Winslow Homer: *The Green Dory*, 1880

Lake Minocqua Surveys for 2002: Lake Soil Fertility of Littoral Zone Sediments and Recreational Lake Use

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Lake Minocqua Surveys for 2002: Lake Soil Fertility of Littoral Zone Sediments and Recreational Lake Use Survey

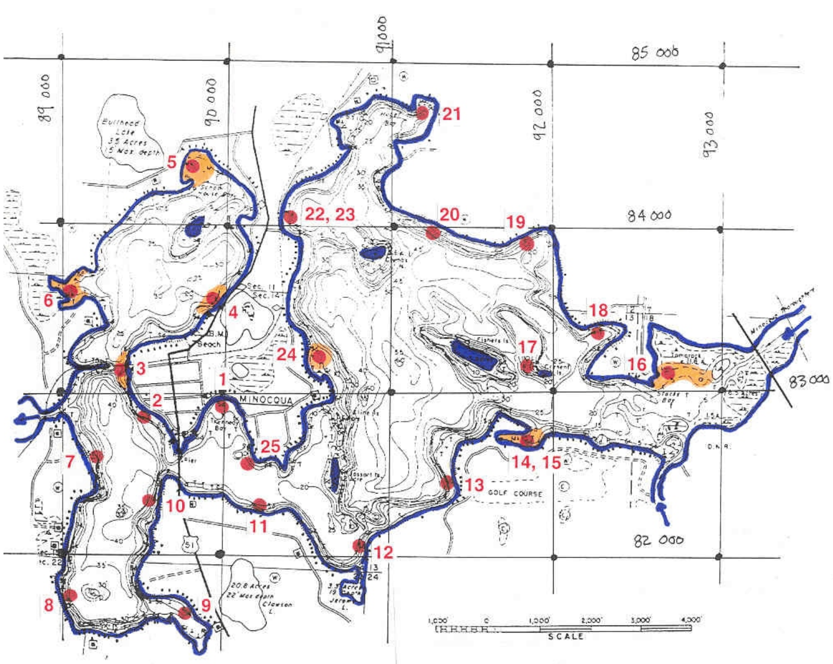
Summary

Two surveys were conducted on Lake Minocqua over the 2002 summer: a lake sediment fertility survey and a lake use survey.

Lake Sediment Fertility and Milfoil: Lake sediments were collected in 3 to 8 feet of water depth from Lake Minocqua on September 27, 2002. The lake "soils" were analyzed for exchangeable ammonia. Other studies have found a correlation of elevated exchangeable ammonia-nitrogen sediment concentrations with nuisance growth of Eurasian watermilfoil (EWM). A nuisance is defined as milfoil matting at the water surface in a continuous canopy covering an area greater than about 5,000 square feet. At lower sediment nitrogen values, we have found that EWM can still grow, but not necessarily to nuisance conditions. In these cases, removal of EWM is unnecessary.

Although as of 2002, EWM is found in several patches in Lake Minocqua, it covers several acres or less.

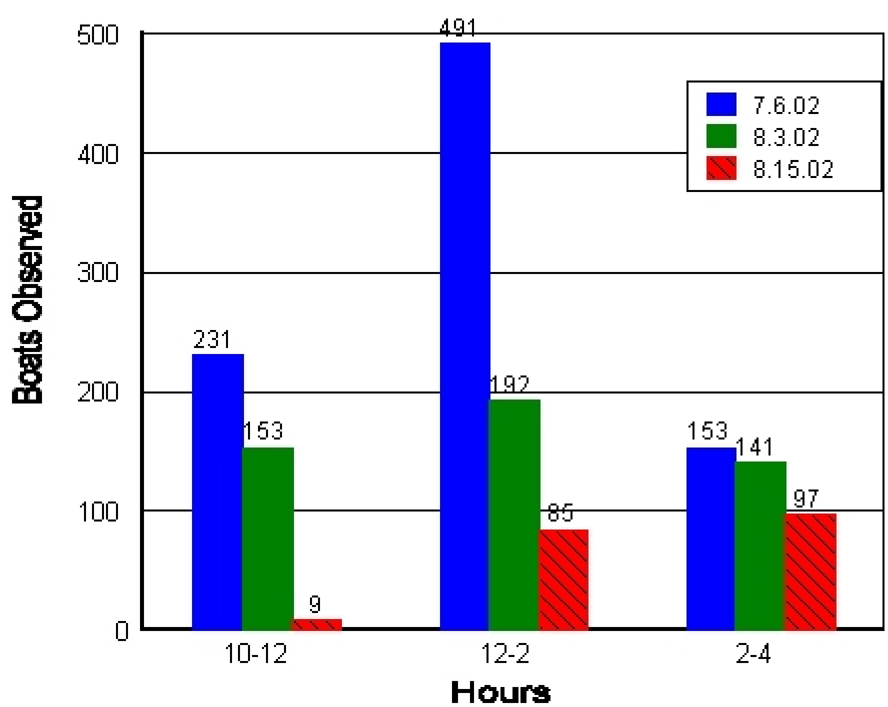
Based on lake sediment analyses, the areas that have the potential to support nuisance EWM are shown in Figure 1. Nitrogen levels were found to be low to moderate at the sample stations. Based on lake sediment results, we would predict ultimate potential nuisance acreages to be 20 acres or less for Lake Minocqua.



Areas that are predicted to support nuisance milfoil growth are shown in orange. Sample sites are shown with red dots. As of 2002, there are no areas in Lake Minocqua producing nuisance (or matting) milfoil growth.

Lake Use Survey: Based on volunteer observations on three dates in July and August of 2002, several conclusions about lake use have been formulated.

- Boat launching on peak days averages a total of about 15 boats per hour, based on data from three launch sites (Table 4).
- Access sites on peak days are twice as busy as off-peak days.
- Thirsty Whale and the Community Center are the most popular access points.
- Early afternoon is the busiest launch time on peak days.
- The highest density of boats on Lake Minocqua is found from 12:00 to 2:00 pm on peak days.
- Because the number of boats observed on the lake is far greater than the number of boats launched at the three access sites, it can be concluded that the majority of boats on the lake are coming from private riparian properties.



Number of boats observed on Lake Minocqua on three dates and for three time periods.

Lake Sediment Fertility Survey

Introduction

The use of lake soil fertility sampling to predict Eurasian watermilfoil growth or aquatic plant growth in general is an evolving area. Based on results from other lakes, it appears nitrogen (as exchangeable ammonium) is important for producing nuisance matting of Eurasian watermilfoil. There appears to be a nitrogen threshold for nuisance milfoil growth. When nitrogen concentrations (as exchangeable ammonium) are greater than about 10 ppm, nuisance milfoil conditions are found in many lakes. Organic matter is another leading indicator for potential nuisance milfoil growth and this is probably because organic matter and nitrogen are related so when there is high organic matter there is also high nitrogen. Based on results from other lakes we predict that the combination of high organic matter and high nitrogen values (as exchangeable ammonium) will sustain nuisance milfoil growth in shallow water (less than 12 feet) on an annual basis unless some other factor limits growth. Limiting factors include things such as milfoil weevils, light penetration, and other unknown variables. When lake bottom areas have moderate fertility, we predict there is the potential to support nuisance growth in some years, but not on a continuous basis.

The objective of this lake soil fertility survey was to characterize the Lake Minocqua soils in the littoral zone in order to better predict where nuisance areas of milfoil growth could occur in the future.

Methods

Lake Soil Survey. Sediment samples were collected from depths ranging from 3 to 8 feet (Table 1). Samples were collected using a modified soil auger, 5.2 inches in diameter. Soils were sampled to a depth of 6 inches. The lake soil from the sampler was transferred to 1-gallon zip-lock bags and delivered to a soil testing laboratory.

Lake sediment samples were collected from sites where plants were present or from open areas were plants were absent. At each sample location, within about a 10-foot radius we noted all aquatic plant species and rated their density on a scale from 1 to 5 with one representing a low density.

At the lab, sediment samples were air dried at room temperature, crushed and sieved through a 2 mm mesh sieve. Sediment samples were analyzed using standard agricultural soil testing methods. Up to sixteen parameters can be tested for each soil sample. For this report only sediment bulk density and exchangeable ammonia are reported. A summary of extractants and procedures is shown in Table 1. Routine soil test results are given on a weight per volume basis.

Table 1. Soil testing extractants used by Eco-Agri Laboratories, Willmar, Minnesota. These are standard extractants used for routine soil tests by most Midwestern soil testing laboratories (reference: Western States Laboratory Proficiency Testing Program: Soil and Plant Analytical Methods, 1996-Version 3).

Parameter	Extractant
P-Bray	0.025M HCL in 0.03M NH_4F
P-Olsen	0.5M $NaHCO_3$
NH_4-N	2N KCL
K, Ca, Mg, Na	1N NH_4OA_c (ammonium acetate)
Fe, Mn, Zn, Cu	DTPA (diethylenetriamine pentaacetic acid)
B	Hot water
SO_4-S	$Ca(H_2PO_4)_2$
pH	water
Organic matter	$K_2Cr_2O_7$ (Walkey-Black Method)
CEC	Sum of exchangeable bases (K, Ca, Mg, Na)

Figure 1. Soil auger used to collect lake sediments.

Reporting Lake Soil Analysis Results: Lake soils and terrestrial soils are similar from the standpoint that both provide a medium for rooting and supply nutrients to the plant.

However, lake soils are also different than terrestrial soils. Lake soils (or sediments) are water logged, generally anaerobic and their bulk density ranges from being very light to very dense compared to terrestrial soils.

There has been discussion for a long time on how to express analytical results from soil sampling. Lake sediment research results are often expressed as grams of a substance per kilogram of lake sediment, commonly referred to as a weight basis (mg/kg). However, in the terrestrial sector, to better relate plant production and potential fertilizer applications to better crop yields, soil results typically are expressed as grams of a substance per cubic foot of soil, commonly referred to as a weight per volume basis. Because plants grow in a volume of soil and not a weight of soil, farmers and producers typically work with results on a weight per volume basis.

That is the approach used here for lake sediment results: they are reported on a weight per volume basis or $\mu g/cm^3$.

A bulk density adjustment was applied to lake sediment results as well. For agricultural purposes, in order to standardize soil test results throughout the Midwest, a standard scoop volume of sediment or soil has been used. The standard scoop is approximately a 5-gram soil sample. Assuming an average bulk density for an agricultural soil, a standard volume of a scoop has been a quick way to prepare soils for analysis, which is convenient when a farmer is waiting for results to prepare for a fertilizer program. It is assumed a typical silt loam and clay texture soil has a bulk density of 1.18 grams per cm^3. Therefore a scoop size of 4.25 cm^3 has been used to generate a 5-gram sample. It is assumed a sandy soil has a bulk density of 1.25 grams per cm^3 and therefore a 4.00 cm^3 scoop has been used to generate a 5-gram sample. Using this type of standard weight-volume measurement, the lab can use standard volumes of extractants and results are reported in ppm which is close to $\mu g/cm^3$. For all sediment results reported here a scoop volume of 4.25 cm^3 was used.

However lake sediment bulk density has wide variations and only a single scoop volume of 4.25 cm^3 was used for all samples. This would not necessarily produce a 5-gram sample. Therefore, for our reporting, we have used a corrected weight volume measurements and results have been adjusted based on the actual lake sediment bulk density. We used a standard scoop volume of 4.25 cm^3, but sediment samples were weighed. Because test results are based on the premise of a 5 gram sample, if our sediment sample was less than 5 grams, then the reported concentrations were adjusted down to account for the less dense bulk density. If a scoop volume weighed greater than 5.0 grams than the reported concentrations were adjusted up. For example, if a 5-gram scoop of lake sediment weighed 2.0 grams, then the correction factor is 2.00 g/ 5.00 g = 0.40. If the concentration was 10 ppm based on 5 grams, then it should be 0.40 x 10 ppm = 4 ppm based on 2 grams. The results could be written as 4 ppm or 4 $\mu g/cm^3$. Likewise, if a 5-gram scoop of lake sediment weighed 6 grams, then the correction factor is 6.00 g / 5.00 g = 1.20. If the concentration was 10 ppm based on a 5 gram scoop, then it should be 1.20 x 10 ppm = 12 ppm based on 6 grams. The result could be written as 12 ppm or 12 $\mu g/cm^3$.

Eurasian watermilfoil is in Lake Minocqua and will be there for the long term. A question is what will it do in the lake. Here is a Eurasian watermilfoil fragment found floating around the public access. Note that roots have developed from one or more nodes. If it settles out, it can start a new plant. Plant fragments are probably drifting around the lake on a routine basis.

Lake Minocqua Lake Sediment Fertility Results

A total of 25 locations were sampled around Lake Minocqua in water depths from 3 to 8 feet. At each location the types of plants were identified (Table 2). Eurasian watermilfoil was found in Lake Minocqua at one sample site. Native plants were found at all sample sites.

Results of the lake sediment analysis are listed in Tables 2 and 3.

A map showing the locations of potential nuisance milfoil growth is shown in Figure 1.

Lake Minocqua volunteers helped with the lake sediment fertility survey as well as the lake use survey.

Table 2. Station locations, sample depth, exchangeable ammonia concentrations, and aquatic plant species found at the sample locations. Numbers under plant species represent plant density on a scale from 1-5 with 5 being most dense. Samples were collected on September 27, 2002. EWM = Eurasian watermilfoil; NWM = northern watermilfoil; Cab = cabbage; Chara = chara; Clasp = claspingleaf pondweed; Ct = coontail; El = elodea; Fern = fern pondweed; Flat = flatstem pondweed; Iso = needle spike rush; Meg = water marigold; Ranu = buttercup; Var = variable pondweed; WC = water celery; and Zost = water stargrass.

Station	GPS		Depth (ft)	Exch. Ammonia (ppm)	Plants Observed															# of species
	EW	N-S			EWM	NWM	Cab	Chara	Clasp	Ct	El	Fern	Flat	Iso	Meg	Ranu	Var	WC	Zost	
1	2-89-983	50-82-907	7	5.2	1	2				1	2									4
2	2-89-568	50-82-823	8	4.5		3				1								1		3
3	2-89-387	50-83-184	7	4.2		1	1											2		3
4	2-89-928	50-83-511	6	11.9		4												1	1	3
5	2-89-819	50-84-332	5.5	23.9						1		3								2
6	2-89-018	50-83-598	6	16.3		1				3		2								3
7	2-89-109	50-82-662	7	5.9		1	1				1	1						1		5
8	2-89-006	50-81-761	7	8.3		1				1								1		3
9	2-89-783	50-81-662	6	6.3								2	1			1				3
10	2-89-593	50-82-303	7	5														1		1
11	2-90-194	50-82-283	7	3.9		1			1	2		1						1		5
12	2-90-813	50-80-054	5	5.2													1	1		2
13	2-91-396	50-82-413	6	4.5		1	1					1								3
14	2-91-827	50-82-709	6	3.6		1	1									1		1		4
15	2-91-827	50-82-709	6	5.2		1	1									1		1		4
16	2-92-721	50-83-135	5	6.4			1			2		3								3
17	2-91-845	50-83-194	3	3.3										2						1
18	2-92-261	50-83-443	6	5.4		2				2		1								3
19	2-91-796	50-83-982	6	4.3			1								1	1				3
20	2-91-233	50-84-050	6	3.9				1									1	1		3
21	2-91-170	50-84-785	6	3.6		1			1	1						1				4
22	2-90-363	50-84-014	7	4.4			1					3								2
23	2-90-363	50-84-014	7	5			1					3								2
24	2-90-510	50-83-145	6	5.1			1			1		1								3
25	2-90-157	50-82-602	7	6.8		2						1						1		3
Number of sites aquatic plant species was observed					1	14	10	1	2	10	2	12	1	1	1	5	2	12	1	--

Table 3. Lake sediment bulk density and exchangeable ammonia concentrations for Lake Minocqua.

Sample Number	Weight of 4.25 cm^3 Scoop (in grams)	Sediment Bulk Density (dry wt in grams/cm^3)	Weight Correction Factor	NH_4 by standard weight-volume (µg/cm^3)	NH_4 by corrected weight-volume (µg/cm^3)	Number of Plant Species at Sample Location
1	5.42	1.275	1.084	4.8	5.2	4*
2	3.56	0.838	0.712	6.3	4.5	3
3	2.36	0.555	1.472	8.9	4.2	3
4	5.41	1.273	1.082	11	11.9	3
5	1.15	0.271	0.23	104	23.9	2
6	1.13	0.266	0.226	72.3	16.3	3
7	5.03	1.184	1.006	5.9	5.9	5
8	6.27	1.475	1.254	6.6	8.3	3
9	5.92	1.393	1.184	5.3	6.3	3
10	6.27	1.475	1.254	4	5	1
11	6.45	1.518	1.29	3	3.9	5
12	5.74	1.351	1.148	4.5	5.2	2
13	5.78	1.36	1.156	3.9	4.5	3
14	1.04	0.245	0.208	17.1	3.6	4
15	1.28	0.301	0.256	20.5	5.2	4
16	0.86	0.202	0.172	54.7	9.4	3
17	5.95	1.4	1.19	2.8	3.3	1
18	6.44	1.515	1.288	4.2	5.4	3
19	6.34	1.492	1.268	3.4	4.3	3
20	6.25	1.471	1.25	3.1	3.9	3
21	4.21	0.991	0.842	4.3	3.6	4
22	4.83	1.136	0.966	4.5	4.4	2
23	4.89	1.151	0.978	5.1	5	2
24	3.67	0.864	0.734	7	5.1	3
25	5.72	1.346	1.114	5.9	6.8	3

* Eurasian watermilfoil was found at Station 1.

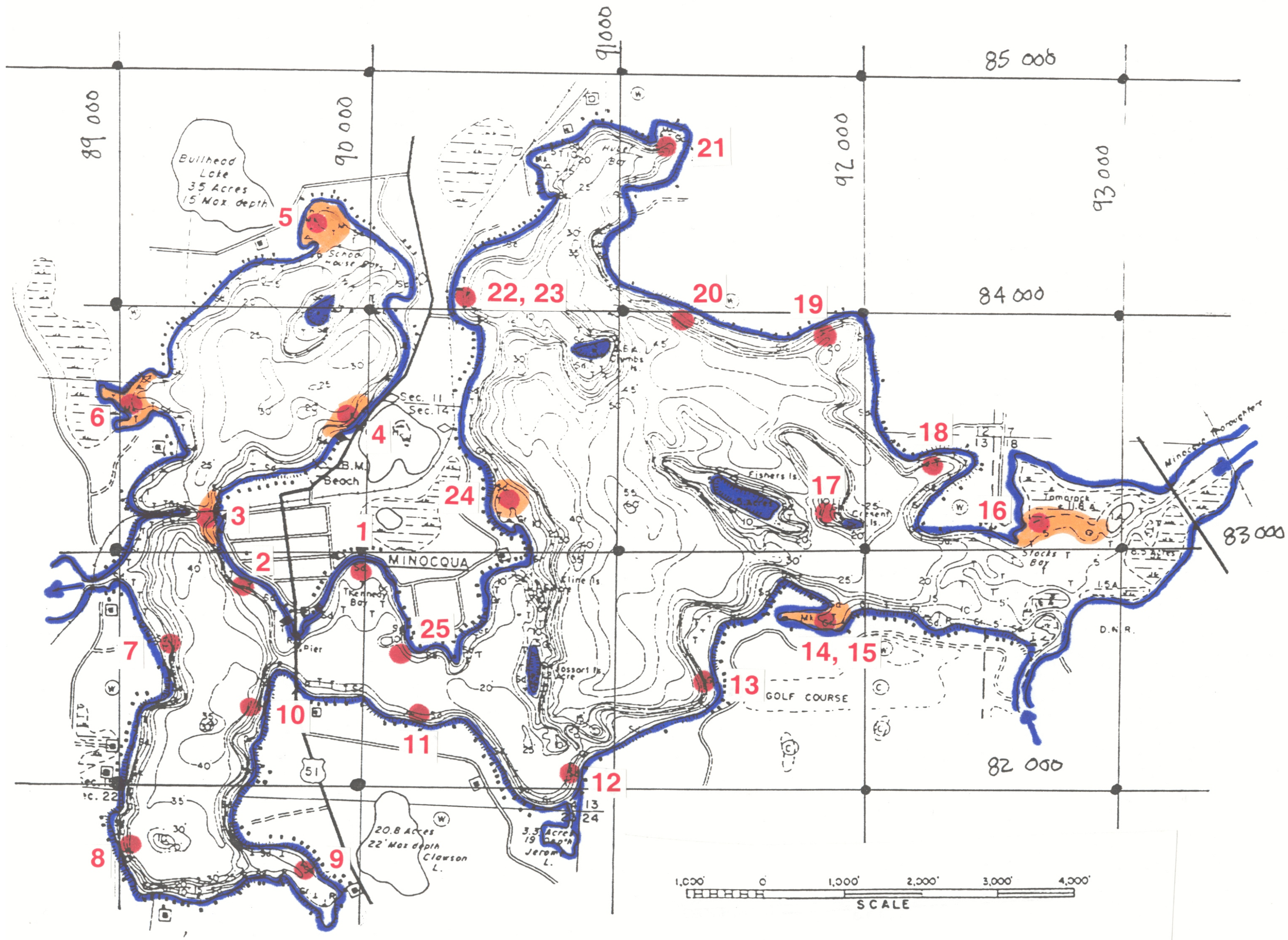


Figure 1. Areas that are predicted to support nuisance growth are shown in orange. Sample sites are shown with red dots. As of 2002, there were no areas producing nuisance milfoil growth.

Examples of aquatic plants found in Lake Minocqua.
[top] Fern pondweed was one of the more common plants found in Lake Minocqua.
[bottom] Flowering rush, an undesirable exotic plant, was found in Lake Minocqua in September. It was verified by growing rhizomes to adults in laboratory aquaria over winter.

Lake Use Survey

Introduction

When are lakes too crowded with boats? It's a question that often comes up on recreational lakes. That's a question that has come up regarding Lake Minocqua. To address that, a lake use survey was conducted in July and August of 2002.

Methods

Lake Association volunteers were positioned at three lake access sites to monitor incoming and outgoing boats on three dates. On the same days, observers were positioned at four locations on Lake Minocqua to make boat counts. Counts were made in 2 or 4 hour segments.

Results

Based on volunteer observations, several conclusions about lake use have been formulated.

- Boat launching on peak days averages a total of about 15 boats per hour, based on data from three launch sites (Table 4).
- Access sites on peak days are twice as busy as off-peak days.
- Thirsty Whale and the Community Center are the most popular access points.
- Early afternoon is the busiest launch time on peak days.
- The highest density of boats on Lake Minocqua is found from 12:00 to 2:00 pm on peak days.
- Because the number of boats observed on the lake is far greater than the number of boats launched at the three access sites, it can be concluded that the majority of boats on the lake are coming from private riparian properties.

Lake use data are summarized in Tables 4 and 5.

Table 4. Boats launched from three access points on two "peak" days and one "off-peak" day.

July 6, 2002 (Saturday, Holiday Weekend) Peak Use Day

	Thirsty Whale	Community Center	Stack's Bay	Total	Boats Launched per Hour
8-10 am	3	8		11	6
10 am - noon		22		22	16
noon - 2 pm		16	12	28	24
2 - 4 pm	14	26		40	20
4 - 6 pm	19	9		28	14
10 am - 2 pm	36		10	46	23
Total	72	81	22	175	18

August 3, 2002 (Saturday) Peak Use Day

	Thirsty Whale	Community Center	Stack's Bay	Total	Boats Launched per Hour
8 - 10 am	5	7		12	6
10 am - noon	--	7		7	4
noon - 2 pm	--	28		28	14
2 - 4 pm	11	4		15	8
4 - 6 pm	13	1		14	7
10 am - 2 pm	28		16	44	11
Total	57	47	16	120	12

August 15, 2002 (Thursday) Off Peak Day

	Thirsty Whale	Community Center	Stack's Bay	Total	Boats Launched per Hour
8 - 10 am	7	1		8	4
10 am - noon		6		6	3
noon - 2 pm		2		2	1
2 - 4 pm	(rain)	(rain)			0
10 am - 2 pm	14			14	7
noon - 4 pm			3	3	1
Total	21	9	3	33	6*

* not counting two rain hours

Table 5. Boats on lake observed from four locations.

July 6, 2002 (4th July weekend)

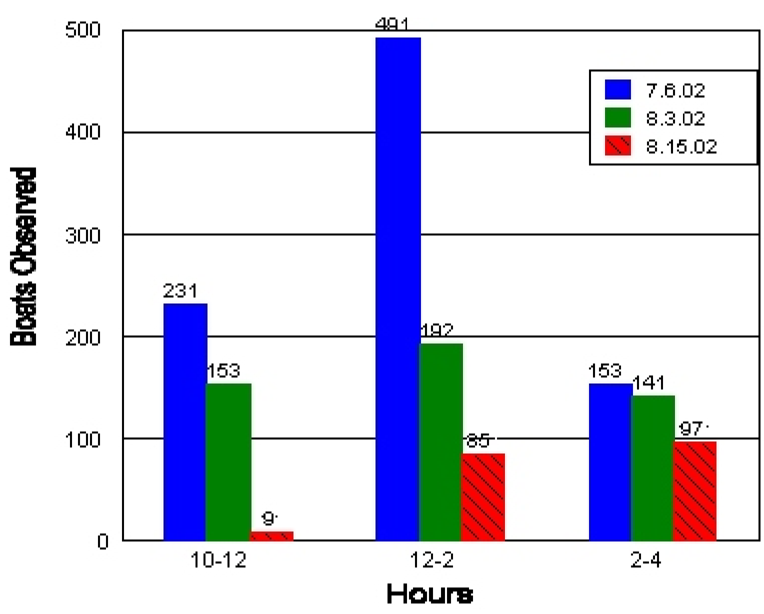
	1	2	3	4	Total
10 am - noon	64	32	84	51	231
noon - 2 pm	142	95	125	129	491
2 - 4 pm	153	--	--	--	--

August 3, 2002 (Saturday)

	1	2	3	4	Total
10 am - noon	34	26	49	44	153
noon - 2 pm	55	35	102	--	192
2 - 4 pm	74	--	67	--	141

August 15, 2002 (Thursday, rain from 12:55 - 1:20 and 1:45 - 2:00)

	1	2	3	4	Total
10 am - noon	9	--	--	--	9
noon - 2 pm	20	18	47	--	85
2 - 4 pm	15	30	30	22	97



Number of boats observed on Lake Minocqua on three dates and for three time periods.

Comparison of Lake Minocqua and White Bear Lake, Minnesota

When is a lake too crowded with boats? That is a topic that has been debated for a number of years. The State of Wisconsin does not regulate boat density on a lake. Actually, boating density is somewhat self-regulated. When a lake gets too many boats and is perceived by boaters to be too crowded, they either leave or don't even go out to the lake.

Lake Minocqua experiences a fairly high boating density based on observations from the lake use survey. For comparison, Lake Minocqua boating density is compared to White Bear Lake (Minnesota) boating density (Table 6).

Table 6. Comparison of lake use statistics for Lake Minocqua and White Bear Lake, Minnesota.

	Minocqua (2002)	White Bear Lake (1999)
Size (ac)	1360	2416
Shoreline (miles)	15.7	11.1
Shoreline boats	701	1127
Shoreline frontage/boat	118 feet/boat	52 feet/boat
Boats launched (peak days)	15/hour	50/hour
Boats on the lake (typical weekend)	200	173
Lake acre/boat (2 peak days)	7 ac/boat	14 ac/boat

For Lake Minocqua, boating density was reported to be high on peak days at 7 lake acres per boat. For comparison, a heavily used lake in the metropolitan area of Minneapolis-St. Paul, White Bear Lake, was found to have a boating density of 14 lake acres per boat on peak days in 1999. Exit surveys by lake users indicated they felt the lake was crowded, but safe.

For Lake Minocqua, lake user surveys should be conducted to determine the user's perception at a peak boating density. That may be the best way to determine if the lake is truly crowded.