Lake Nokomis, July 10, 2008

Fish Assesment of Lake Nokomis (ID #27-0019), Hennepin County, Minnesota in 2008

Survey Dates: July 10 - 11, 2008

MnDNR Permit Number: 15384

Submitted to:
Minneahaha Creek Watershed District and MnDNR

Prepared by:
Steve McComas
Blue Water Science
St. Paul, Minnesota

August 2008
Updated January 2009

Fish Assessment of Lake Nokomis (ID #27-0019), Hennepin County, Minnesota in 2008

Summary

Lake Nokomis is a 204 acre lake located in Hennepin County, Minnesota.

On July 10 and 11, 2008, a fish survey using trapnets was conducted on Lake Nokomis. The objective of the fish survey was to characterize existing fish conditions and to determine if fish densities were high enough to be contributing to the observed poor water quality in Lake Nokomis.

Results of the 2008 fish survey are shown in Table 1. A total of nine species were sampled. The fish catch was dominated by bluegill sunfish with moderate numbers of black crappies, black bullheads, and pumpkinseed sunfish. Other species were sampled in low numbers, but within normal ranges for lakes of the Lake Nokomis type, based on MnDNR ranges. No carp were sampled during this survey. Carp may be present in Lake Nokomis, but they do not appear to be present at a high density.

Bluegill sunfish may be at a high enough density to contribute to poor water quality in Lake Nokomis. It is recommended that a bluegill reduction program be implemented with a fish removal effort coupled with stocking largemouth bass, walleyes, and channel catfish.

Table 1. Lake Nokomis trapnet results for the fish survey conducted in July 2008.

	Bluegill	Black Bullhead	Black Crappie	Golden Shiner	Hybrid Sunfish	Pumpkin-seed	Walleye	White Sucker	Yellow Perch
Thursday (7/10)	673	4.7	22	0	0.3	4	0.5	0.8	0.5
Friday (7/11)	276	6.7	6.2	0.2	0	2.5	0.5	0.2	0.5
Totals (12 nets)	5692	68	166	1	2	39	6	6	6
2008 Fish/net	**474**	**5.8**	**14**	**0.1**	**0.2**	**3.3**	**0.5**	**0.5**	**0.5**
MnDNR Normal Range	7.5 - 63	0.7 - 26	1.8 - 21	0.2 - 0.8	NA	0.7 - 4.2	0.3 - 1.2	0.2 - 1	0.3 - 2

Conclusions and Recommendations

The carp population in Lake Nokomis is probably at a moderate level and is not directly limiting aquatic plant growth. Rather, the combined effects of carp and high densities of bluegill sunfish may contribute to poor mid-summer water transparency, which in turn, limits plant growth.

To sustain good water quality in Lake Nokomis (1.4 m transparency, 40 ppb of TP, and 14 ppb of Chlorophyll), fish removal of bluegill sunfish and carp combined with additional stocking of channel catfish is recommended.

Another option to consider, if feasible, is to draw down Lake Nokomis about 5-feet for up to three years. A drawdown would create conditions for more plant colonization of Lake Nokomis, leading to better water clarity. Currently, plant growth is documented out to about 10 feet. It is estimated that the lake area from 0 - 10 feet is only about 20 acres (BWS estimate), but the lake area from 0 - 15 feet is 100 acres (MnDNR). If the lake level was dropped five feet, up to about 90 acres would be 10 feet or less and aquatic plant distribution would increase and improve water clarity. If a summer average clarity increases to 7 or 8 feet, than plant growth could become established out to 15 feet of water depth and the lake could be returned to it's normal level. Maintaining a broad distribution of aquatic plant growth coupled with a balanced fish population could sustain good water quality conditions for the long term in Lake Nokomis.

Sequence of Events for Nokomis Projects

1. Remove bluegill sunfish by trapnetting. Removal goal is 100 pounds/acre or 20,000 pounds for Lake Nokomis. This could occur over three years. Should start in 2009.

2. Winter seining for carp. Carp do not appear to be a major factor at this time, but seining could confirm this. If a winter seining effort produced less than 15,000 pounds, seining could be discontinued. This could occur over the 2009-2010 winter.

3. Stock channel catfish, walleyes, and largemouth bass in 2009. Channel catfish would be the primary predator species for bluegill control. This would not interfere with the tiger muskie stocking program.

4. Conduct a seedbank growth project for sediments collected between 10-15 feet of water depth to see if there are viable native aquatic plant seeds or propagules (summer of 2009).

5. Conduct annual aquatic plant surveys to track distribution, diversity, and depth of colonization of plants.

6. Two to three years after initiation of fish projects, if water quality does not meet unimpaired status, conduct a 5-foot lake draw down for 1 to 3 years to stimulate aquatic plant growth.

Introduction

Lake Nokomis is a 204-acre lake, located in Hennepin County, Minnesota.

In July of 2008, the Minnehaha Creek Watershed District contracted for a fish survey with Blue Water Science with a permit number 15384 granted from the MnDNR. The objectives were to characterize the fish community and to determine if fish were contributing to the poor water quality or lack of submerged aquatic plants that have been observed in Lake Nokomis.

Methods

Six standard trapnets were used for two days to survey fish in Lake Nokomis. The trapnet was a MnDNR-style with a 4 x 6 feet square frame with two funnel mouth openings and 50-feet lead. Net mesh size was ½ inch (bar length). Six standard trap nets were set on Wednesday morning July 9, 2008. Six nets were fished for the following 2 days (July 10, 11). Trapnet locations are shown in Figure 1 and pictures of a typical trapnet are shown in Figure 2.

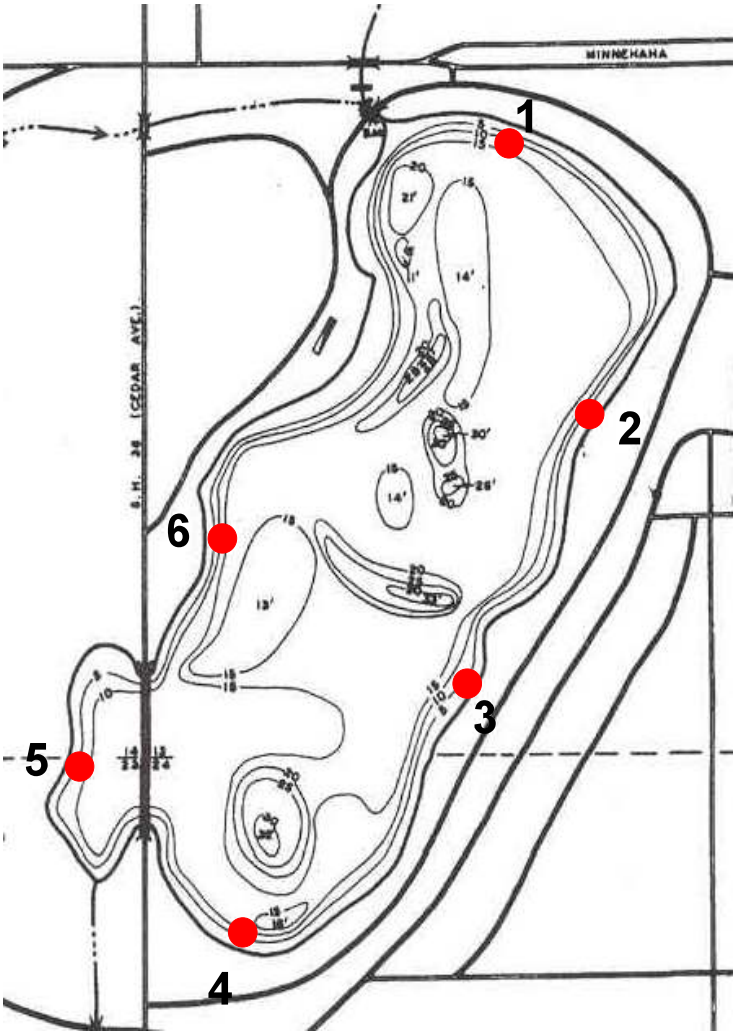


Figure 1. Map of trapnet sets.

Figure 2. [top] A trapnet is a live fish trap. Fish run into the 50-foot lead net and follow it back through a series of hoops with funnel mouths. Fish end up in the back hoop.
[middle] A handheld net is used to remove the fish from the back of the trapnet.
[bottom] Fish are transferred to tubs, then they are counted and measured.

Results

A total of nine fish species were sampled in Lake Nokomis on July 10, 11, 2008. The fish catch was dominated by bluegill sunfish. The number of bluegill sunfish caught per net was high with the average haul of 474 per net (Table 1). This is above the normal range of 8-63 bluegills per lift for a lake like Lake Nokomis.

Bullheads, crappies, and pumpkinseed sunfish were found in moderate numbers and other fish sampled were within a normal range for lakes of the Lake Nokomis type, as defined by the MnDNR.

Carp were not sampled in this fish survey. They are probably present in Lake Nokomis but at low densities.

Table 1. Lake Nokomis trapnet results for the fish survey conducted in July 2008.

Net	Bluegill	Black Bullhead	Black Crappie	Golden Shiner	Hybrid Sunfish	Pumpkin-seed	Walleye	White Sucker	Yellow Perch
Thursday (7/10)									
1	837	4	39		1	7	1	4	
2	1642	1	5			7			
3	1188	9	30			5	2		
4	330	2	18		1	3			1
5	30		2			2			2
6	12	12	35					1	
subtotal	4039	28	129		2	24	3	5	3
fish/net	**673**	**4.7**	**22**	**0**	**0.3**	**4**	**0.5**	**0.8**	**0.5**
Friday (7/11)									
1	960	13	27			5	3	1	2
2	241	13	5	1		3			
3	402	12	1			6			1
4	37		1			1			
5	13	2	3						
6									
subtotal	1653	40	37	1		15	3	1	3
fish/net	**276**	**6.7**	**6.2**	**0.2**	**0**	**2.5**	**0.5**	**0.2**	**0.5**
Total Fish (12 nets)	5692	68	166	1	2	39	6	6	6
Fish/ Trapnet	**474**	**5.7**	**14**	**0.08**	**0.2**	**3.3**	**0.5**	**0.5**	**0.5**
MnDNR Normal Range*	7.5 - 63	0.7 - 26	1.8 - 21	0.2 - 0.8	NA	0.7 - 4.2	0.3 - 1.2	0.2 - 1	0.3 - 2

Fish lengths are shown in Table 2. Approximately 97% of the bluegill catch were 6 inches or less, and were probably stunted. Black crappies had a bimodal distribution and were represented by at least a couple of year classes. Black bullheads were mostly 9 - 10 inches and were not stunted. Walleyes were present, but their lengths were only up to 15 inches. Their population would not be able to keep bluegills under control.

Table 2. Length frequency of fish species (as total length) for the Lake Nokomis fish survey.

Size Range (in)	Bluegill (n=360)	Black Bullhead (n=59)	Black Crappie (n=165)	Golden Shiner (n=2)	Hybrid Sunfish (n=2)	Pumpkin-seed (n=32)	Walleye (n=6)	White Sucker (n=6)	Yellow Perch (n=5)
<3.0	1		2						
3	17								
3.5	47		1			2			
4	43		5		1	2			
4.5	9	1	8			8			1
5	60		26		1	14			
5.5	87		5			3			
6	87		9			2			2
6.5	8		13			1			
7	1		46	2					1
7.5			22						
8		2	12						
8.5			9						
9		33	3						1
9.5		16	2				1		
10		7	1				1		
10.5									
11							2		
11.5			1						
12									
13									
14							1		
15							1	1	
16								2	
17									
18								1	
19								2	
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									

Figure 3. Top left: Bluegill sunfish.
Top right: Walleye.
Bottom left: Golden shiner.
Bottom right: Tub of fish collected on July 11, 2008 from one net.

Summary of Past Fish Surveys

There have been 13 fish surveys from 1948 - 2008. The number of species has ranged from a low of 7 in 1972 to a high of 15 in 1996. Walleyes were the primary piscivore in 2008. Largemouth bass haven't been sampled since 2001 and northern pike haven't been sampled since 1982. Tiger muskies are probably present, but in low numbers. They were not sampled in 2008. Bluegills were at an all time high in 2008. Crappies have also been found a high levels in the past, especially in 1996 and in 1992. Carp are known to be in Lake Nokomis but have not been sampled in a fish survey since 1996 (Table 3).

Table 3. Lake Nokomis MnDNR trapnet results for fish surveys conducted from 1948 - 2005. The 2008 survey was conducted by Blue Water Science.

	1948 May 5	1958 May 19	1972 July 1	1975 Aug 5	1977 June 29	1982 June 25	1987 June 24	1991 May 2	1992 June 22	1996 June 24	2001 July 19	2005 July 18	2008 July 10	% occurrence for 13 surveys
Bluegill	0.9	20	1	0.4	21	23	75	0.4	115	94	54	27	474	100%
Black Bullhead	1	6.7	2	0.6	3.4	13	12	26	6	7.8	1.6	1.3	5.7	100%
Black Crappie	1.6	83	12	11	16	98	28	5	133	293	23	2	14	100%
Bowfin						0.3	0.3					0.2		23%
Brown Bullhead				0.1		0.3								15%
Carp	0.08	0.2		0.3	0.6	2			0.4	0.2				54%
Golden Shiner		0.5			0.4	0.1	0.3	0.1	5.1	4.3	0.9	0.2	0.08	77%
Goldfish											0.1			8%
Green Sunfish		0.3					1.8	0.1		1.4	2.4	0.1		46%
Hybrid Sunfish		0.3		0.3	0.6	1.9	2.3		1.1	0.2	4.4	0.9	0.2	77%
Large-mouth Bass	0.3	0.3					1.3			0.1	0.1			39%
Northern Pike			0.1	0.1	0.3	0.3								31%
Pumpkin-seed		16			0.7	4	7	0.7	13	2.2	3.8	0.6	3.3	77%
Tiger Muskie										0.2	0.1	0.1		23%
Walleye						0.9	0.3	3	3.1	2	0.4	1.2	0.5	62%
White Crappie			8.9							1.6				15%
White Sucker	0.08	0.1	0.6	0.2	1	4.5		1.3	2.3	1.3	0.4	2.1	0.5	92%
Yellow Bullhead	0.08					0.5	0.8	0.6	0.3	0.3	0.1			54%
Yellow Perch	0.08	1.7	12	2	2.7	4.3	15	5	15	21	6.8	3.8	0.5	100%
Number of fish species	8	11	7	9	10	14	12	10	11	15	14	12	9	

Fish Impacts on Lake Nokomis Water Quality

Currently, bluegill sunfish are abundant in Lake Nokomis with higher densities than regional averages. Also, there was a noticeable lack of gamefish in the lake. In this case, gamefish would be important because they would serve as a population control on panfish. Without this control, bluegill numbers have become very high.

At the present density, bluegills probably are contributing to poor water quality in Lake Nokomis. How do panfish cause poor water quality? Bluegills deplete zooplankton in the water column as well as feed off the bottom. The bottom feeding results in resuspension of lake sediments, but there is another impact. Bluegills ingest sediment along with food particles, and excrete most of the sediment which is high in phosphorus. This is another way phosphorus gets in the water column. At high bluegill densities, their impact is similar to bottom feeding carp.

Stomach content analysis of bluegills in other lakes with high bluegill densities showed insect parts along with bottom detrital material and confirms that bluegills are feeding off the bottom (McComas, unpublished). The result is an elevated phosphorus concentration in the lake resulting in abundant algae growth combined with the suspension of bottom lake sediments that together produce poor water clarity.

Potential phosphorus loading from bluegill sunfish is shown in Table 4.

Table 4. Bluegill phosphorus excretion rates (from Schaus et al 1997) are 1.0 to 2.3 µg/g/hr for unfed fish and 1.2 to 5.7 µg/g/hr for fish that were fed. For Lake Nokomis a rate of 3.0 µg/g/hr was used (72 µg/g/day). Therefore, 72 µg x 454 g/pound = 33 mg-P/pound of fish/day. Assume 300 pounds of fish/ac, 300 pounds/ac x 33 mg-P = 9,900 mg = 9.9 g/ac/day. For 204 acre Lake Nokomis: 204 ac x 9.9 g/ac/day = 2,020 g/day = 737 kg/yr.

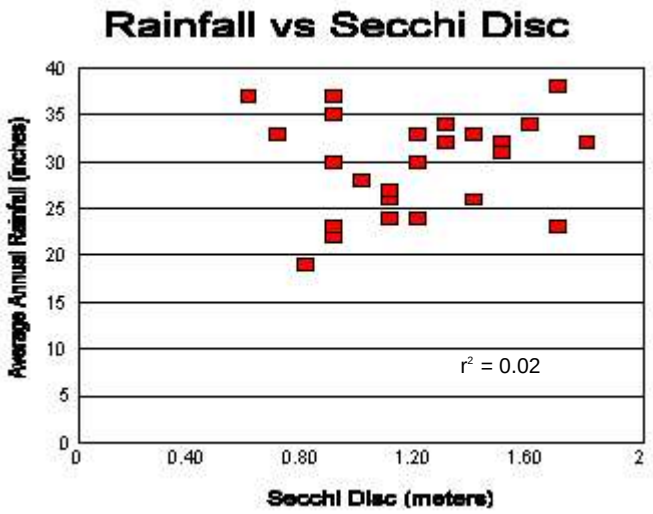
Bluegill Sunfish (pound/ac)	Theoretical Bluegill Phosphorus Loading (in kg/yr) for Lake Nokomis (204 acres)
0	0
50	123
100	246
150	369
200	492
250	614
300	737
350	860
400	983

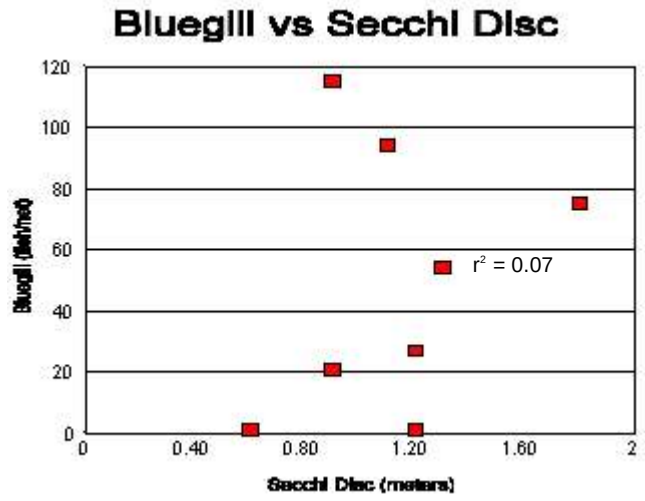
The estimated phosphorus loading from bluegill sunfish is high enough at 737 kg/yr to impact Lake Nokomis water quality. However, p-loading from bluegill may be over-estimated. There may be less than 300 lbs of bluegills/lake acre and they are not feeding all 365 days of the year. That's why the excretion rate was set at 3.0 µg/gram of fish/hour. Also, the biggest impact comes from fish feeding in the lake sediments and excreting "new" phosphorus compared to feeding in the water column and "recycling" water column phosphorus. At this time, it is unknown how much time bluegills feed in the water column verses in the sediments.

Although fish are suspected as being a water quality factor, many variables are involved. There is basically no correlation to the number of bluegills per trapnet and Secchi disc summer averages ($r^2 = 0.07$)(Table 5). However, there is also no correlation to rainfall, which is a surrogate for watershed loading as well ($r^2 = 0.02$). The role of fish impacts on water quality is not completely understood in Lake Nokomis.

Table 5. Lake Nokomis trapnet results for the fish survey conducted in previous years.

	Secchi (m)	Average Annual Rainfall (inches)	Bluegill fish/net	Black Crappie fish/net	Carp fish/net	Carp fish/net x 100
1948		17	1	2	0.1	8
1958		16	20	83	0.2	20
1972	1.2	24	1	12	0	0
1973		21				
1974		19				
1975		35	1	11	0.3	30
1976		17				
1977	0.9 (6.29)	35	21	16	0.6	60
1978		30				
1979		31				
1980	0.9	22				
1981	1.0 (6.23)	28				
1982		30	23	98	2	200
1983		39				
1984	0.9	37				
1985		32				
1986		37				
1987	1.8 (6.24)	32	75	28	0	0
1988	0.8	19				
1989	0.9	23				
1990	0.7	33				
1991	0.6	37	1	5	0	0
1992	0.9	30	115	133	0.4	40
1993	1.5	32				
1994	1.2	30				
1995	1.4	26				
1996	1.1	26	94	293	0.2	20
1997	1.6	34				
1998	1.4	33				
1999	1.5	31				
2000	1.3	32				
2001	1.3	34	54	23	0	0
2002	1.7	38				
2003	1.7	23				
2004	1.1	27				
2005	1.2	33	27	2	0	0
2006	1	28				
2007	1.1	24				
2008	1.1	22	474	14	0	0





Fish Impacts on Water Quality in Other Lakes: For centuries (going back to Chinese fish farmer reports), it's been known fish have impacts on water quality. In Minnesota, as early as 1916, carp were being seined out of lakes because of their deleterious effect on aquatic plants and water clarity (McComas 2003a).

More recently, experiments in eutrophic Swedish lakes showed dense fish populations of planktivorous and benthivorous fish resulted in high concentrations of chlorophyll, blooms of blue-green algae and low transparency (Andersson et al 1978).

A variety of fish species can cause adverse water quality impacts, and a summary of fish species that can impact water quality is shown in Table 6.

Table 6. List of fish that have been documented to cause poor water clarity.

Species	Situation	Reference
Carp	Adverse water quality and plant impacts have been known for some time.	Lamarra 1975; Zambrano et al 2001; Parkos et al 2003
Black bullheads	Eagle Lake, Cottonwood County, cleared up after a rotenone treatment	McComas, unpublished
Smallmouth buffalo	Mesocosm experiments found smallmouth buffalo enhanced turbidity, algae, nitrogen, and phosphorus.	Shormann and Cotner 1997
Crucian carp	Fish density: 1,960 lb/ac (in mesocosm) produces a lot of algae.	Andersson et al 1978
Gizzard shad	Nutrient excretion by bottom-feeding fish, in this case gizzard shad, produces nutrients for algae growth. Fish density was 370 lbs per acre.	Schaus et al 1997
Bream and roach	Fish density: 800 lb/ac (in mesocosm) produces a lot of algae.	Andersson et al 1978
Young of year walleye	Larval walleye (9 mm TL) stocked at 50 fish/m^3 produced lower clarity and more algae than ponds stocked at 10 fish/m^3.	Qin and Culver 1995
Mosquitoe fish	Water quality improves dramatically when a fungal infection kills more than 80% of the *Gambusia* (Mosquitoe Fish).	Nagdali and Gupta 2002
Fathead minnows	Ponds with fathead minnows had poorer water clarity and fewer aquatic plants than fishless ponds.	Zimmer et al 2001
Bluegill sunfish	High density of over 1,400 bluegill sunfish per trapnet was correlated with poor clarity and no submerged aquatic plants in Pond 213.	McComas, 2003b
Bluegill sunfish and black bullheads	High density of bluegill sunfish (465/lift) and black bullheads (97/lift) were suspected of causing poor water quality in Lee Lake.	McComas, 2004
Bluegill sunfish	High density of bluegill sunfish of 193 bluegills/net and 50 black bullheads/net were suspected of causing poor water quality in Alimagnet Lake.	McComas, 2005

Lake Sediment Conditions and Potential Impacts from Fish

Estimating a carp population and its biomass in a lake is difficult. A standard technique is to use trapnet results from fish surveys and compare to regional averages to determine a high or low carp population. This approach is helpful, but there is still uncertainty involved. An additional technique is to look for signs of carp activity in a lake.

At low to moderate carp densities, carp will feed in aquatic plant beds where high quality macro-invertebrates are present. At low densities, some plants are uprooted but many are still intact. Carp are not a problem in these situations and do not significantly contribute to water quality problems. However, at high carp densities, after plant bed feeding is exhausted, carp go to open sand and mud flat areas to feed. The food quality of macro-invertebrates is lower in these areas, and is a secondary feeding area.

When feeding in lake sediments, carp create small bowl-like depressions in the sediments, much like what is shown in Figure 4. These depressions can be seen in shallow water and indicate a high density of carp are present in a lake.

In July of 2008, a shoreline "carp indicator" survey was conducted in Lake Nokomis. No bowl-like depressions were observed in Lake Nokomis in the course of the survey. Although carp are observed in Lake Nokomis, their population may be low to moderate.

Figure 4. These are bowl-like depressions caused by carp feeding. These depressions were observed in aquaria with carp at the Blue Water Science labs and were similar to what has been observed in lakes with high density of carp. These bowl-like depressions were not observed in Lake Nokomis.

Aquatic Plant Conditions and Potential Impacts from Fish

Lack of aquatic plants in a lake can be an indicator of excessive numbers of bottom feeding fish. Bottom feeding fish, such as carp, can uproot plants in their search for food. Initially, the scarcity of submerged aquatic plants in Lake Nokomis (Figure 5) was attributed to excessive numbers of bottom feeding fish. But the lack of aquatic plants in Lake Nokomis may be related to other factors.

Figure 4. Submerged plants are scarce in Lake Nokomis. A plant assessment was conducted by Blue Water Science in July 2008. Only two submerged plant species were observed, coontail and Eurasian watermilfoil.

A modified point intercept survey was conducted by the Minneapolis Park and Recreation Board in September of 2008. A map of aquatic plant distribution is shown in Figure 6. Plants were restricted to nearshore areas around the perimeter of Lake Nokomis. Plants did not grow in water deeper than 10 feet.

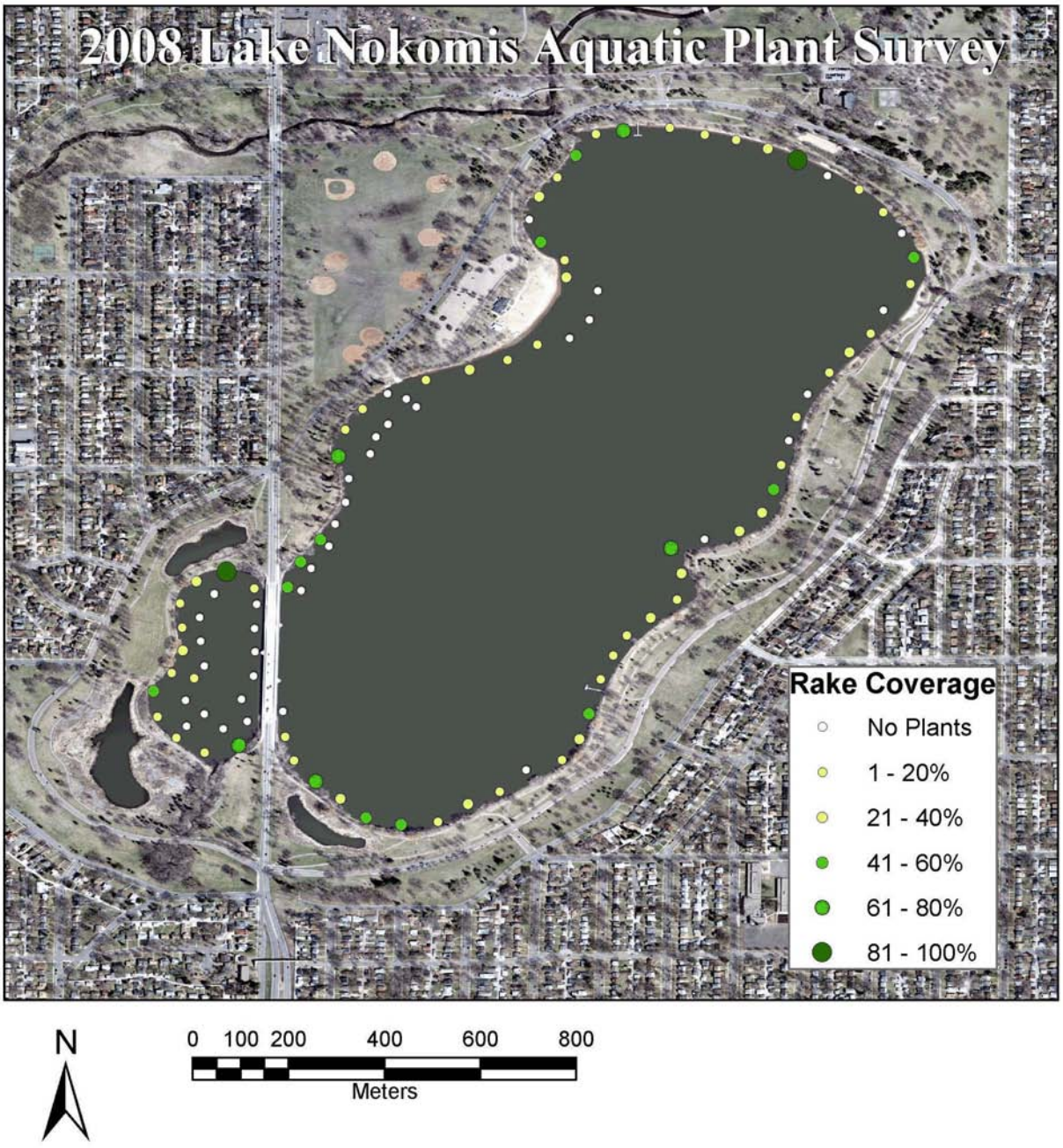


Figure 6. Aquatic plant distribution in Lake Nokomis in September, 2008 (source: Minneapolis Park and Recreation Board).

Aquatic plants have been sparse and found with a low diversity in Lake Nokomis for some time. A summary of aquatic plant surveys from 1982 - 2008 is shown in Table 6. In the most recent surveys of 2008 plants did not grow deeper than 10 feet of water (MPRB and Blue Water Science). Aquatic plants were estimated to cover about 16 acres of lake area, based on an assessment by Blue Water Science in July 2008. Although this is only 7% lake area, the bathymetry of the lake is a factor. Water depth drops off relatively quickly after the 10-foot depth. Plants are not growing deeper than 10-feet because they are light limited and it probably is not due to fish impacts.

For Lake Nokomis, it is estimated that the lake area between 0 to 10 feet is about 20 acres and that plants occupy about 16 acres. This is only 4 acres less than what might be expected based on the water clarity. If fish are having an impact it is an indirect impact, that is, their indirect impact comes from contributing nutrients to produce algae blooms which produce mid-summer transparencies around 1 meter or less. Then aquatic plants are light-limited. A rule of thumb is plants grow to about twice the depth of mid-summer Secchi readings. Plants would not be expected to grow much deeper than about 9 feet in Lake Nokomis. It does not appear that fish are directly uprooting plants and limiting their growth from that mechanism.

Table 6. Aquatic plant species observed in Lake Nokomis. Eurasian watermilfoil was first observed in Lake Nokomis in 1995.

	1982 June 23 - 25 (MnDNR)	1992* June 22 - 25 (MnDNR)	2005 August % occur (14 points) (MPRB)	2008 September % Occur (105 points) (MPRB)
Cattail		Present		
Hardstem bulrush		Present		
Sedge	Present			
Narrowleaf pondweed	Common	Present		
Sago pondweed	Common	Occasional		
Curlyleaf pondweed	Common	Occasional		
Water stargrass	Present			
Coontail			57%	20%
Eurasian watermilfoil			21%	61%
Floatingleaf pondweed				Present

* plants observed only along the north and northeast shore.

Conclusions and Recommendations

The carp population in Lake Nokomis is probably at a moderate level and is not directly limiting aquatic plant growth. Rather, the combined effects of carp and high densities of bluegill sunfish may contribute to poor mid-summer water transparency, which in turn, limits plant growth.

To sustain good water quality in Lake Nokomis (1.4 m transparency, 40 ppb of TP, and 14 ppb of Chlorophyll), fish removal of bluegill sunfish and carp combined with additional stocking of channel catfish is recommended.

Another option to consider, if feasible, is to draw down Lake Nokomis about 5-feet for up to three years. A drawdown would create conditions for more plant colonization of Lake Nokomis, leading to better water clarity. Currently, plant growth is documented out to about 10 feet. It is estimated that the lake area from 0 - 10 feet is only about 20 acres (BWS estimate), but the lake area from 0 - 15 feet is 100 acres (MnDNR). If the lake level was dropped five feet, up to about 90 acres would be 10 feet or less and aquatic plant distribution would increase and improve water clarity. If a summer average clarity increases to 7 or 8 feet, than plant growth could become established out to 15 feet of water depth and the lake could be returned to it's normal level. Maintaining a broad distribution of aquatic plant growth coupled with a balanced fish population could sustain good water quality conditions for the long term in Lake Nokomis.

Sequence of Events for Nokomis Projects

1. Remove bluegill sunfish by trapnetting. Removal goal is 100 pounds/acre or 20,000 pounds for Lake Nokomis. This could occur over three years. Should start in 2009.

2. Winter seining for carp. Carp do not appear to be a major factor at this time, but seining could confirm this. If a winter seining effort produced less than 15,000 pounds, seining could be discontinued. This could occur over the 2009-2010 winter.

3. Stock channel catfish, walleyes, and largemouth bass in 2009. Channel catfish would be the primary predator species for bluegill control. This would not interfere with the tiger muskie stocking program.

4. Conduct a seedbank growth project for sediments collected between 10-15 feet of water depth to see if there are viable native aquatic plant seeds or propagules (summer of 2009).

5. Conduct annual aquatic plant surveys to track distribution, diversity, and depth of colonization of plants.

6. Two to three years after initiation of fish projects, if water quality does not meet unimpaired status, conduct a 5-foot lake draw down for 1 to 3 years to stimulate aquatic plant growth.

References

Andersson, G., H. Berggren, G. Cranberg, and C. Glenn. 1978. Effects of planktivorous and benthivorous fish on organisms and water chemistry in eutrophic lakes. Hydrobiologia 59:9-15.

Brabrand, A., B.A. Faafeng, and J.P.M. Nilssen. 1990. Relative importance of phosphorus supply to phytoplankton production: fish excretion versus external loading. Canadian Journal of Fisheries and Aquatic Sciences 47:364-372.

Lamarra, V.A., Jr. 1975. Digestive activities of carp as a major contributor to the nutrient loading of lakes. Verh. Int. Ver. Limn. 19:2461-2468.

McComas, S.R. 2003a. Lake and pond management guidebook. CRC Press, Boca Raton, FL.

McComas, S.R. 2003b. Fish survey of Pond 213P, Apple Valley, Minnesota. Prepared for the City of Apple Valley, Minnesota.

McComas, S.R. 2004. Fish survey of Lee Lake, Lakeville, Minnesota in 2004. Prepared for the City of Lakeville, Minnesota.

McComas, S.R. 2005. Fish survey of Alimagnet Lake, Apple Valley and Burnsville, Minnesota in 2005. Prepared for the Cities of Apple Valley and Burnsville.

Nagdali, S.S. and P.K. Gupta. 2002. Impact of mass mortality of a mosquito fish, *Gambusia affinis* on the ecology of a fresh water eutrophic lake (Lake Naini Tal, India). Hydrobiologia 468:45-51.

Parkos III, J.J., V.J. Santucci, Jr, and D.H. Wahl. 2003. Effects of adult common carp (*Cyprinus carpio*) on multiple trophic levels in shallow mesocosms. Canadian Journal of Fisheries and Aquatic Sciences 60:182-192.

Qin, J. and D.A. Culver. 1995. Effect of young-of-the-year walleye (*Percidae: Strizostedion vitreum*) on plankton dynamics and water quality in ponds. Hydrobiologia 297:217-227.

Schaus, M.H., M..J. Vanni, T.E. Wissing, M.T. Bremigan, J.E. Garvey, and R.A. Stein. 1997. Nitrogen and phosphorus excretion by detritivorous gizzard shad in a reservoir ecosystem. Limnology and Oceanography 42:1386-1397.

Shapiro, J., B. Forsberg, V. Lamarra, G. Lindmark, M. Lynch, and G. Zoto. 1982. Experiments and experiences in biomanipulation. Studies of biological ways to reduce algal abundance and eliminate blue-greens. Interim Report, Limnological Research Center University of Minnesota 19. Rep. EPA-600/3-82-096, Corvallis Environmental Research Laboratory, Oregon.

Shormann, D.E. and J.B. Cotner. 1997. The effects of benthivorous smallmouth buffalo (*Ictiobus bulalus*) on water quality and nutrient cycling in a shallow flood plain lake. Lake and Reservoir Management 13:270-278.

Zambrano, L., M. Scheffer, and M. Martinez-Ramos. 2001. Catastrophic response of lakes to benthivorous fish introduction. Oikos 94:344-350.

Zimmer, K.D., M.A. Hanson, M.G. Butler, W.G. Duffy. 2001. Influences of fathead minnows and aquatic macrophytes on nutrient partitioning and ecosystem structure in two prairie wetlands. Arch. Hydrobiologia. 150:411-433.

Appendix A

Minnesota DNR Fish Permit

End date amended 7-3-08

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
FISH MANAGEMENT SECTION, DIVISION OF FISH AND WILDLIFE
SPECIAL PERMIT NO. 15384
(General and Miscellaneous)
Date: 25 June 2008

TO WHOM IT MAY CONCERN:
Permission is hereby granted to:

Steve McComas
Blue Water Science
550 South Snelling Avenue
St. Paul, MN 55116

to collect fish by fyke (trap) netting on the water bodies listed on the attached page. Up to four (4) nets may be set for up to four (4) nights per lake. All fish will be returned to the water after appropriate measurements. Unidentified fish may be collected and transported for identification. All nets left overnight will have a tag with the permit number and Blue Water Science. A copy of this permit shall be carried while sampling.

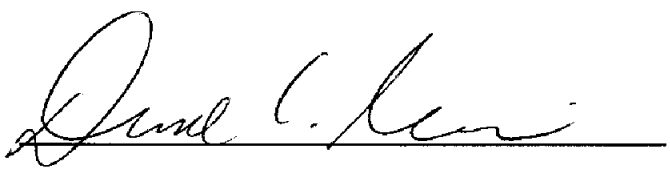
Collections from designated infested waters (see http://files.dnr.state.mn.us/eco/invasives/infestedwaters.pdf for current list) should be done with care to avoid incidental transfer of aquatic invasive species. According to Minnesota Rule 6216.0500, water from infested waters may not be used to transport wild animals and water may not be transported from designated infested waters without a separate permit from DNR - Division of Ecological Resources. Questions about permits, requests for an application, and completed applications should be directed to: Jay Rendall, Invasive Species Prevention Coordinator, 500 Lafayette Road, St. Paul, MN 55155, email at jay.rendall@dnr.state.mn.us, or phone at 651-259-5131.

The Area Fisheries Supervisor and Regional Enforcement Manager must be notified in advance of sampling. Your letter of application does not constitute advance notification of your intent to sample.

A report detailing collection of activities (species, numbers, and collection sites) will be submitted to the Division of Fish and Wildlife by 31 January of each year.

This permit is valid from date of issuance through 31 December 2008, but may be revoked at any time.

DONALD L. PEREIRA
FISHERIES RESEARCH AND POLICY MANAGER



I hereby certify that I have read and understand the provisions of this permit and understand that this permit is not valid unless it is signed by me.

Permittee Signature	**Title**	**Date**

Steve McComas
Special Permit 15384
25 June 2008

	County	Responsible Party
Lakes:		
North Arbor	Hennepin	City of Maple Grove
South Arbor	Hennepin	City of Maple Grove
West Arbor	Hennepin	City of Maple Grove
Nokomis	Hennepin	Minnehaha Creek Watershed District

cc: Division of Fish and Wildlife
Daryl Ellison, West Metro Area Fisheries Supervisor, Eden Prairie (651-952-826-6771)
Steve Jacobson, Acting Regional Enforcement Manager, St. Paul (320-845-4767)
Dirk Peterson, Regional Fisheries Manager, St. Paul