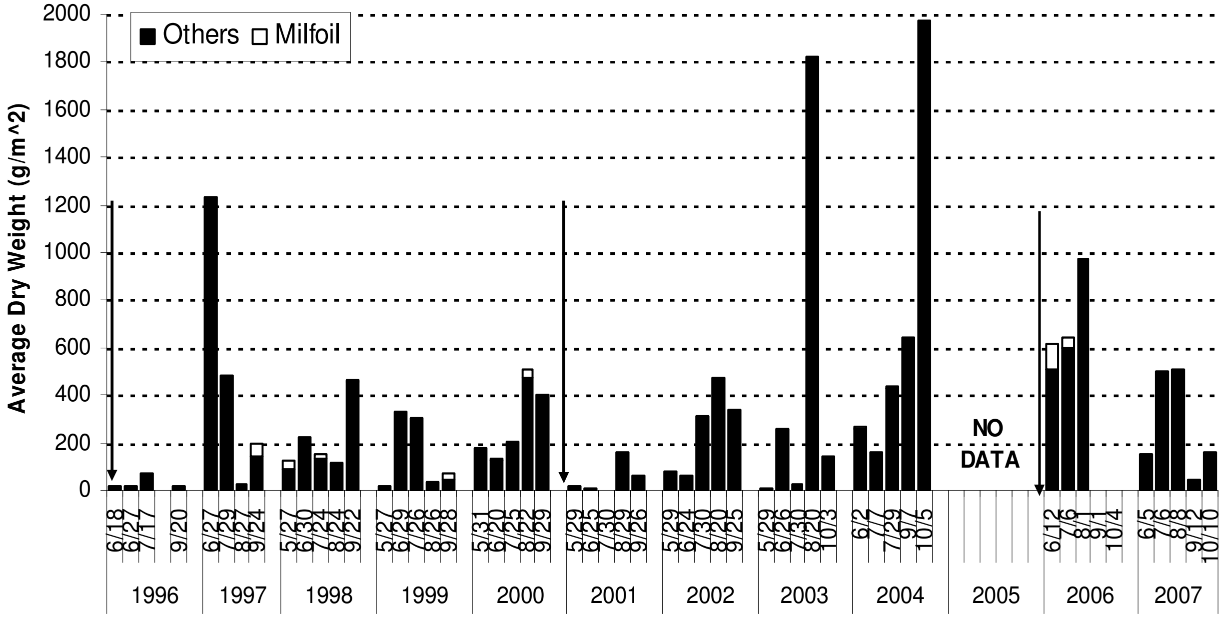

Figure 3. Comparison of dry weight (g/m^2) of EWM and other plants combined, site #2, 1996-2007. Each bar represents the mean of five replicate samples. Arrows represent Sonar application.

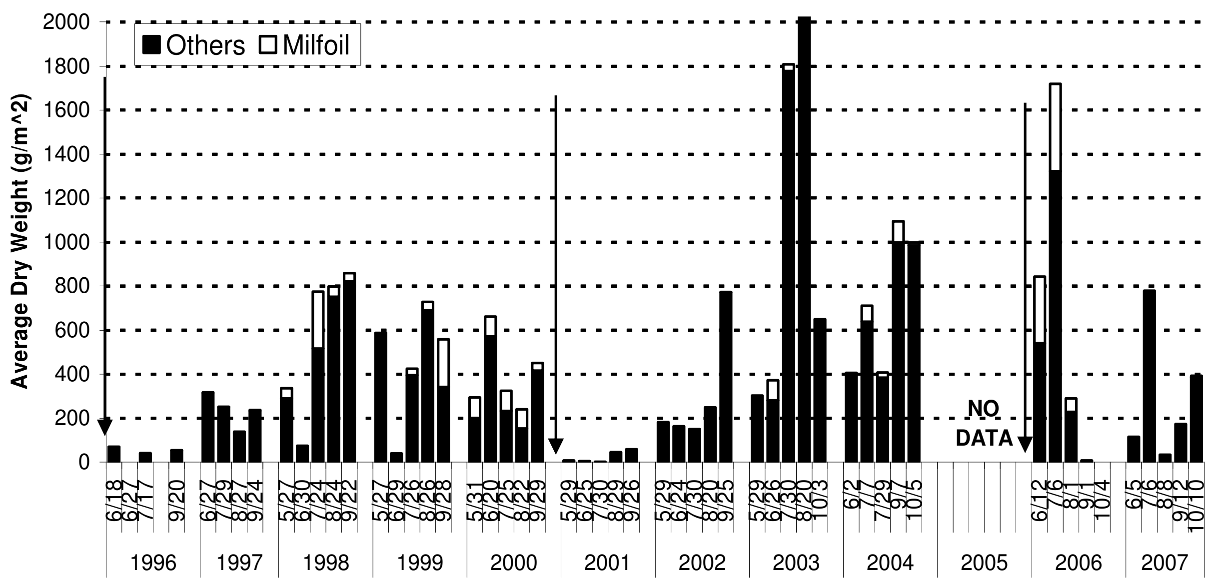

Figure 4. Comparison of dry weight (g/m^2) of EWM and other plants combined, site #3, 1996-2007. Each bar represents the mean of five replicate samples. Arrows represent Sonar application.

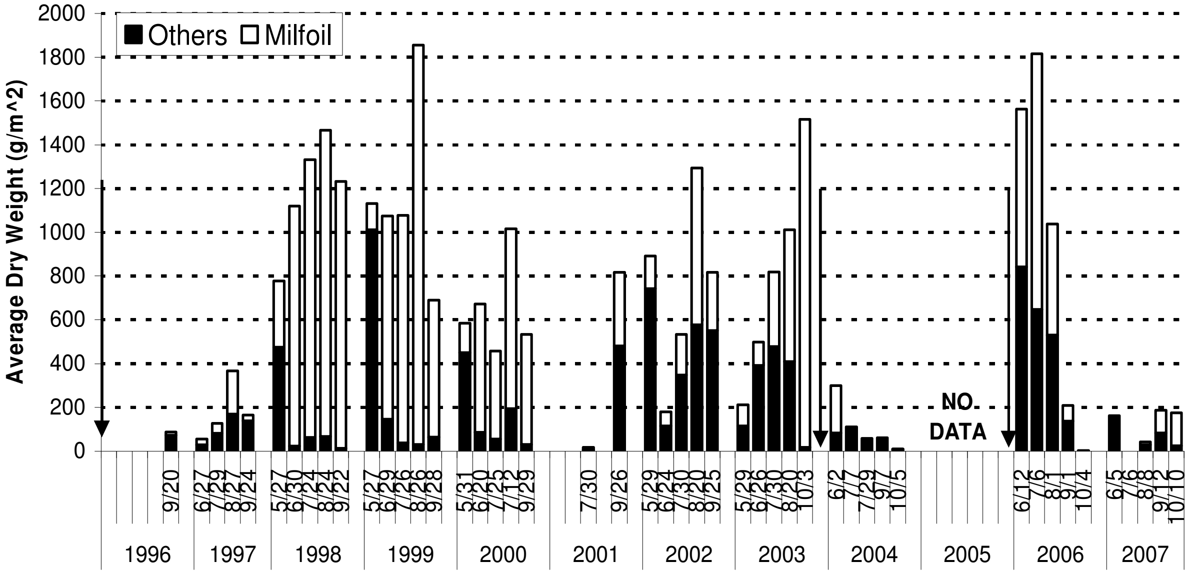

Figure 5. Comparison of dry weight (g/m^2) of EWM and other plants combined, site #4, 1996-2007. Each bar represents the mean of five replicate samples. Arrows represent Sonar application.

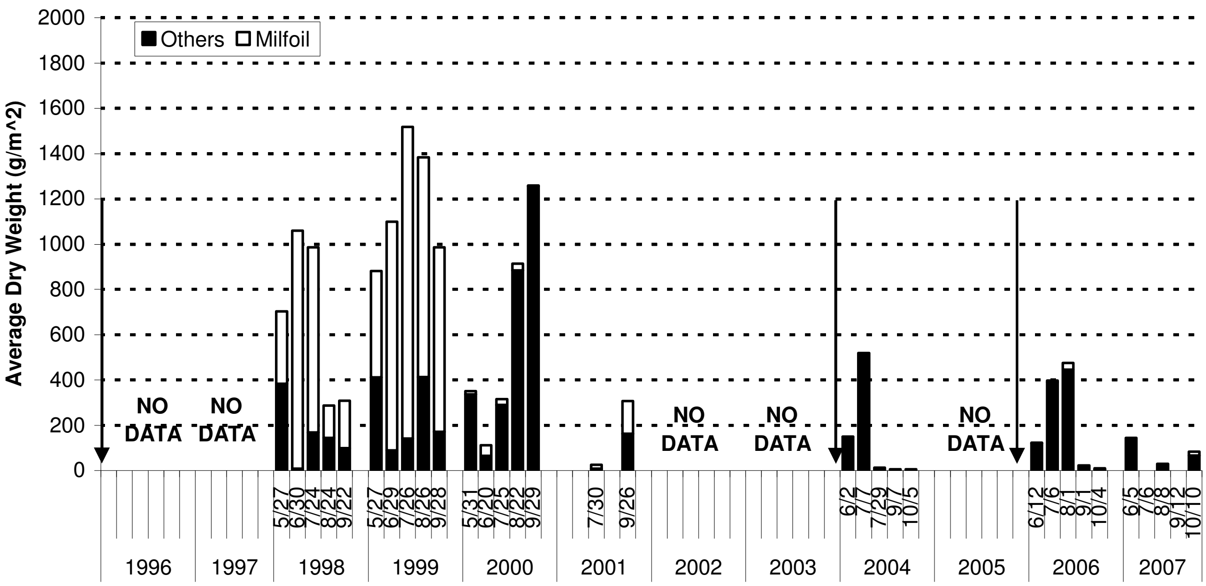

Figure 6. Comparison of dry weight (g/m^2) of EWM and other plants combined, site #5, 1996-2007. Each bar represents the mean of five replicate samples. Arrows represent Sonar application.

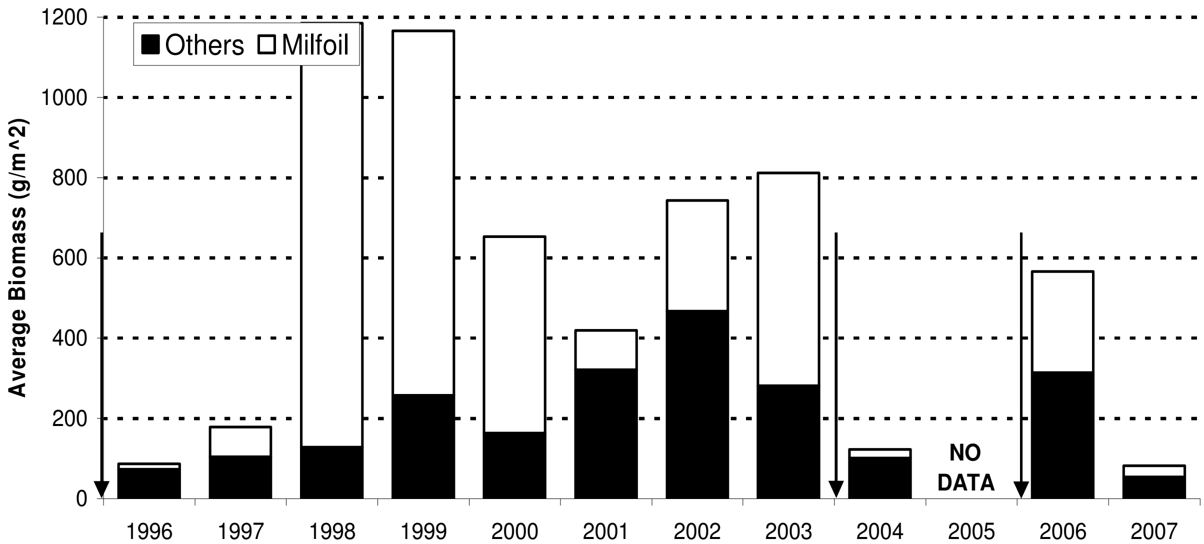

Figure 7. Comparison of mean annual biomass of EWM and other aquatic plants, 1996-2007, in the upper basin. Arrows represent Sonar application.

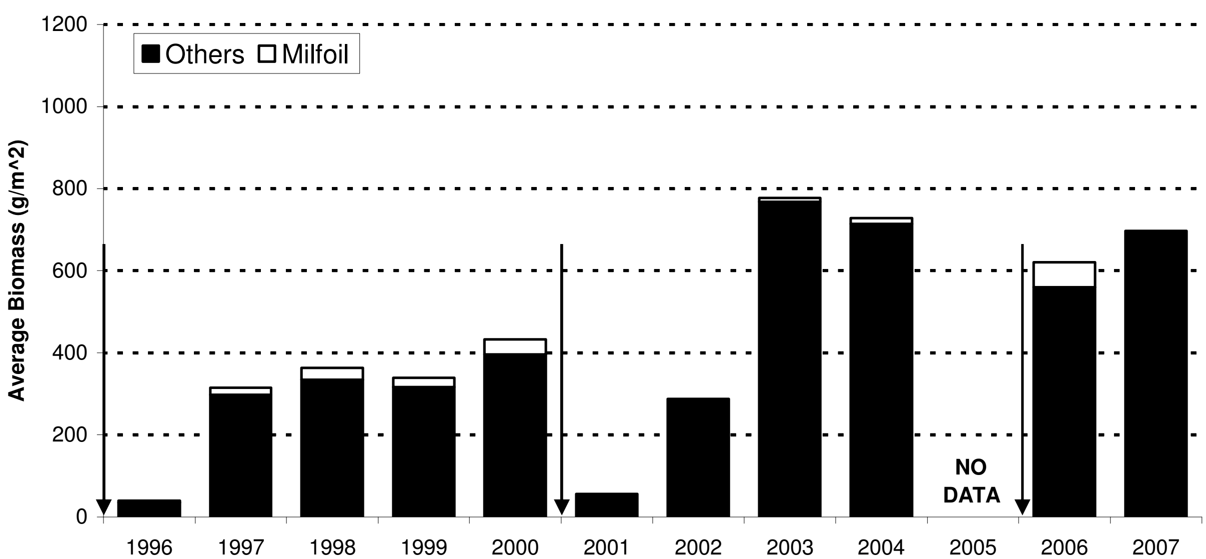

Figure 8. Comparison of mean annual biomass of EWM and other aquatic plants, 1996-2007, in the lower basin. Arrows represent Sonar application.

DISCUSSION

The amounts of aquatic plant species recorded as dry weight (biomass) (Table 1-25) varies widely by site, specific replicate sampling and over time and space due to the clumped distributions of aquatic macrophytes and their periods of seasonal growth and decomposition. Comparisons of biomass (Figures 2-4, 8) document a reduction in amounts of non-target plant species after each SONAR application which then exhibit rapid recoveries. After each herbicide application *Myriophyllum spicatum*, the target organism, was decimated then slowly increased over three or four years before again becoming a perceived problem.

In the Upper Basin the history of SONAR treatment has been different from the Lower because of efforts with biological control in the early 2000s using *Eurychiopsis leconti* to manage *M. spicatum* there (Figure 7). Those attempts had no decipherable impacts on *M. spicatum* biomass. In 2001 treatment with SONAR in the Lower Basin had an impact on plant biomass in the Upper Basin indicating some “upstream” migration of herbicide (Figure 7).

Long-term trends indicate a gradual increase in non-target aquatic macrophytes over the years in the Lower Basin (Figure 8) concurrent with the desired management of *M. spicatum*. We believe those trends indicate annual utilization of nutrients in the system formerly available to the large populations of *M. spicatum* present before SONAR treatments were begun in the early 1990s. In the Upper Basin sampling immediately after herbicide application in 2006 (Figures 5, 7) documented large residual numbers of plants before the full impacts of treatment were evident. That same phenomenon is documented to a lesser extent at several locations and times (Figures 2 -8).

In the fall of 2007 we recognized a newly introduced aquatic macrophyte in the lake, the first since our current work started on Lake Moraine in 1996. It is starry stonewort (*Nitellopsis obtusa*). Data we recorded for *Chara vulgaris* (common stonewort) in 2007 at Site # 1 (Tables 1, 6, 11, 16, 21) is confused with *N. obtusa* and is recorded as *C. vulgaris* in this report.

REFERENCES

Aquatic Ecosystem Restoration Foundation (AERF). 2005. Aquatic Plant Management. Best Management Practices in Support of Fish and Wildlife Habitat. Marietta, Georgia.

APHA, AWWA, WEF. 1992. Standard methods for the examination of water and wastewater, 18th ed. American Public Health Association. Washington, D.C.

Anon. 1988. Madison County septic system survey. Madison County Planning Department, Wampsville, NY 13163.0

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. 1978. The effects of Simazine® on the molluscan fauna of Moraine Lake, New York. The Nautilus. 92(3) 129-134.

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, NY. Tech. Rept. #5. SUNY Oneonta Bio. Fld. Sta., Oneonta, NY.

Harman, W. N., M.F. Albright, P. H. Lord and M. Miller. 2000. Aquatic macrophyte management plan facilitation of Lake Moraine, Madison County, NY. Tech. Rept. #9. SUNY Oneonta Bio. Fld. Sta., Oneonta, NY.

Harman, W. N., M. F. Albright, P. H. Lord and M. E. Miller. 2002. Aquatic macrophyte management plan facilitation of Lake Moraine, Madison County, NY. Tech. Rept. #13. SUNY Oneonta Bio. Fld. Sta., Oneonta, NY.

Harman, W.N., M.F. Albright and K. Blanchard. 2005a. Aquatic plant management plan facilitation of Moraine Lake, Madison County, NY. Tech. Rept. # 22. SUNY Oneonta Bio. Fld. Sta., Oneonta, NY.

Harman, W.N., L.P. Hingula, and C.E. Macnamara. 2005b. Does long-term macrophyte management in lakes affect biotic richness and diversity? Journal of Aquatic Plant Management 43:57-64.

Kastens, K. A. 1974. Lake Moraine: Algae and weeds, the problems and the solutions. Unpublished manuscript, Colgate University, Hamilton, NY.

SePRO Corporation, 1999. Options for Aquatic Plant Management. 11550 North Meridian Street Suite 600, Carmel, IN 46032.

Slater, John. 2006. Personal Communication. Moraine Lake Association.