Upper Saranac Lake Eurasian Watermilfoil

ANNUAL MONITORING REPORT

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Paul Smith's College
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Acknowledgements

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Project Summary

In the summer of 2004 in concert with the expanded milfoil harvesting effort in Upper Saranac Lake, the Adirondack Watershed Institute began an independent study supported with funds from the Upper Saranac Lake Foundation. The objectives of this independent study are to assess the manual control effort and to measure the effectiveness of control (e.g. duration, methods, native plant response). Details of the methods used to meet these objectives are found in the Research Methods section of this report. The results of this study thus far show that milfoil density has been maintained at a comparatively low level during the maintenance period. However, the number of sites with year to year increases in milfoil density and the overall average density of milfoil both increased in 2009 compared to the two previous years of maintenance control, suggesting that the milfoil population is gradually re-expanding. Most of this increase could be attributed to one site, the previously matted area in Saginaw Bay, which also illustrated how rapidly milfoil density can increase, with density increasing from about 200 stems per acre to over 2,500 stems per acre from May to August in 2009. The milfoil data collected at the non-managed site in Fish Creek Pond showed that significant population expansion can occur through the fall; in fact, in 2007, the greatest increase in density occurred from August to October. Year to year differences in milfoil density in Fish Creek Pond were positively correlated with growing degree days (GDD), a weather suitability indicator based on temperature that was used to estimate the length and quality of the growing season. Growing season length varied from 110 to 140 days and GDD varied from 1,016 to 1,727. This large variation in growing season length and GDD and the corresponding effect on aquatic plant growth represents a challenge to timing management activity. When management activity ends in August during a year with a longer growing season and/or higher GDD, significant unchecked plant growth can occur into the fall. This results in higher starting milfoil densities the next year. If management activity were able to be extended into the fall in good growing years, then this should minimize population expansion the next year. Twenty four species of aquatic plants have been observed on the transects, with the most commonly occurring species being water nymph, eelgrass, Robbins pondweed, and stonewort. Eurasian watermilfoil currently ranks 14th in terms of relative abundance in Upper Saranac Lake. Aquatic plant diversity follows a strong seasonal pattern, with maximum diversity occurring in August of each year. Aquatic plant diversity has increased over time at sites that had high milfoil levels reported in 2004. This finding demonstrates that high milfoil density suppresses native plant diversity and reducing milfoil density through hand harvesting allows the native plant community to re-colonize and increase diversity.

The Upper Saranac Lake milfoil control program and aquatic plant monitoring project continue to be valuable sources of information for other lake groups, agencies, and non-profits interested in aquatic invasive species. A peer-reviewed paper on the first 5 years of this study was recently published in the Journal of Aquatic Plant Management (Kelting and Laxson, 2010). We recommend continued monitoring not only to support the management effort in Upper Saranac Lake but also to support the larger need for good long term information on management.

Research Methods

Year 2004

In 2004, thirteen sites with historically high milfoil populations were selected in Upper Saranac Lake (Figure 1). At each site, a combination of the line intercept method and fixed plot method are being used to monitor the presence and abundance of aquatic plants. Both of these methods have been used for over 100 years in forest ecosystem studies, and have since been adopted as standard methods in aquatic ecosystem studies (Madsen 1999). The methods described below are the same as those used on Lake George in peer-reviewed milfoil studies (Madsen et al. 1988; Madsen et al. 1991; and Eichler et al. 1995).

Two to four transect lines were established at each site in 2004. The endpoints of each transect line were marked permanently with rebar and PVC pipe. The location of each endpoint was then geo-referenced with a sub-meter GPS unit (Trimble ProXR owned by Paul Smith's College), so the points and transects could be plotted using GIS and relocated and reestablished if needed.

Each transect was laid out by first locating the near-shore endpoint at 1 meter depth. We then moved perpendicular to the shoreline and located the second endpoint at 5 meters depth. The 1 and 5 meter depths bracket the extent of milfoil, and are consistent with work done on Lake George (Eichler et al. 1995; Madsen et al. 1988). At several locations the lake bottom had very little slope, in which case 45 meter long transects were established and the corresponding depths at the endpoints were recorded.

Species presence was determined for 3 meter intervals along each transect line. A SCUBA diver swam the line which was marked by a rope floating midway between the top and bottom of the lake. The diver recorded species as present if they intersected the vertical plane from bottom to surface.

The SCUBA diver also determined species abundance at 1, 3, and 5 meters depth along each transect line in 1 m^2 plots established at these depths. Abundance was measured by counting the number of stems by species and estimating percent canopy cover by species. Percent canopy cover by species was estimated using the same abundance classes used by Eichler et al (1995) in Lake George: abundant (greater than 50%), common (25 to 50%), present (15 to 25%), occasional (5 to 15%), rare (1 to 5%), and none.

The original plan was to measure the transects every 30 days from May through September (5 measurements), but the total number of measurements taken varied from 3 to 5 in 2004.

Year 2005

To increase the accuracy of transect measurements, increase efficiency, and to facilitate controlled harvesting of milfoil at the transect sites by the dive crews, the location of each transect was marked permanently in May of 2005. Nylon rope with markings every 3

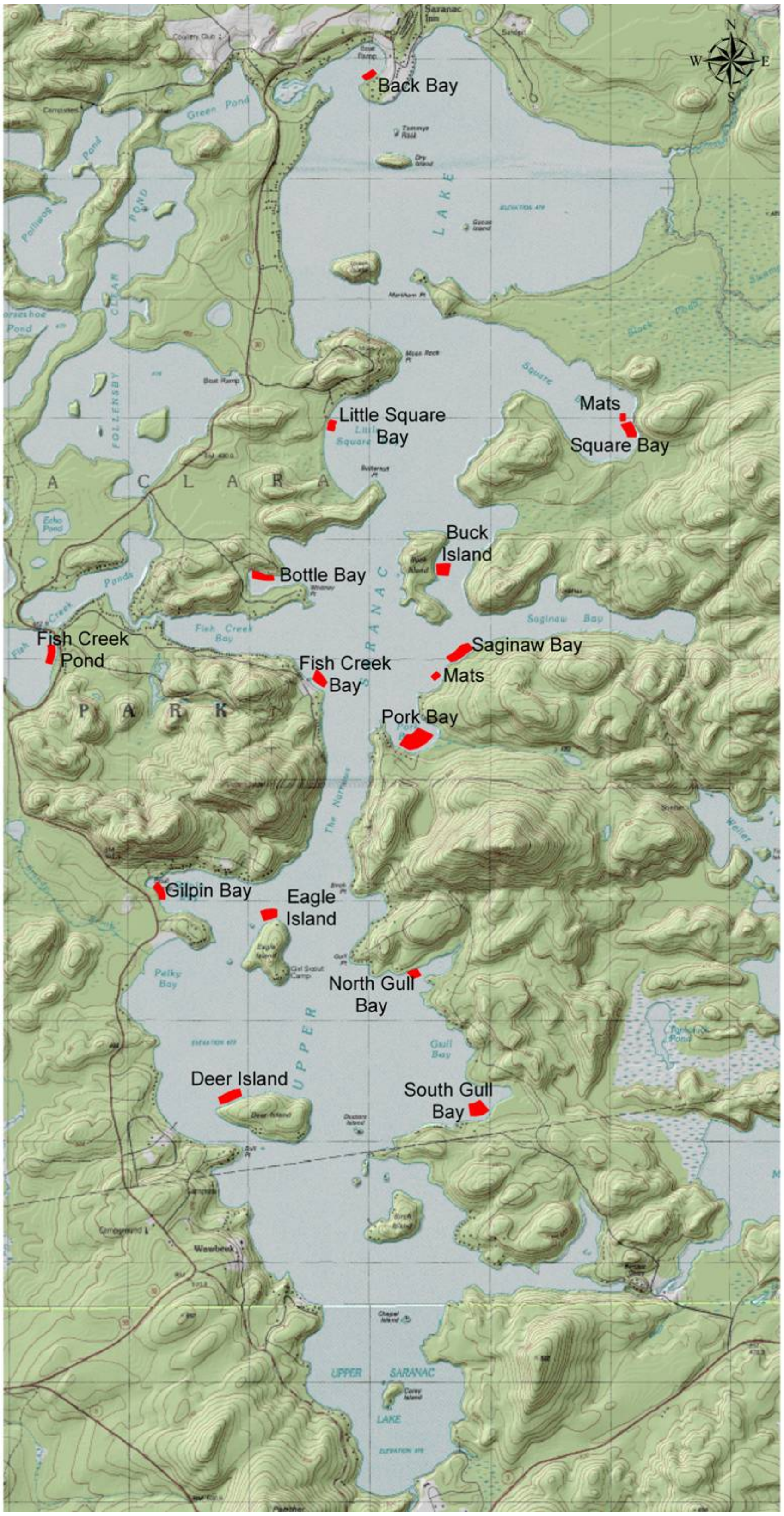

Figure 1. Site locations for long-term monitoring.

meters was fixed to the bottom along each transect line. About 12,000 feet (2.3 miles) of nylon line was fixed to the lake bottom.

Instead of just recording species presence along the transect lines, as was done in 2004, milfoil stems were counted in 1 meter wide bands in each 3 meter transect segment. This change increased the bottom surface area sampled for milfoil and allowed for more accurate scaling of milfoil stem counts. The improved accuracy of this approach was verified when actual milfoil stem counts by the dive crews were similar to those estimated from transects measurements. Milfoil height was recorded using a 4 level scaling system for each plant in each segment. The presence of all other species was recorded using the same procedure used in 2004.

Two additional sites were added to examine milfoil regrowth after removing benthic mats (labeled Mat 1 and Mat 2 in Figure 1). Following mat removal in mid-May, a single 45 meter long transect line was laid down along the centerline of each of the two matted areas. These transects were measured using the same procedure described previously.

All transects were measured 5 times on an approximate 30 day interval, beginning in May and ending in September. Each set of measurements were collected in a one week period. The same water quality data collected in 2004 was again collected in 2005. To insure consistency in harvest timing, all transects were harvested over a three day period in late June and again in late August, for a total of two harvests per season in 2005 and 2006.

Year 2006

An additional month of sampling was added for 2006, increasing the total number of samplings to six months and extending the sampling season into mid-October thereby obtaining two sets of measurements after the final milfoil harvest (only one post-harvest set was collected in 2005).

We also added one more sampling site, bringing the total number of sites to sixteen. This site was located in Fish Creek Ponds, west of the Route 30 Bridge, in an area were milfoil has not been controlled (Figure 1). This site provides data on milfoil growth in the absence of management and will be a valuable benchmark against which to compare milfoil regrowth at the other 15 sites. This site was established and measured following the same procedures used for the other sites.

Results

The average milfoil density by month and year is shown in Figure 2. The presentation of results has been altered to more easily see the annual changes in milfoil density, and the two months of complete data (all transects measured) from 2004 have also been added to the figure. The vertical dashed line denotes the change in management effort, with 2004 – 2006 being intensive management and 2007 – 2009 being maintenance management.

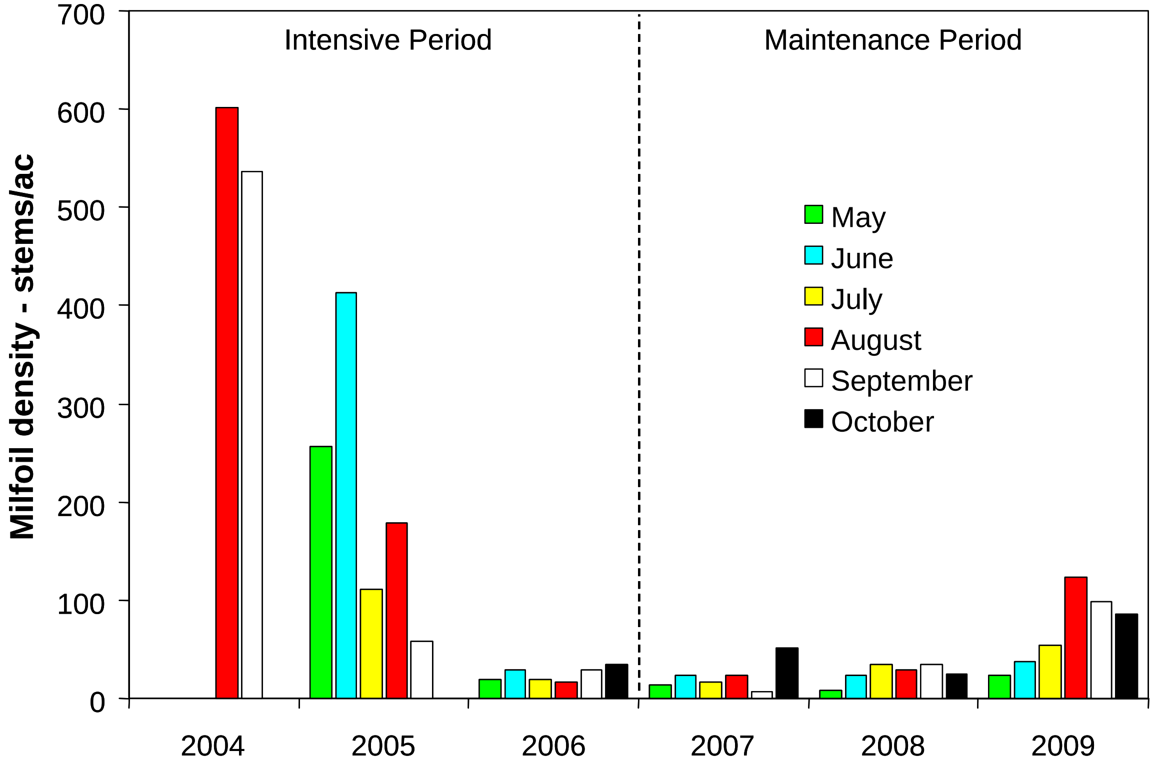

Figure 2. Average milfoil density by month and year at the 15 monitoring sites located in Upper Saranac Lake, New York.

The exponential decline in milfoil density in response to intensive management is clearly seen, compare August of 2004 at 600 stems per acre to August of 2006 at 25 stems per acre (Figure 2). The low milfoil density attained in the third year of intensive management was able to be maintained in 2007 and 2008, the first two years of maintenance management. However, the 2009 milfoil density results suggest that the milfoil population has started to expand and thus maintenance management may not be able to hold the population at a sustained low level. But, a close look at the site specific milfoil densities reveals that the previously matted area in Saginaw Bay contributes most of the increase in milfoil density observed in 2009 (Figure 3), with this location representing 76% of the increased density. Discounting this one site, the October density is similar to 2007.

Fig. 3a.

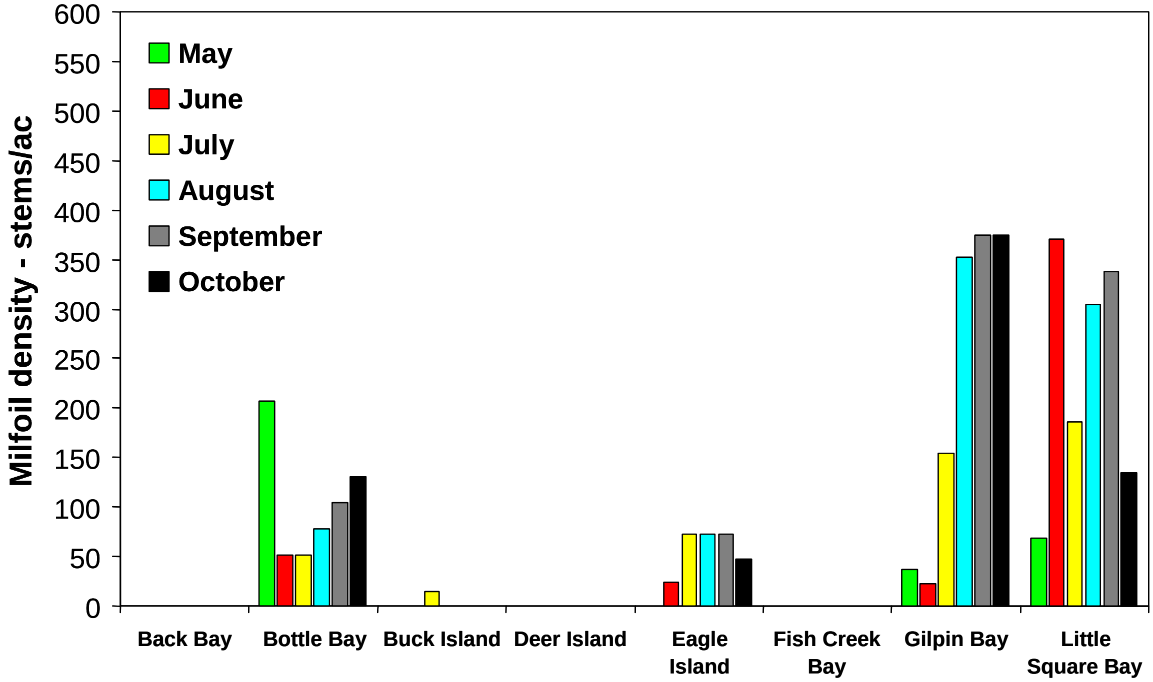

Fig. 3b.

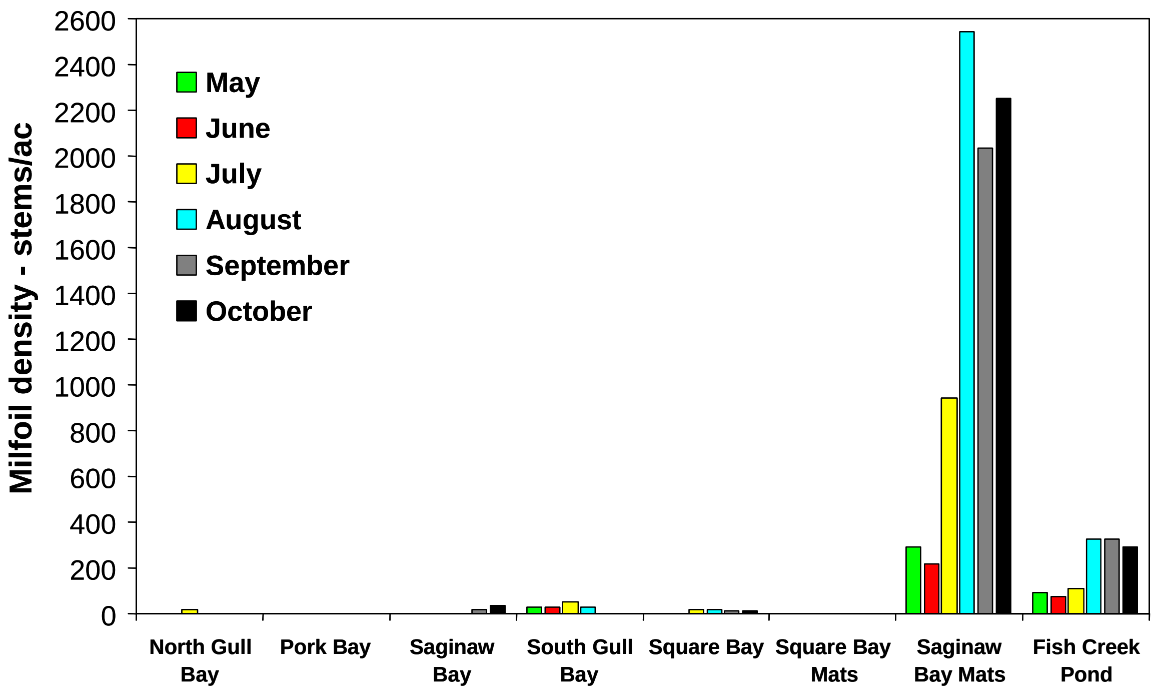

Figure 3. Average milfoil density by month in 2009 for the 15 monitoring sites in Upper Saranac Lake and 1 monitoring site located in Fish Creek Pond, New York.

Though the previously matted location in Saginaw Bay contributed the most to the increased milfoil density observed in 2009, the number of sites with year to year increases in milfoil density has risen steadily since 2006. This trend is illustrated in Figure 4, which shows the year to year change in milfoil density measured in September. Milfoil density only increased at two sites from September 2005 to 2006, while increased milfoil density occurred at six sites from September 2008 to 2009. So, though the overall milfoil density continues to be very low compared to 2004, the fact that the number of sites with year to year increases in milfoil density has gone up indicates that a gradual re-expansion of the milfoil population is occurring.

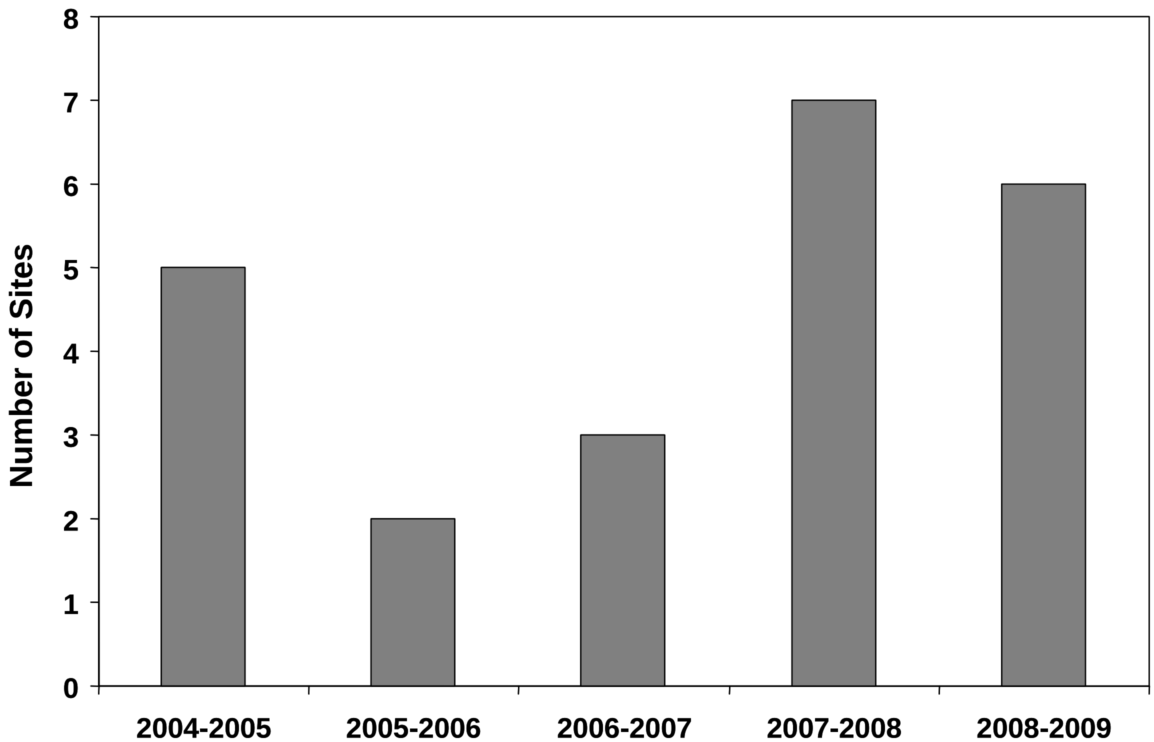

Figure 4. Number of sites with year to year increases in September milfoil density for the 15 monitoring sites located in Upper Saranac Lake, New York..

Close examination of the monthly milfoil densities by site (see Appendix for all years by site) shows that there is a tremendous amount of variation in milfoil densities. Some of this variation is due to harvesting activity and the remaining variation is due to a combination of factors (e.g. substrate type, nutrients, weather conditions). The site in Fish Creek Pond was established to gain some understanding of milfoil growth in the absence of management and what factors may be influencing that growth. At the Fish Creek Pond site, there is a large dynamic range in seasonal growth, with a 4 to 6 fold seasonal fluctuation in density (Figure 5). Significant population expansion can occur through the fall months; for example, in 2007, milfoil density increased 35% from September to

October. This is a long growing season, with significant variation from year to year, but the data shows that there could be up to two months of growth after harvesting ceases in August. Some of this growth carries over into the following year, as evidenced by higher May density when October density of the preceding year is higher. This poses a challenge to management, when management activity ends in August. Higher starting densities in May of the next year should be expected when the October densities of the previous year area also high. This is illustrated somewhat in Figure 5, wherein zero milfoil was present in May of 2007 after a low density in October of 2006. Whereas, October 2007 had high density and May of 2008 had a comparatively high initial density (whereas there was none recorded the previous year).

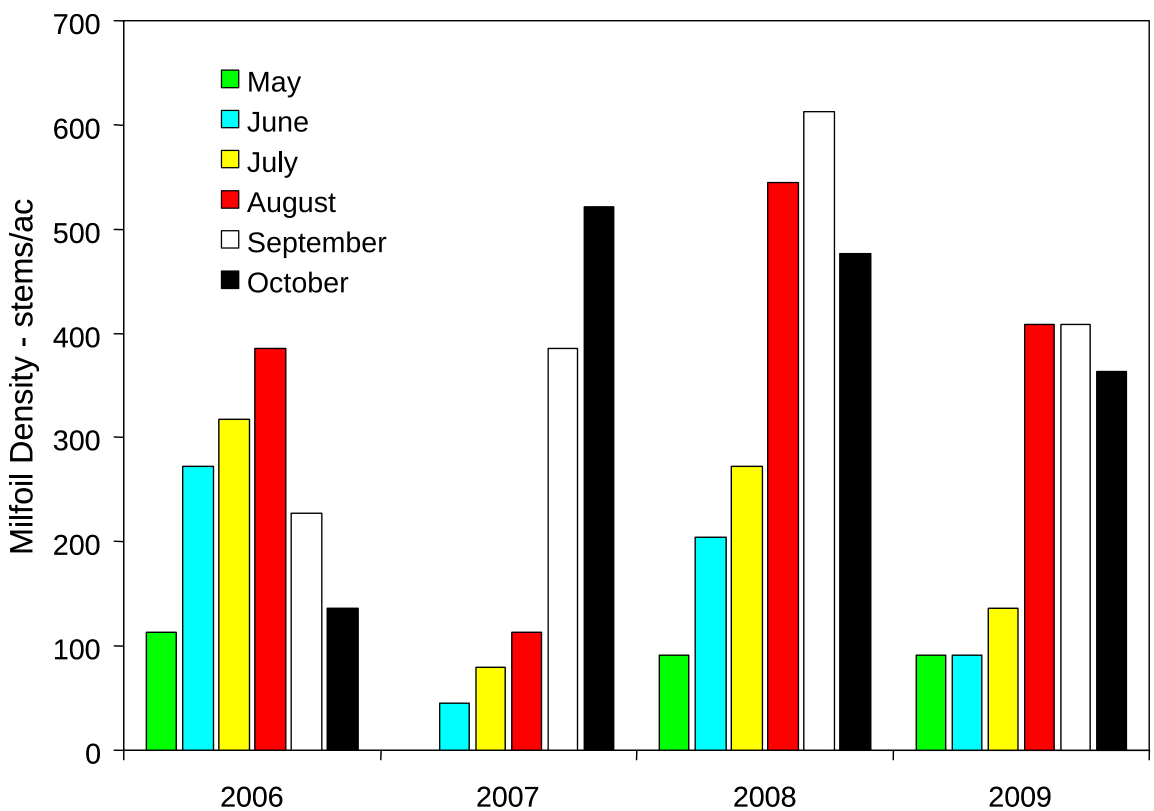

Figure 5. Milfoil density by month and year at the non-managed site in Fish Creek Pond, New York. Note, monitoring began at this site in 2006.

The year to year variation in milfoil density at the non-managed site in Fish Creek Pond is most likely explained by differences in weather conditions. The relationship between growing season weather conditions and milfoil growth was explored using historical weather data obtained for the weather station located at Sunmount in Tupper Lake (Coop ID 308631). A principle weather related indicator used in agriculture to compare growing conditions across years is the growing degree day (GDD), a measure of heat accumulation used to characterize the growing season. Growing degree days are calculated using the formula:

$$GDD = \frac{T_{max} + T_{min}}{2} - T_{base}$$

Where, T_{max} is the maximum daily temperature, T_{min} is the minimum daily temperature, and T_{base} is the temperature at which growth begins. The T_{base} for milfoil was assumed to be 59^{o}F, as reported by Smith and Barko (1990). These calculations were adjusted to water temperature based growing degree days by correlating air temperature with water temperature measured in Fish Creek Pond. The growing season start dates were defined as the first date of the year when a positive growing degree day was calculated and the growing season end dates were defined as the last date of the year when a positive growing degree day was calculated. The number of days in the growing season and the cumulative growing degree days were calculated after defining the start and end dates. Total rainfall and the percent cloudy days were also determined for each growing season directly from the Tupper Lake weather data. All of these variables are summarized for the six years of this project in Table 1.

Table 1. Weather summary table for the 2004 through 2009 growing seasons.

Year	Growing Season			Growing Degree Days	Total Rainfall (inches)	Cloudy Days (%)
	Start Date	End Date	Days			
2004	5/15	10/02	140	1,094	20.5	49
2005	6/03	10/12	131	1,727	18.5	38
2006	5/31	9/26	118	1,111	17.3	52
2007	5/27	10/12	138	1,281	14.3	37
2008	6/03	9/21	110	1,399	17.1	50
2009	5/29	9/18	112	1,016	16.1	44

The challenges of understanding aquatic plant growth and milfoil response to management are well illustrated by the summary data in Table 1. With the exception of 2004, growing season start dates were similar, ranging from 5/27 to 6/03. Growing season end dates, however, were more variable, ranging from as early as 9/18 in 2009 to as late as 10/12 in 2005 and 2007. This resulted in a large range in growing season length, from as short as 110 days to as long as 140 days. There was a large variation in GDD as well, ranging from a low of 1,016 in 2009 to a high of 1,727 in 2005. Total rainfall and cloudy days also varied from year to year.

Though, we only have four years of data for Fish Creek Pond, a strong positive correlation exists between milfoil stem density and GDD on the Fish Creek Pond transects (Figure 6). A theoretical biological growth curve is also indicated as a reference line on this figure to show that the correlation data does fit what should be expected biologically. Given that GDD is a function of temperature and also sunlight, cooler and/or cloudier summers will have lower GDD and less aquatic plant growth, as is suggested by the correlation in Figure 6.

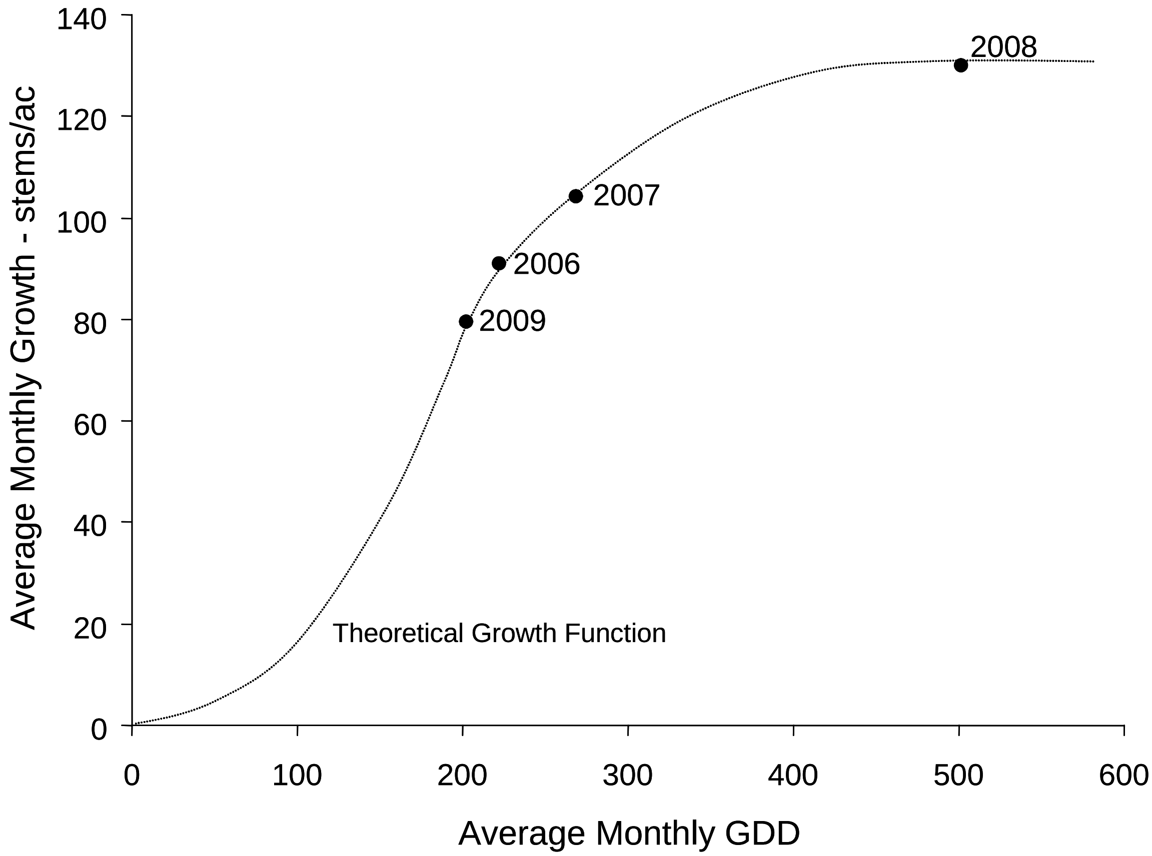

Figure 6. Correlation between average monthly milfoil growth measured in Fish Creek Pond and average monthly growing degree days (GDD) estimated from water temperature data.

Considering that milfoil density and GDD are positively correlated, we should expect to see the milfoil density at the transect sites in Upper Saranac Lake to vary with year-to-year differences in GDD. However, given that the management effort has varied over time, this correlation cannot be established for the entire six years of milfoil data. But, if we consider the management effort as relatively constant during the maintenance period, then based on the GDD estimates in Table 1, milfoil density in Figure 2 should have been highest in 2008 and lowest in 2009. The actual milfoil density does not match this prediction, in fact, 2009 had the highest milfoil density despite having the lowest GDD in the maintenance period. This is further evidence that the maintenance control program may not be sufficient to keep up with milfoil regrowth.

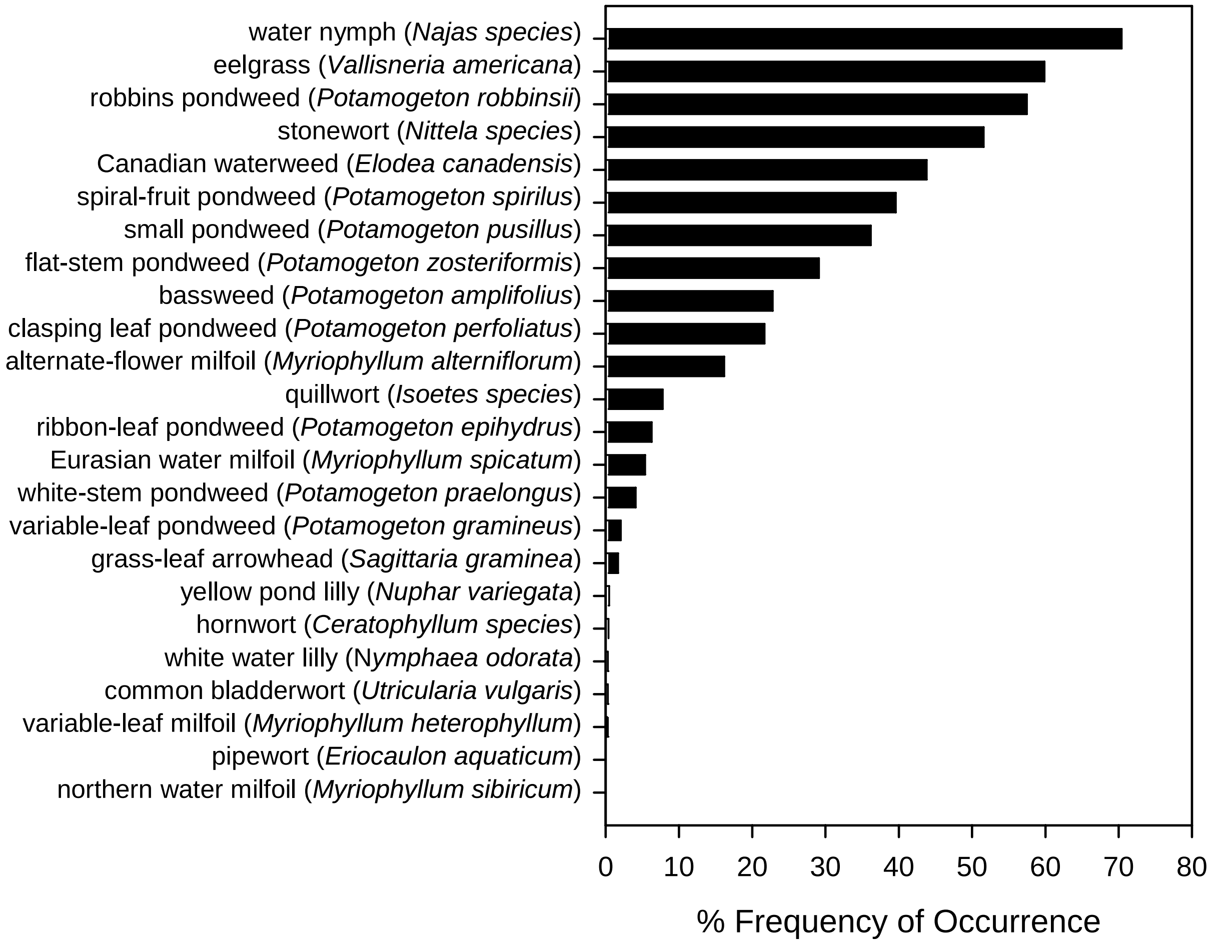

Figure 7. Average percent frequency of occurrence of all aquatic plant species observed on the transect segments during the month of August 2005-2009 in Upper Saranac Lake and Fish Creek Pond, New York.

Twenty four species of aquatic plants have been observed on the transects (Figure 7). These species are ranked based on percent frequency of occurrence, which is defined as the percent of transect segments that a given species was recorded as present on: it is being used as an index of relative abundance for each species. Of these 24 species, water nymph, eelgrass, Robbins pondweed, and stonewort were the most frequently observed species, occurring on greater than 50% of transect segments. Eurasian watermilfoil ranked 14^{th} in terms of relative abundance. Variable-leaf milfoil, another invasive aquatic plant, was observed on the Fish Creek Pond transects, but at very low relative abundance. In 2009, the harvesting crew also discovered and removed some variable-leaf milfoil stems on the managed side of the bridge over Fish Creek Pond.

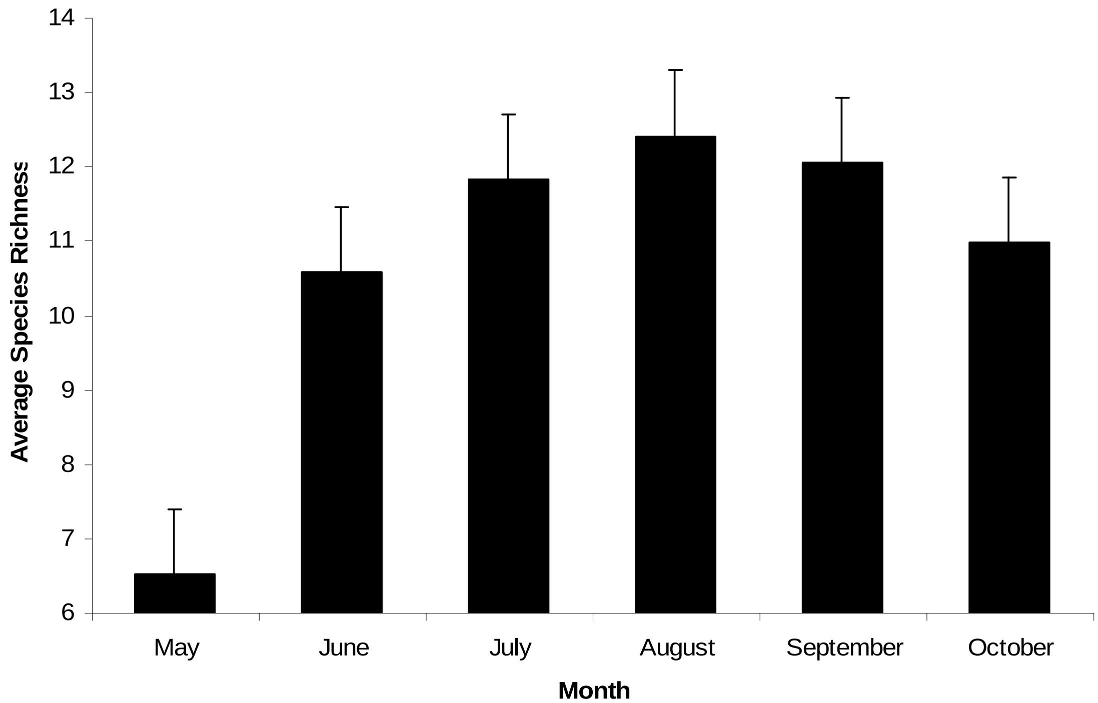

Figure 8. Average species richness by month for the 15 monitoring sites located in Upper Saranac Lake, New York.

Species richness is the total number of species observed, and is used as a measure of diversity, wherein higher species richness is interpreted as higher diversity. Figure 8 shows the average species richness by month for the 15 monitoring sites in Upper Saranac Lake. There is a strong seasonal trend in species richness, with 6 to 7 species observed in May, increasing to 12 to 13 species in August and then declining into the fall. This same pattern occurs every year.

There is a weak parabolic correlation between species richness and milfoil % frequency of occurrence (Figure 9). Species richness and milfoil are positively correlated at low milfoil % frequency of occurrence, with this correlation turning negative at high milfoil % frequency of occurrence. Milfoil grows better on higher quality sites (Grace and Wetzel, 1978; Smith and Barko, 1990), so milfoil % frequency of occurrence is an indicator of site quality. As site quality increases, the number of species that can be supported also increases, thus species richness increases as site quality increases. At lower density the positive correlation between milfoil and species richness suggested in Figure 9 reflects a gradient in site quality that can support milfoil and a diversity of native aquatic plants, but, as milfoil density increases available site resources are used by the milfoil which reduces the ability of the site to support other native plants (at higher densities, the milfoil out competes the native aquatic plants and diversity goes down, thus the parabolic relationship between milfoil % frequency of occurrence and species richness).

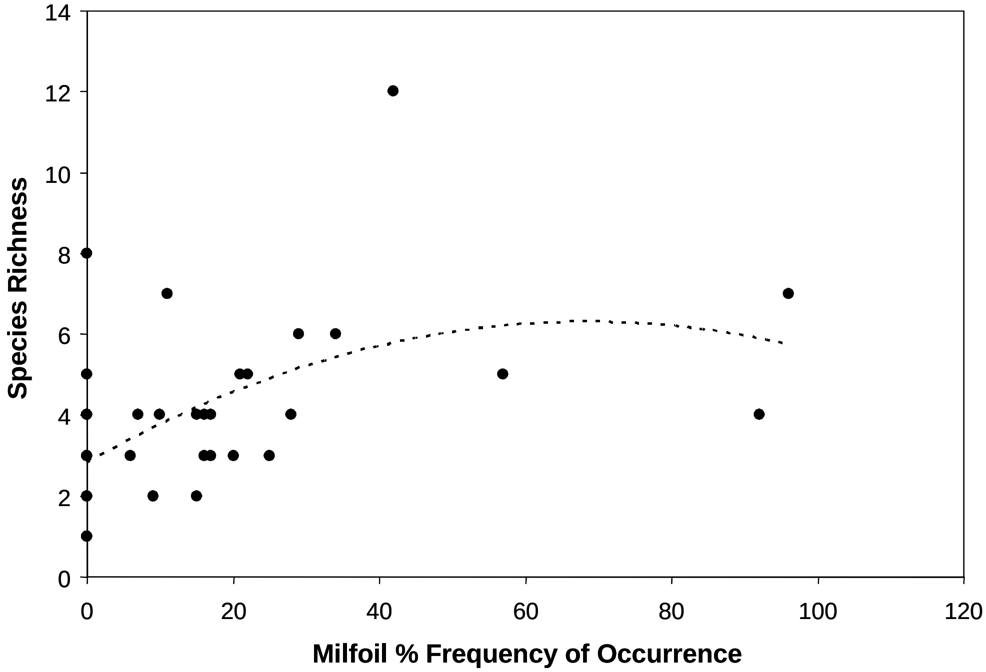

Figure 9. Correlation between species richness and milfoil % frequency of occurrence in August 2004 for 13 monitoring sites located in Upper Saranac Lake, New York.

If milfoil suppresses species richness on higher quality sites, then species richness should increase when milfoil is removed from these sites. This response was examined by splitting the sites into two groups; low milfoil defined as less than 50% milfoil density in 2004 and high milfoil defined as greater than 50% milfoil density in 2004. Species richness over time was then calculated for these two groups (Figure 10). This analysis showed that species richness has increased significantly over time at the sites that were categorized as having high milfoil density in 2004, while species richness has been comparatively steady over time at the sites that were categorized as having low milfoil density in 2004. The increase in species richness over time at the high milfoil density sites is consistent with what is suggested in Figure 9; that is, high milfoil density suppressed native plant diversity, and reducing the milfoil density at these sites allowed native plants to re-occupy the site and increase species richness. This finding is consistent with other studies that have measured native plant responses to milfoil (e.g. Madsen et al., 1991).

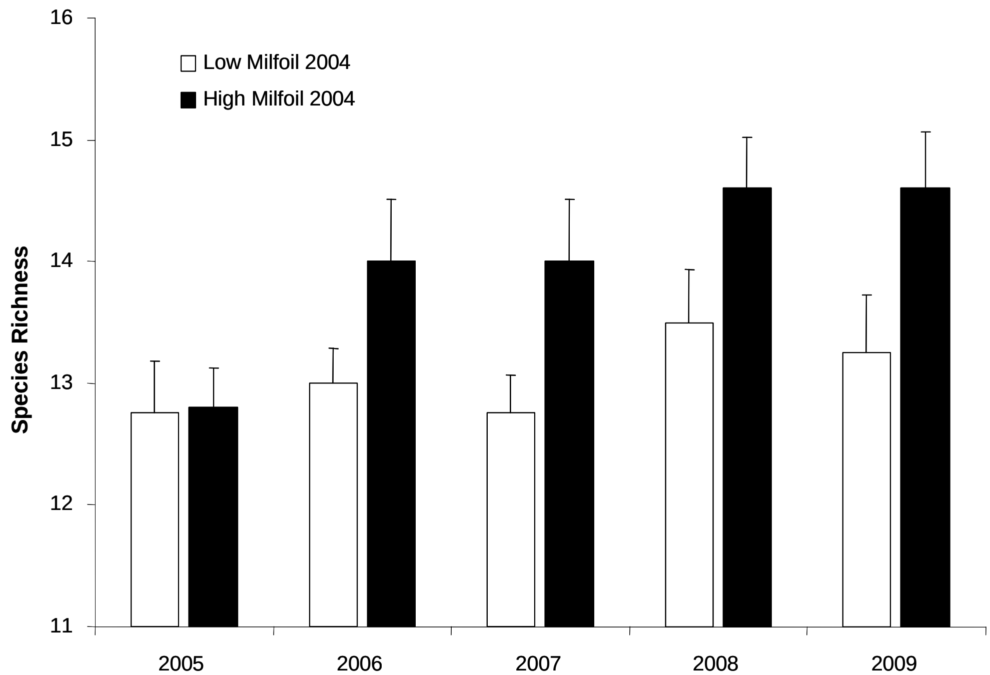

Figure 10. Average species richness in August 2005-2009 for sites grouped into low (<50%) and high (>50%) milfoil percent frequency of occurrence based on 2004 survey data in Upper Saranac Lake, New York.

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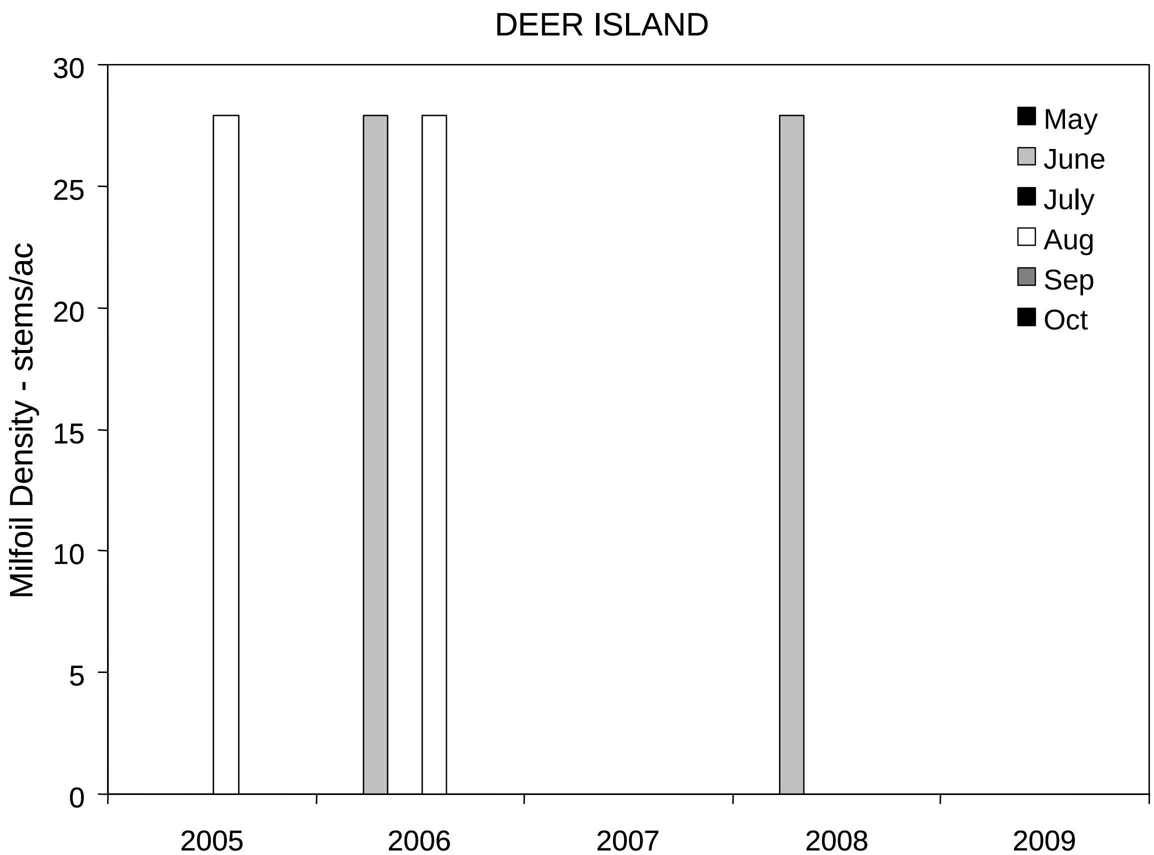
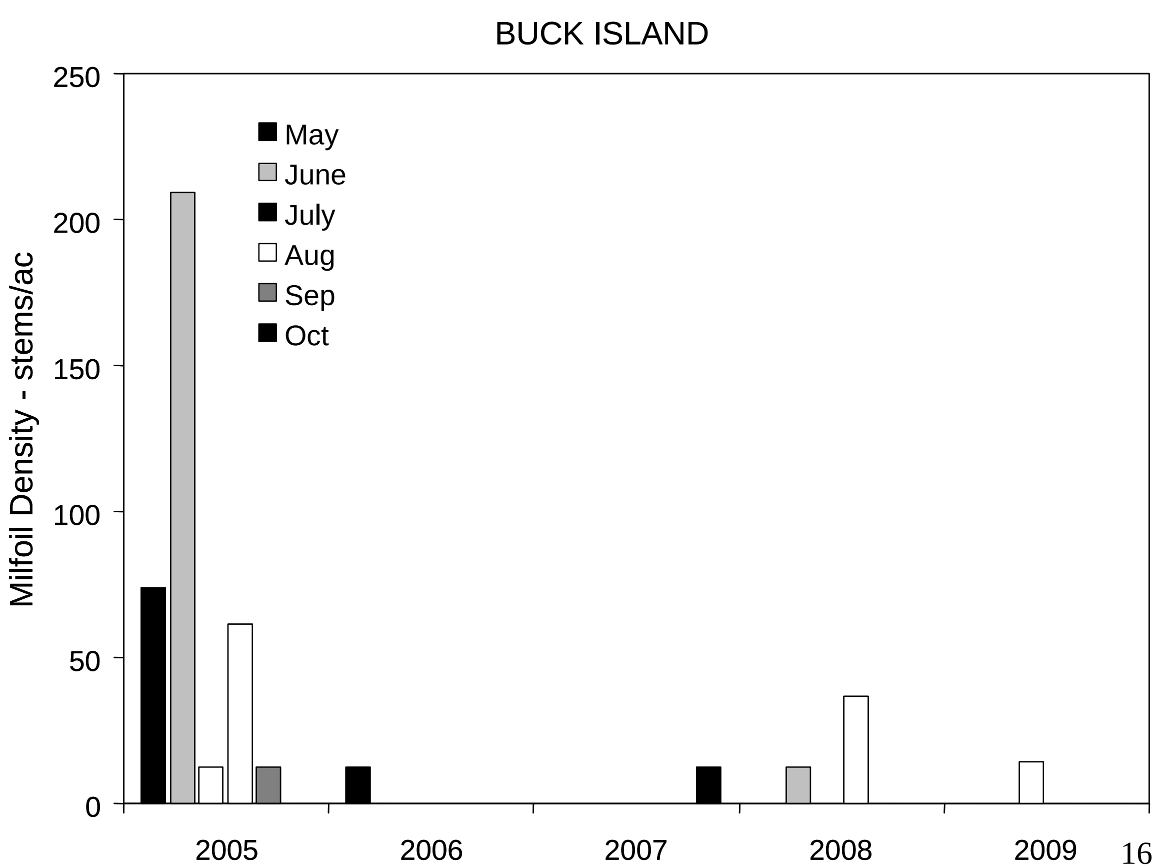
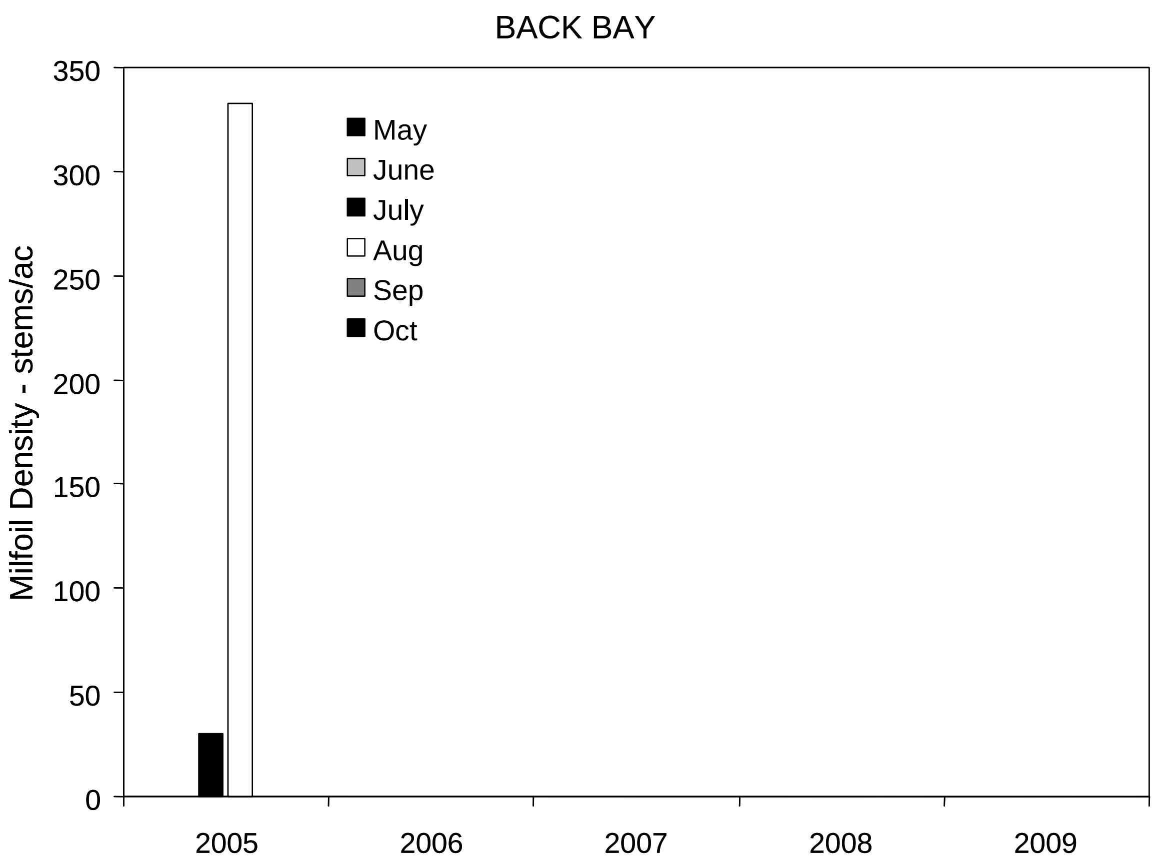
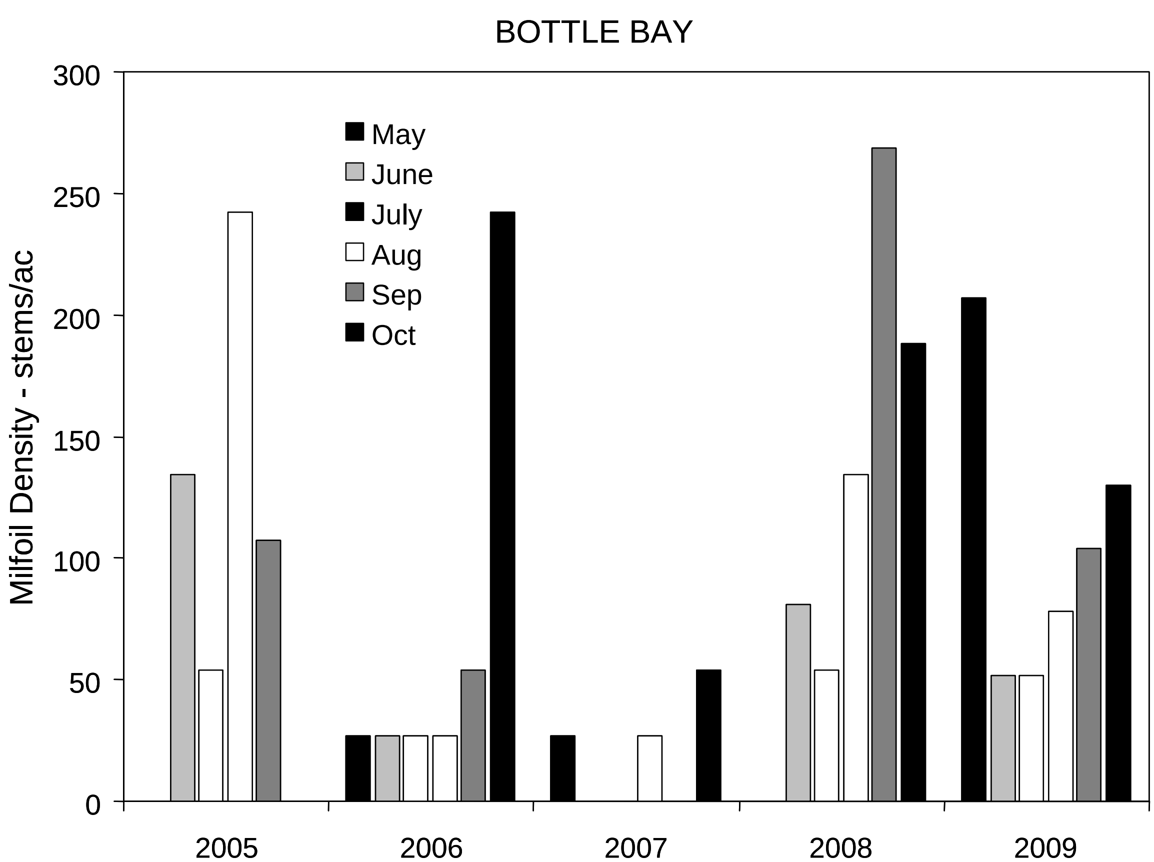
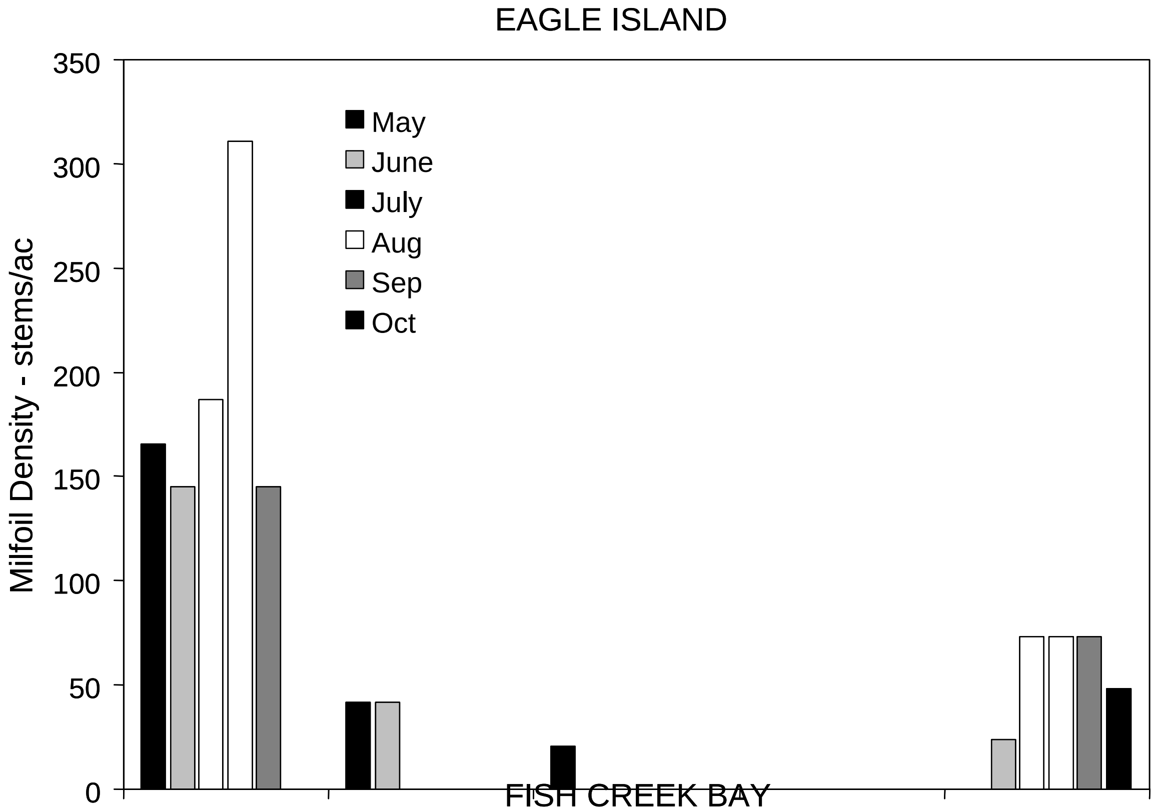
<u>Appendix</u> - Transect site level milfoil changes over time

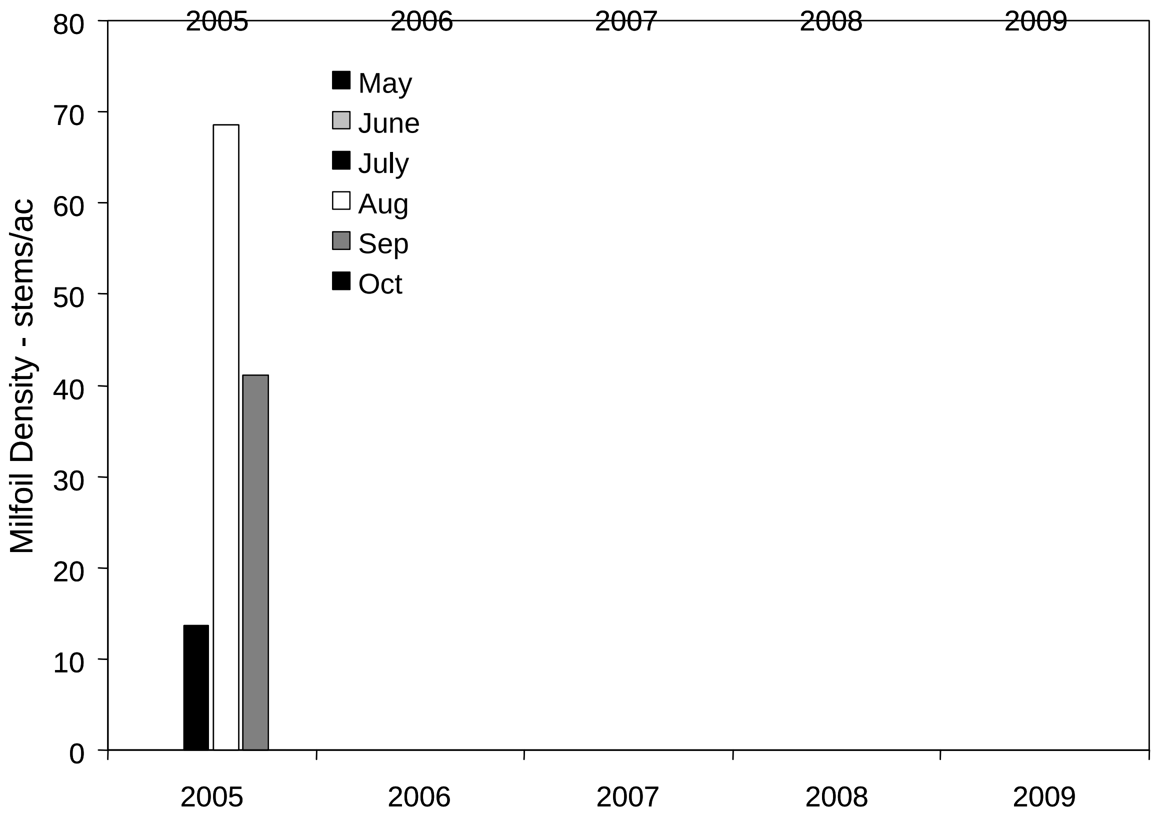


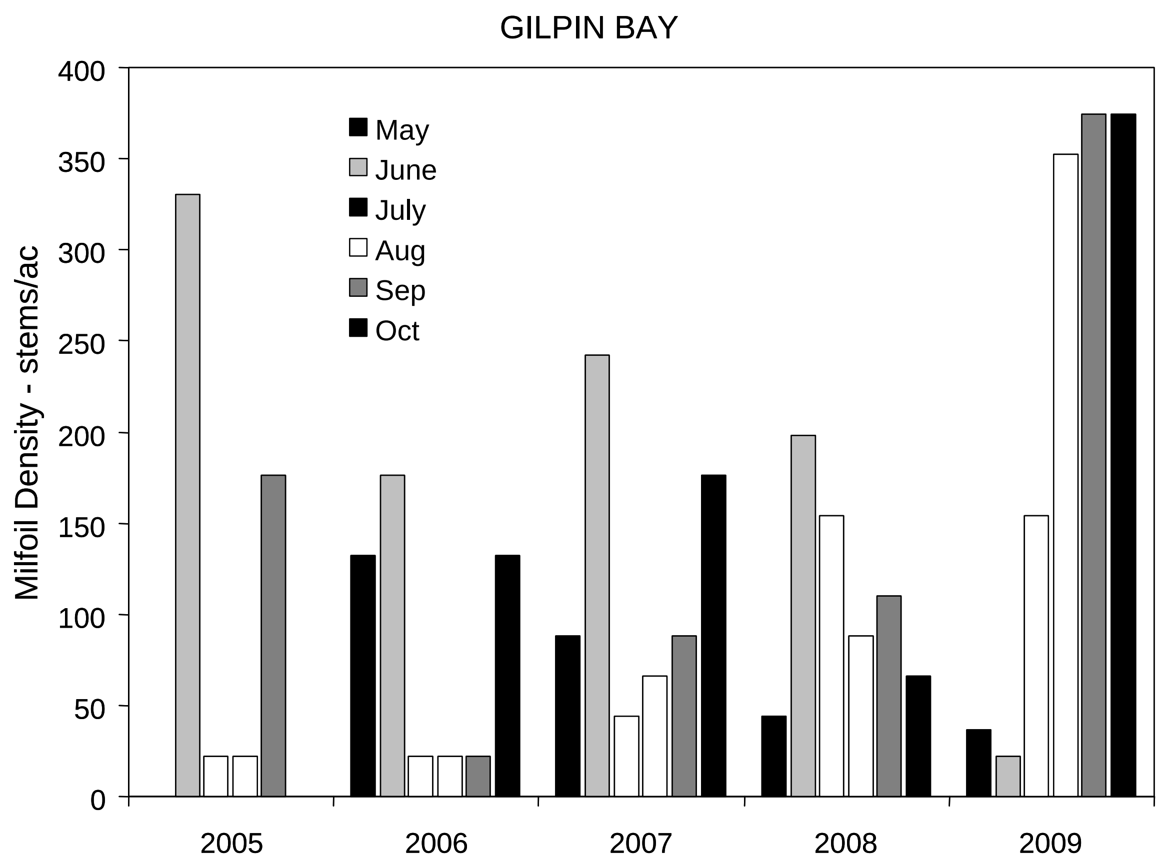


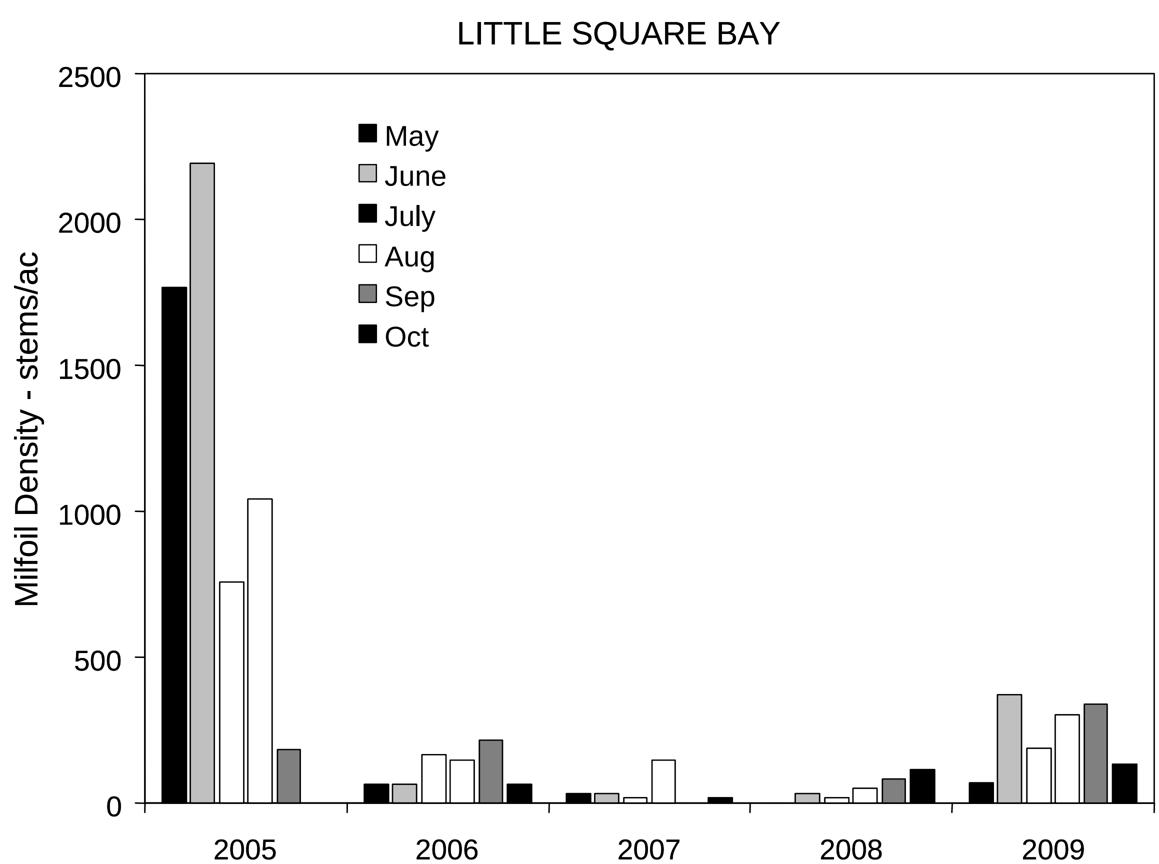

BACK BAY
Milfoil Density - stems/ac
350
300
250
200
150
100
50
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009

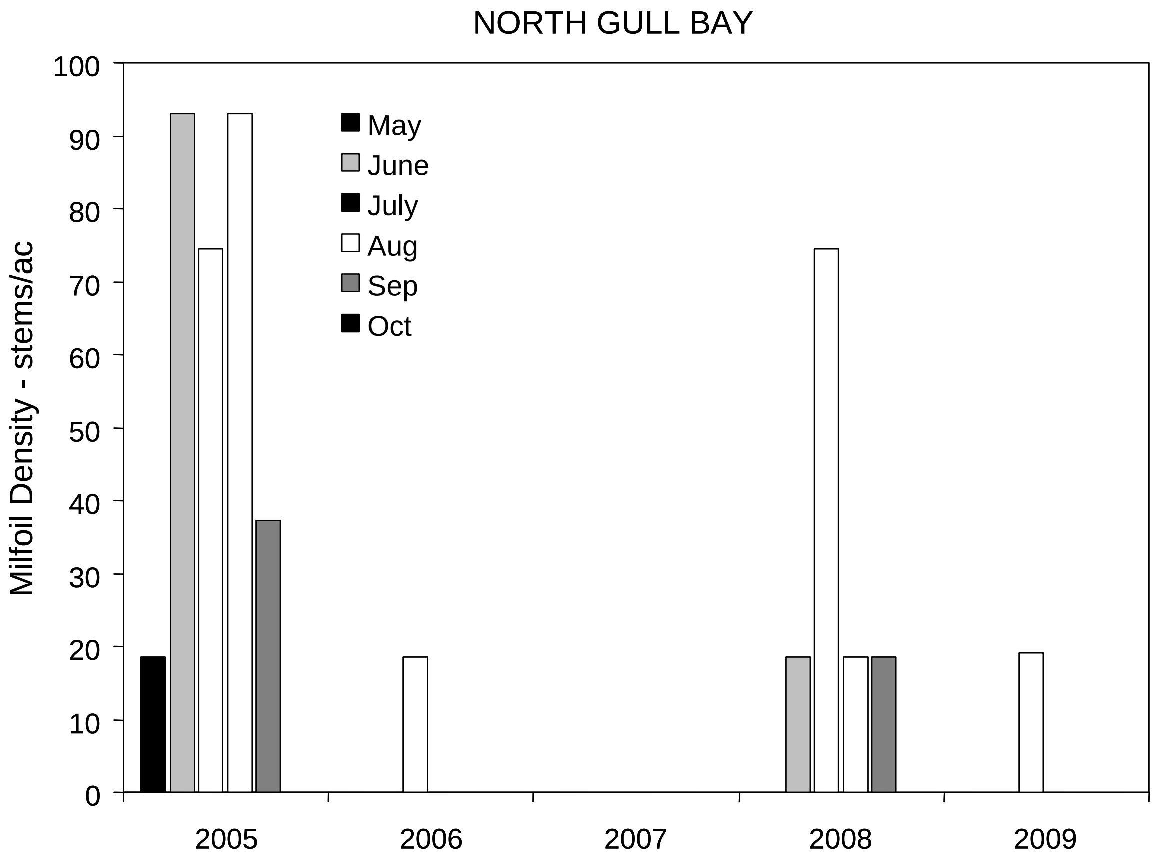

BOTTLE BAY
Milfoil Density - stems/ac
300
250
200
150
100
50
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


EAGLE ISLAND
Milfoil Density - stems/ac
350
300
250
200
150
100
50
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009

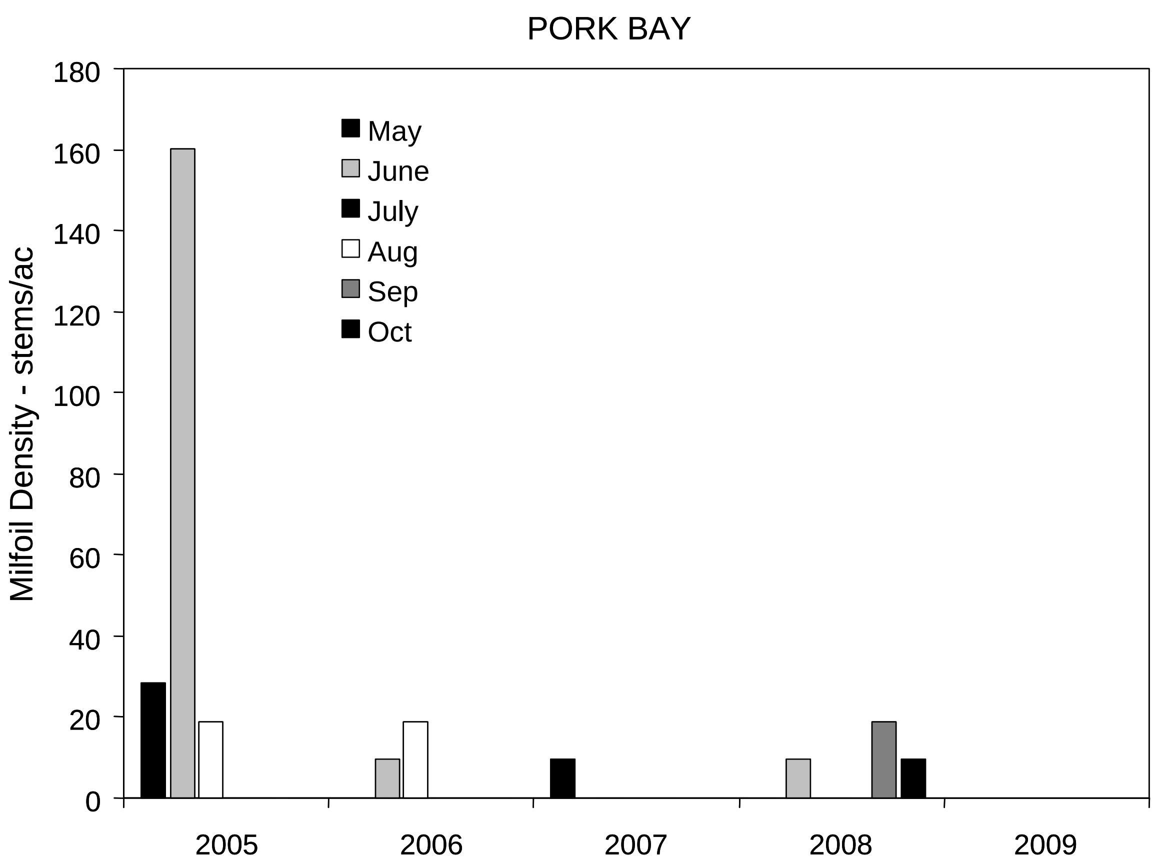

FISH CREEK BAY
Milfoil Density - stems/ac
80
70
60
50
40
30
20
10
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


GILPIN BAY
Milfoil Density - stems/ac
400
350
300
250
200
150
100
50
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009

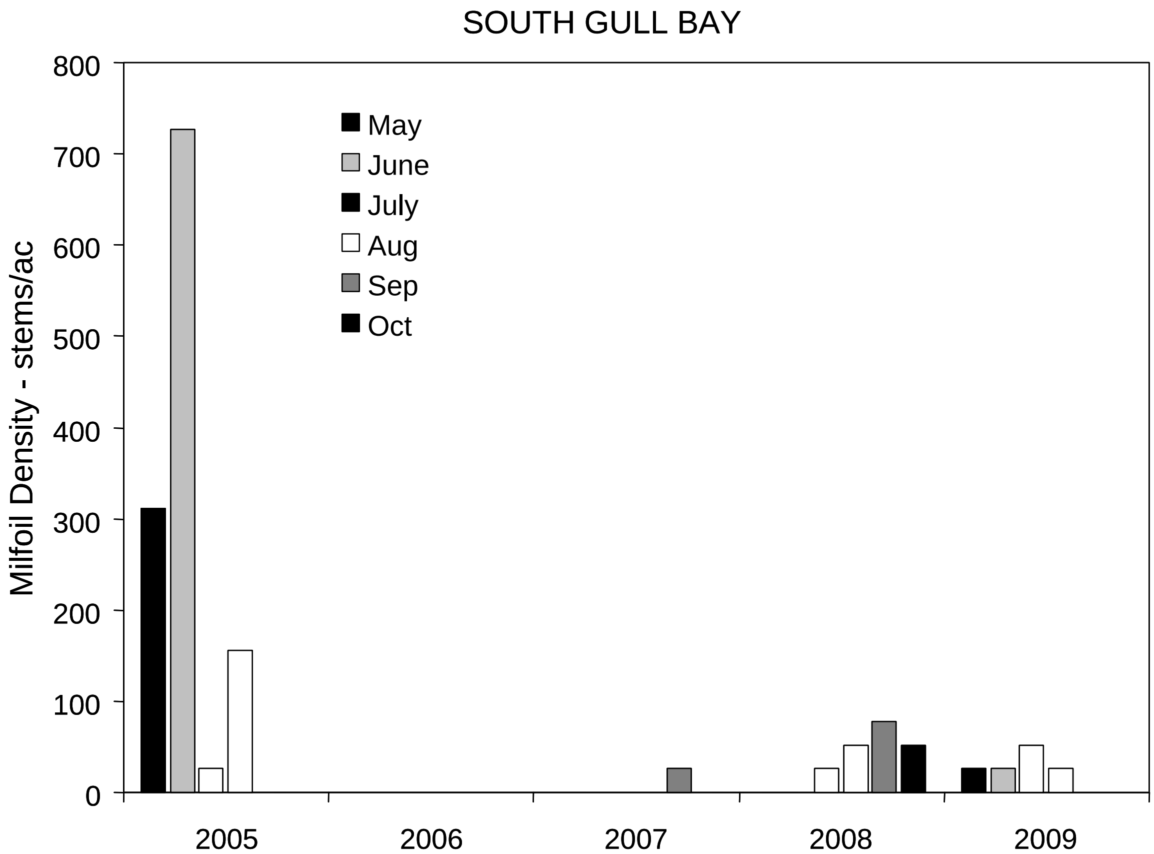

LITTLE SQUARE BAY
Milfoil Density - stems/ac
2500
2000
1500
1000
500
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009

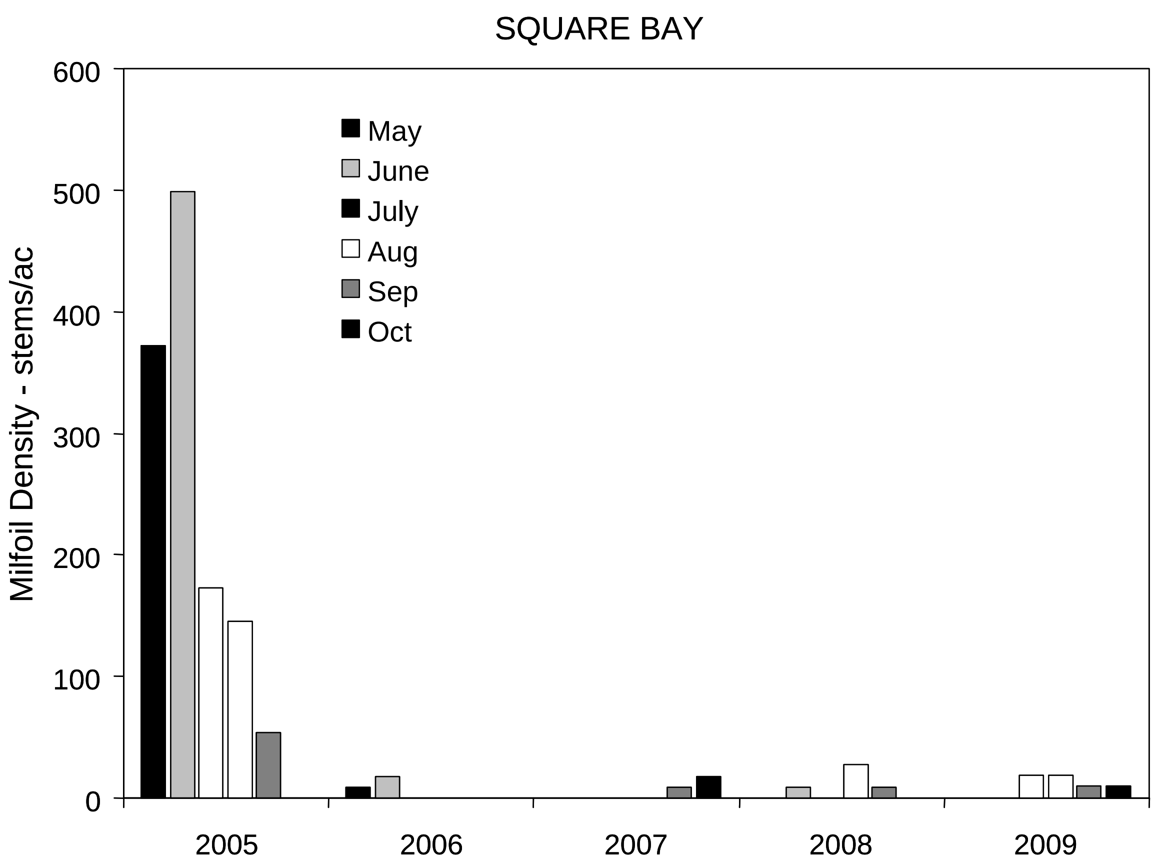


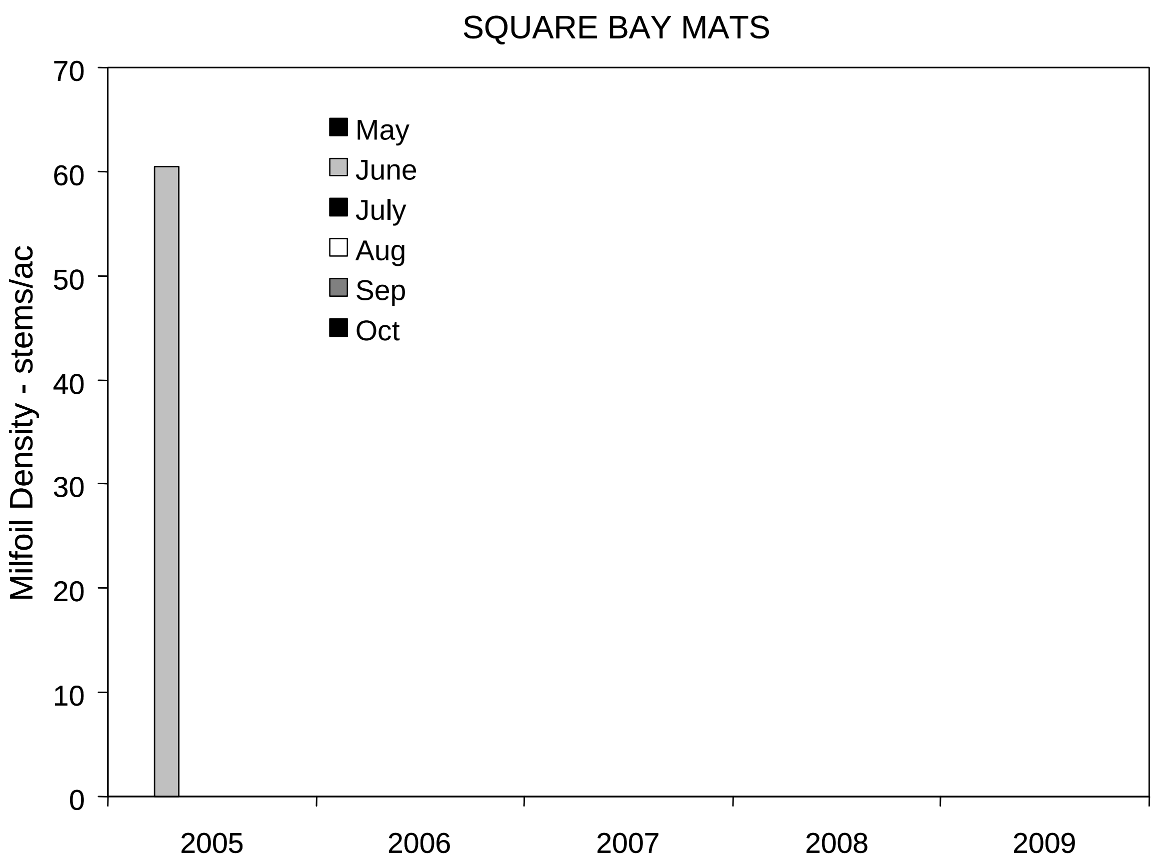
NORTH GULL BAY
Milfoil Density - stems/ac
0
10
20
30
40
50
60
70
80
90
100
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009

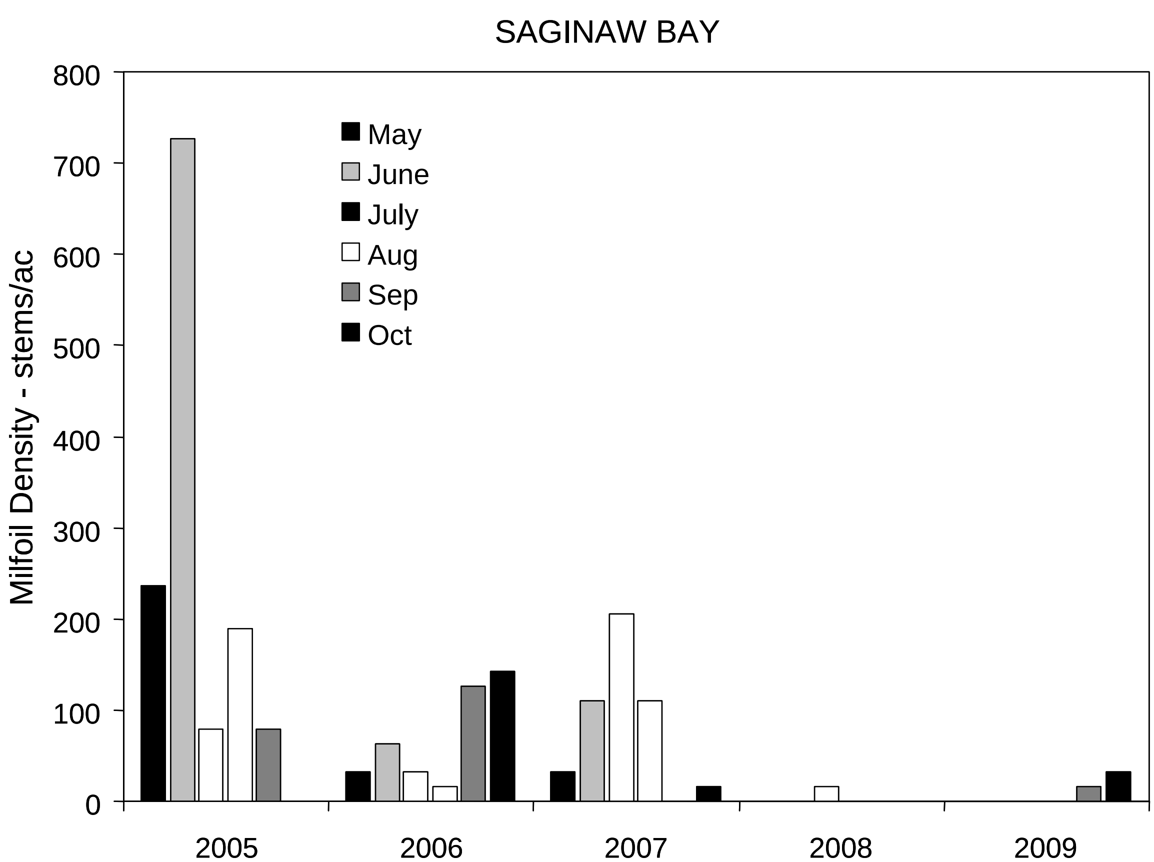


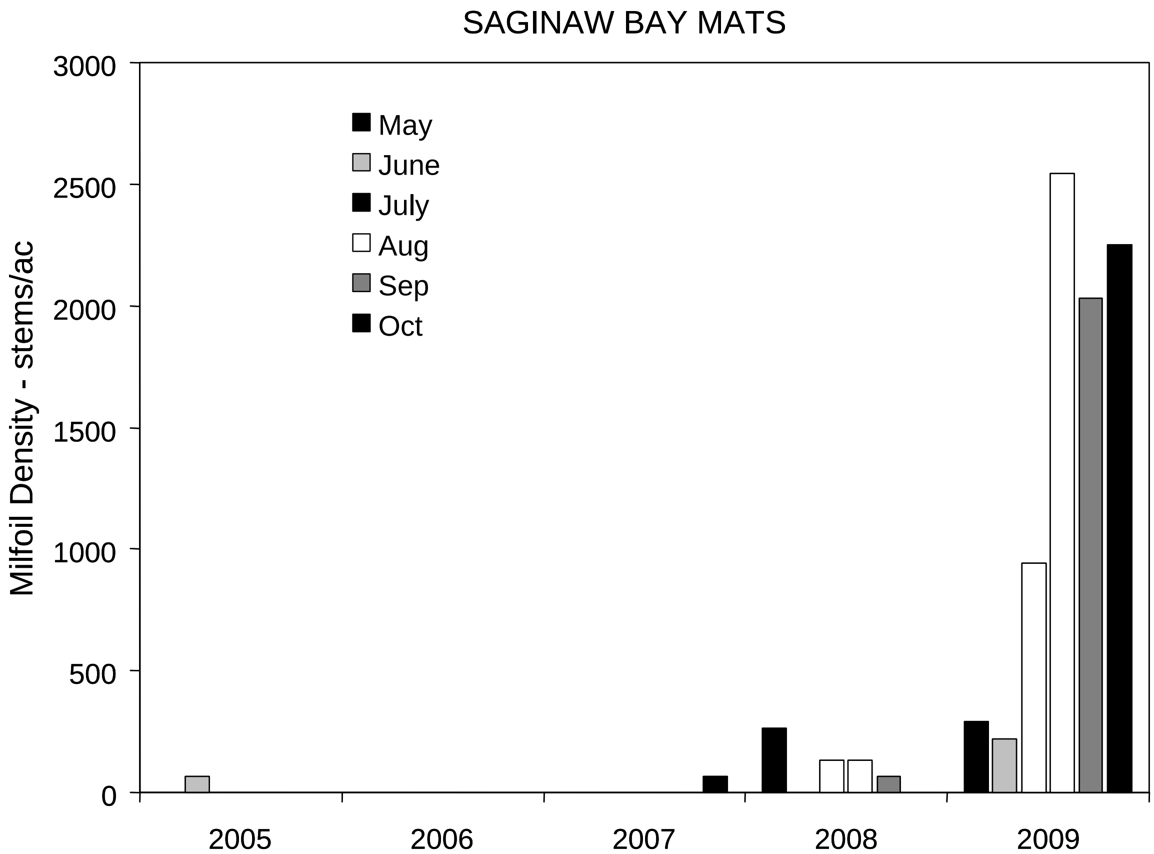
PORK BAY
Milfoil Density - stems/ac
0
20
40
60
80
100
120
140
160
180
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


SOUTH GULL BAY
Milfoil Density - stems/ac
0
100
200
300
400
500
600
700
800
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


SQUARE BAY
Milfoil Density - stems/ac
0
100
200
300
400
500
600
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


SQUARE BAY MATS
Milfoil Density - stems/ac
0
10
20
30
40
50
60
70
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


SAGINAW BAY
Milfoil Density - stems/ac
0
100
200
300
400
500
600
700
800
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009


SAGINAW BAY MATS
Milfoil Density - stems/ac
3000
2500
2000
1500
1000
500
0
May
June
July
Aug
Sep
Oct
2005
2006
2007
2008
2009