

An assessment of the zebra mussel population of Platte Lake (2004) and its influence on the cyanobacterium *Microcystis aeruginosa*

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Introduction

Zebra mussels (*Dreissena polymorpha*) are known to have widespread ecological impacts in freshwater systems. Such impacts include increases in: underwater light penetration, macrophyte growth, benthic productivity, mortality of native clam species, and the frequency and intensity of cyanobacterial blooms.

Zebra mussels are highly successful invaders and competitors as a result of many of their life history characteristics. For example, zebra mussels are unique freshwater mollusks in that they have microscopic, free swimming larvae. Such larvae are capable of seeking out viable substrate, thus expanding populations. Adult females are highly fecund, producing in excess of one million eggs per year. These gametes are released during numerous spawning events throughout the year, allowing this species to quickly colonize lakes and streams.

In addition to reproduction, zebra mussels are efficient filter feeders. Each adult mussel can filter greater than one liter of water per day, consuming primarily detritous and phytoplankton (Stegemann 1992). Water becomes clearer over time as zebra mussel populations consume food particles or seston at very high rates. Food that is not consumed is either rejected entirely, or coated with a layer of mucus and expelled as pseudofeces.

Recently, an increase in cyanobacterial blooms, particularly the species *Microcystis aeruginosa*, has been reported in southwest Michigan as well as Leelanau County. In Platte Lake (Benzie County), a similar bloom was observed in 2003. Such blooms are believed to be promoted by established zebra mussel populations (Raikow 2004); in fact, *M. aeruginosa* densities can be linked to zebra mussel population filtering capacities (Keilty and Woller, 2004). Zebra mussels reject *M. aeruginosa* as unpalatable while consuming their competitors (Vanderploeg et. al 2001). *M. aeruginosa* is typically found in the upper layers of the limnion, far from siphons of large zebra mussel populations. The resulting conditions are ideal for *M. aeruginosa* growth, resulting in population explosions, or “blooms”.

The purpose of this study was to assess the zebra mussel population at specific locations in Platte Lake and estimate their impact on phytoplankton assemblages.

Methods

Big Platte Lake was separated into three regions; south, east and outflow. Samples were collected from 13 sites throughout the lake (Appendix A1). At deep locations, those greater than 15 feet, bottom samples were collected using petite ponar dredge. These samples were emptied into a large bucket and zebra mussels were extracted by hand, counted, and measured in length. At shallow depths, those less than 15 feet, quadrats of the lake bottom were randomly sampled. At these locations, all zebra mussels were identified within the quadrat, counted, and measured in length.

Results

Zebra mussel densities were determined by dividing the counts at individual sites by the area of the collection device used at each site (Table 1 and Appendix A2). There was not a significant relationship between either zebra mussel density and lake-region or depth.

The lake was divided into four zones based on depth: 0 to 10 feet, 10 to 20 feet, 20 to 30 feet, and greater than 30 feet to calculate the total number of zebra mussels in the lake. The total number was determined by multiplying the mean number of zebra mussels in each depth zone by the area of zone (Table 2). The sum of the four zones is the estimated total number of zebra mussels within Platte Lake, approximately 10.1 billion.

Mean zebra mussel shell lengths ranged from 4.3 – 14.0mm (Table 1, Figure 1, Appendix A3). Zebra mussel shell lengths collected at sites 1 and 4 containing *Chara sp.*, were significantly smaller than sites with clear or bare substrate. Regression analyses for zebra mussel shell length as a function of depth were significant (p-value < 0.02, Figure 2) and shell lengths were shown to be significantly different at depths (0-10 feet, 11-20 feet and 21-30 feet) using ANOVA (p-values < 0.00005).

Several studies have estimated zebra mussel filtering rates. For example, Reeders et. al (1993) determined filtering rates based on mean shell length according to:

$$f_z = 0.37 / (0.293 + 52.38 * e^{-0.367 * L}) \quad (1)$$

f_z = filtration rate of an individual zebra mussel (L/ind/day)

L = zebra mussel shell length (mm)

Stegemann (1992) estimated that individual adult zebra mussels filter approximately 1 liter of water per day.

$$f_z = 1 \quad (2)$$

Canale and Chapra (2002) divided zebra mussels into small, medium, and large size classes and determined that

$$f_z = 0.206 f_s + 0.848 f_M + 2.41 f_L \quad (3)$$

where f_s , f_M , and f_L are the fractions of the population that are small (L less than 10mm), medium (L between 10 and 20mm), and large (L greater than 20mm).

These filtering rates can be used to estimate the filtering capacity of the zebra mussel population (FC), based on the size of the population (Z), the filtering rate of the individuals (f_z) and the volume of water being filtered (V).

$$FC = V / (f_z Z) \quad (4)$$

Note that FC is equivalent to the time necessary to filter V and can be calculated using the sum of zebra mussel activity in each depth zone as shown in Table 3. The values range between 7.9 and 45.8 days for the entire lake and 5.1 and 29.4 days for the lake volume above 30 feet.

Discussion

Distribution and Length

Zebra mussel densities were greatest near the outflow where waters are shallow and plankton is in high supply (Appendix A2). These populations were “reefs” of large, adult zebra mussels in high densities. In other regions, samples tended to have either high densities or larger animals. For example sites 3 and 4, contain relatively young, small individuals, but the densities are the highest recorded (Appendix A2).

Zebra mussels found attached to *Chara sp.*, the macrophyte common to Platte Lake, rarely exceed 10mm in length. This is typical not only in Platte Lake, but in several Leelanau County lakes as well (Keilty and Woller 2004). Large adults are rarely found attached to *Chara sp.* likely because this substrate is not stable enough to counterbalance wave action and larger zebra mussels. In addition as the plant grows, longer portions with older, larger attached zebra mussels may slough off.

The shrub-like growth formation of *Chara sp.* results in the vertical extension of potential zebra mussel habitat. Beds of *Chara sp.* can support extremely dense populations of young zebra mussels capable of reproduction (zebra mussels reach reproductive age anywhere from a few months to a year based on water temperatures). Although young populations may not substantially contribute to the filtering capacity of the overall zebra mussel population, they very well could influence the population’s expansion and growth by supplying billions of viable gametes per year.

Filtering Capacity

Vanderploeg et. al (2001) demonstrated that zebra mussels selectively reject *M. aeruginosa*, while consuming more desirable species, including green algae and diatoms.

In addition, the buoyancy of *M. aeruginosa* effectively removes it from lake bottoms, (where zebra mussel filtering and consumption occur). As numbers of competing algae, decline, *M. aeruginosa* and other cyanobacteria thrive, exploiting newly available resources.

Since the amount of *M. aeruginosa* is related to the total number of zebra mussels and the lake/basin-wide alteration of algal species composition, Keilty and Woller (2004) describe maximum *M. aeruginosa* concentrations in several Leelanau County lakes as a function of zebra mussel filtering capacity assuming a rate of 1L/ind/day (Figure 3).

The maximum *M. aeruginosa* density in Platte Lake was 2562 cells/mL on July 28, 2004. This value and a filtering capacity of 7.9 days is shown in Figure 3 for comparison. Note that the measured concentration in Platte Lake is somewhat higher than would be predicted using zebra mussel activities alone. However, the Leelanau County lakes are ultra-oligotrophic (TP = 5µg/L), whereas Platte Lake contains higher total phosphorus (TP about 8µg/L) which contributes to cyanobacterial growth potential.

In addition to zebra mussels, cyanobacterial blooms are influenced by a number of environmental factors. Higher concentrations of total phosphorus, and water temperatures greater than 20° C (Robarts and Zohary 1987) for example, favor cyanobacterial growth. Since blooms have been observed in regional lakes with lower total phosphorus concentrations, Platte Lake is at greater risk for continual, relatively high concentrations of seasonal cyanobacteria.

Recommendations

Based on the measured data and additional field observations, the population of zebra mussels in Platte Lake is likely changing as a function of time and is unevenly distributed (mean densities vary from 0 to 9,515 ind/m²). The results of this study should be treated as approximations because relatively few samples were collected for this assessment. If greater accuracy is desired, it is recommended that sampling continue in 2005 and be expanded to approximately 50 sites, (including those sampled in 2004). The majority of additional locations should be concentrated in the south and east regions (because of the large amount of suitable zebra mussel habitat) and near the outflow where filtering potential is high. Further effort should be made to examine the relationship between zebra mussel density and water depth to anticipate population growth and future impacts.

The cyanobacterial blooms promoted by established populations of zebra mussels may produce the hepatotoxin, microcystin. Samples from Platte Lake should be tested for microcystin using field kits produced by Envirologix. If such testing shows elevated levels of toxin, further evaluation should be considered. It is recommended that additional samples be archived, by freezing in amber glass for possible quantitative analyses.

Little Platte

Based on observations from the public access site on the south side and the boat launch on the north, there were no zebra mussels found in Little Platte Lake. It is likely, due to its proximity to other, heavily zebra mussel infested lakes, that they have been introduced, perhaps on more than one occasion. Little Platte Lake may not provide sufficient suitable habitat or that individuals have not established highly visible populations. It is unknown how the zebra mussel population will respond in the future, therefore occasional spot checks may be appropriate to track expansion.

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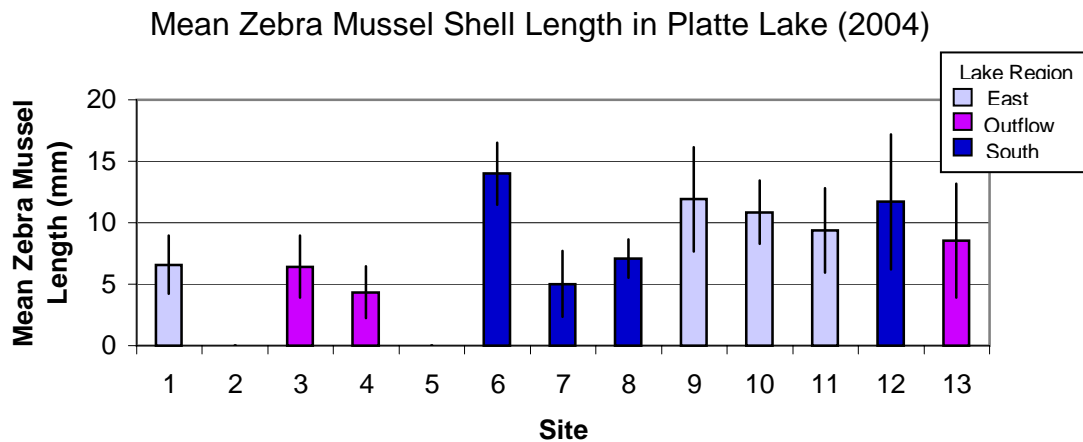


Figure 1. Mean zebra mussel shell length (mm) at sample sites and lake regions (East, Outflow, South) in Platte Lake (2004). Error bars indicate standard error.

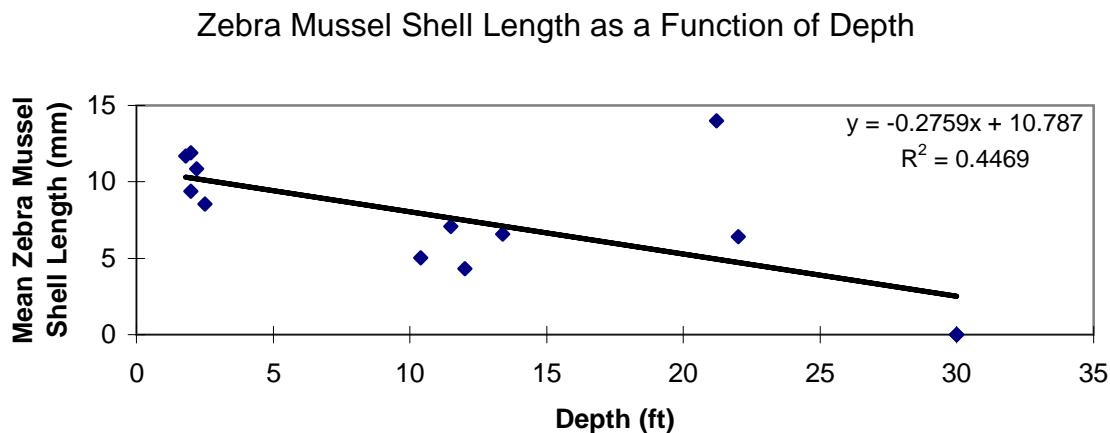


Figure 2. Regression analyses of zebra mussel shell length (mm) as a function of depth (ft) in Platte Lake (2004).

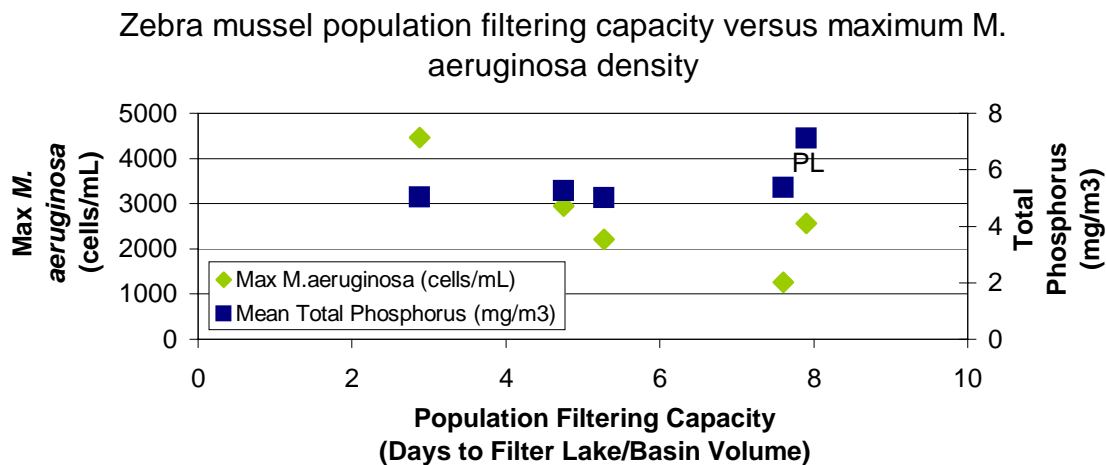


Figure 3. Comparison of Platte Lake (PL, 2004) zebra mussel population filtering capacity (days to filter lake/basin volume), maximum *M. aeruginosa* density (cells/mL) and total phosphorus (mg/m³) with data from Leelanau County (2002/03) .

Date	Site	Latitude	Longitude	Depth (ft)	Zebra Mussel Count ind	Zebra Mussel Density ind/m ²	Shell Length (mm)	Notes	collection method
7/18/2004	9	44.70648	-86.11422	2.0	131	797	11.9	outflow	hoop
7/18/2004	10	44.70584	-86.11492	2.2	206	1254	10.9	outflow	hoop
7/18/2004	11	44.70227	-86.11933	2.0	205	1248	9.4	N of launch	hoop
8/1/2004	12	44.68489	-86.06217	1.8	10	20	11.7	public access	hoop
8/1/2004	13	44.67715	-86.09880	2.5	11	9	8.5	Heiman's	hoop
Average				2.1	113	666	10.5		
7/17/2004	7	44.68972	-86.08056	10.4	51	2196	5.0		ponar
7/17/2004	8	44.68750	-86.07722	11.5	13	560	7.1		ponar
7/17/2004	1	44.69694	-86.11917	13.4	92	3961	6.6	some chara	ponar
7/17/2004	4	44.68167	-86.10278	12.0	221	9515	4.3	chara	ponar
Average				11.8	94.3	4058.0	5.8		
7/17/2004	3	44.68222	-86.10333	22.0	127	5468	6.4		ponar
7/17/2004	6	44.69000	-86.08167	21.2	7	301	14.0		ponar
Average				21.6	67.0	2884.7	10.2		
7/17/2004	2	44.68333	-86.10250	30.0	0	0.0	0.0		ponar
7/17/2004	5	44.68694	-86.08417	30.0	0	0.0	0.0		ponar
Average				30.0	0.0	0.0	0.0		

Table 1. Location and measured zebra mussel counts, densities, and shell lengths in Platte Lake (2004).

Zone	Area m ²	Mean Density ind/m ²	Total ind
0-10	3,988,099	666	2,654,194,406
10-20	1,008,279	4058.0	4,091,590,361
20-30	1,172,676	2884.7	3,382,851,282
30+	4,079,114	0	0
	10,248,168		10,128,636,049

Table 2. Calculation of the total number of zebra mussels in Platte Lake (2004).

Zone	Area m ²	Total ind	Mean Length mm	Stegemann L/ind/day	Reeders L/ind/day	Canale L/ind/day	
0-10	3,988,099	2,654,194,406	10.5	1	0.26	0.848	
10-20	1,008,279	4,091,590,361	5.8	1	0.06	0.206	
20-30	1,172,676	3,382,851,282	10.2	1	0.24	0.848	
30+	4,079,114	0					
		Filtering Capacity (Days)		7.9	45.8	13.4	Whole Lake Volume
		Filtering Capacity (Days)		5.1	29.4	8.6	Surface Volume

Table 3. Calculation of filtering capacity of the whole Lake and surface volume using different filtering rates.

Appendix A – Maps

A1 – Sample Sites

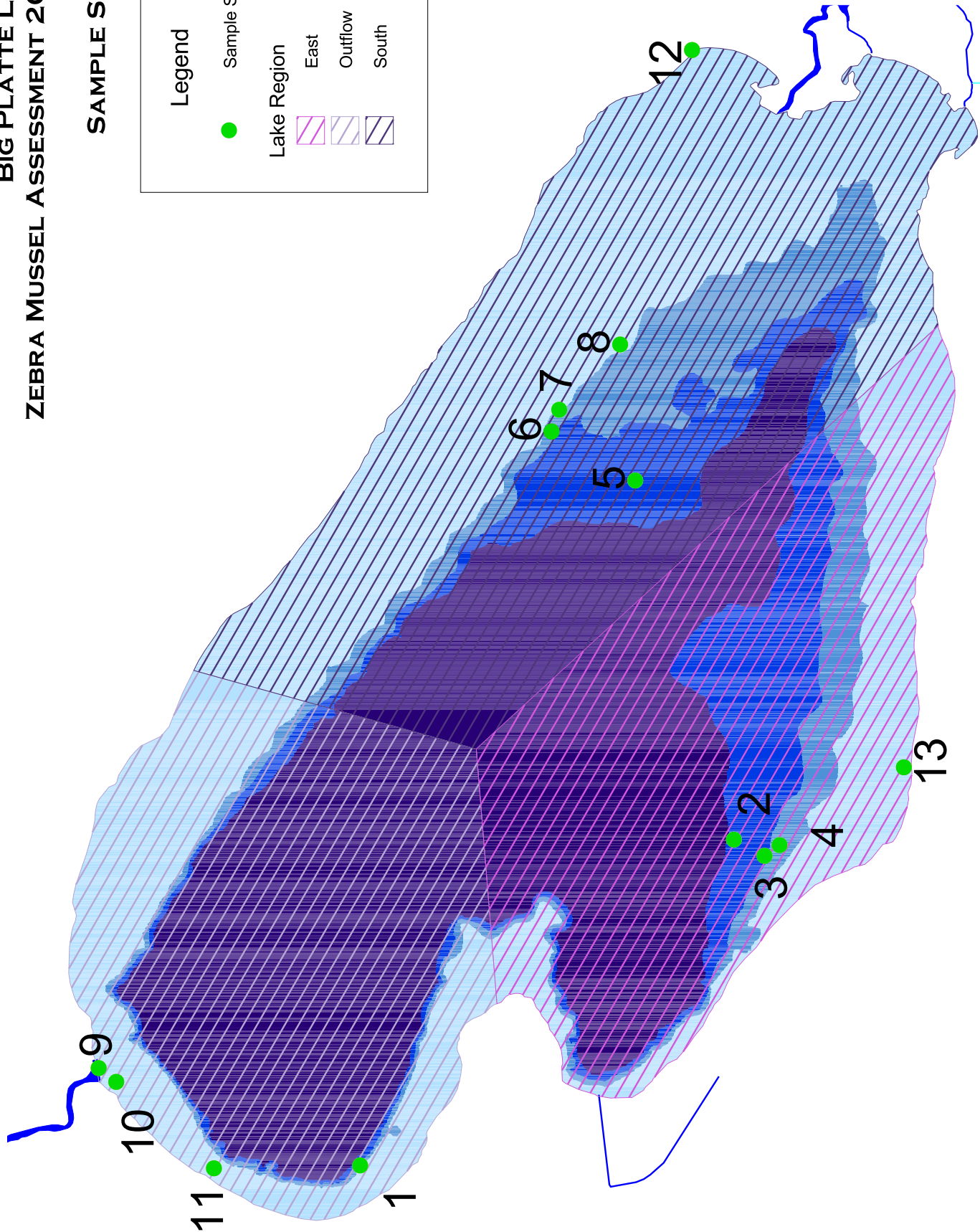
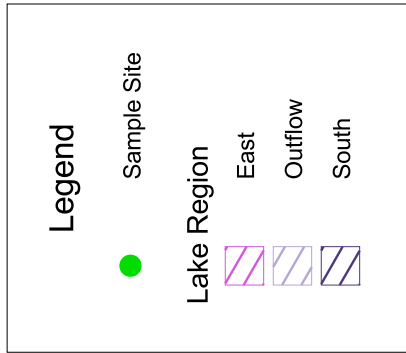
A2 – Zebra Mussel Densities

A3 – Zebra Mussel Lengths

A4 – Zebra Mussel Individual Filtering Capacities

BIG PLATTE LAKE
ZEBRA MUSSEL ASSESSMENT 2004

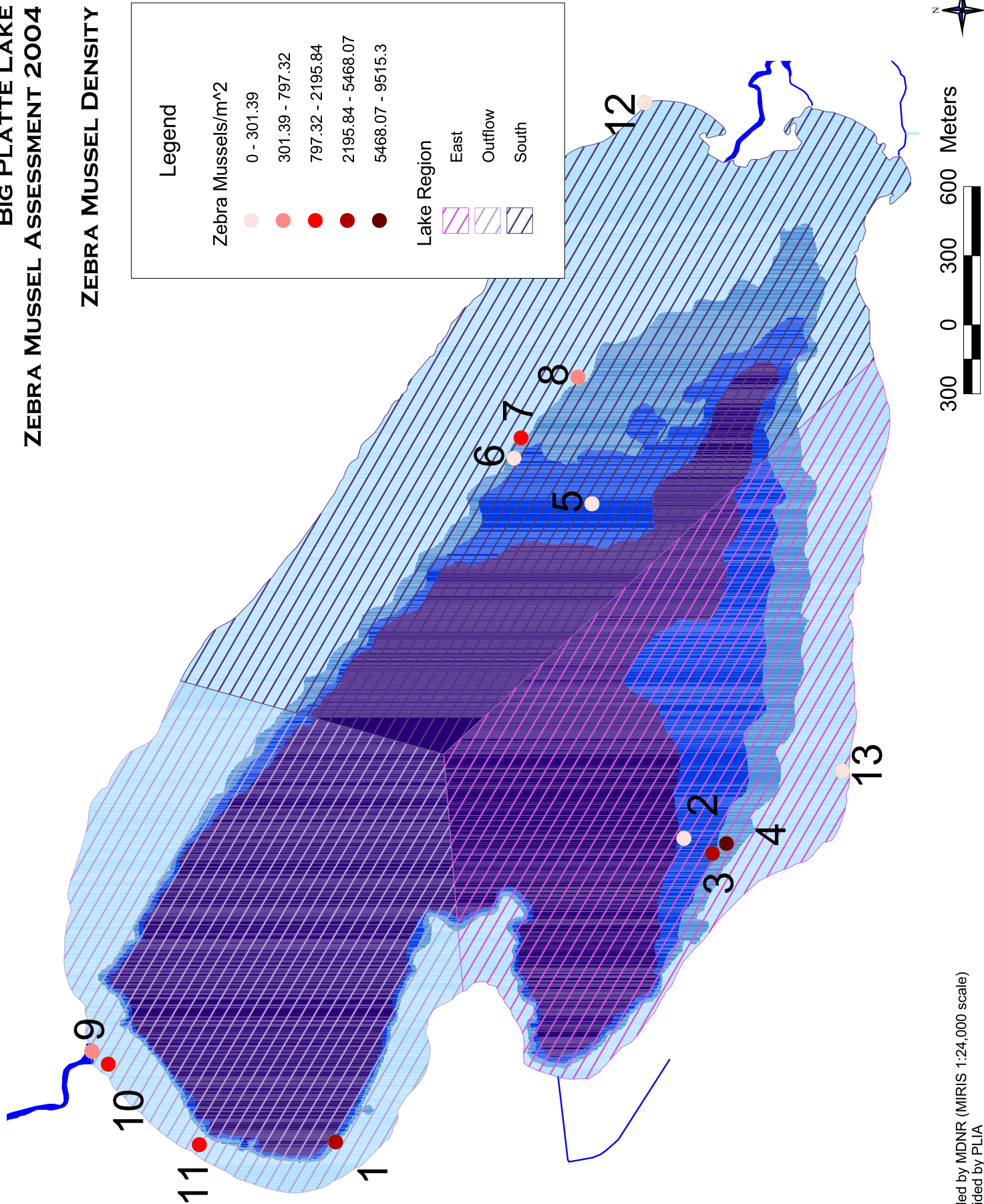
SAMPLE SITES



Source:
Hydrology provided by MDNR (MIRIS 1:24,000 scale)
Bathymetry provided by PLIA

BIG PLATTE LAKE ZEBRA MUSSEL ASSESSMENT 2004

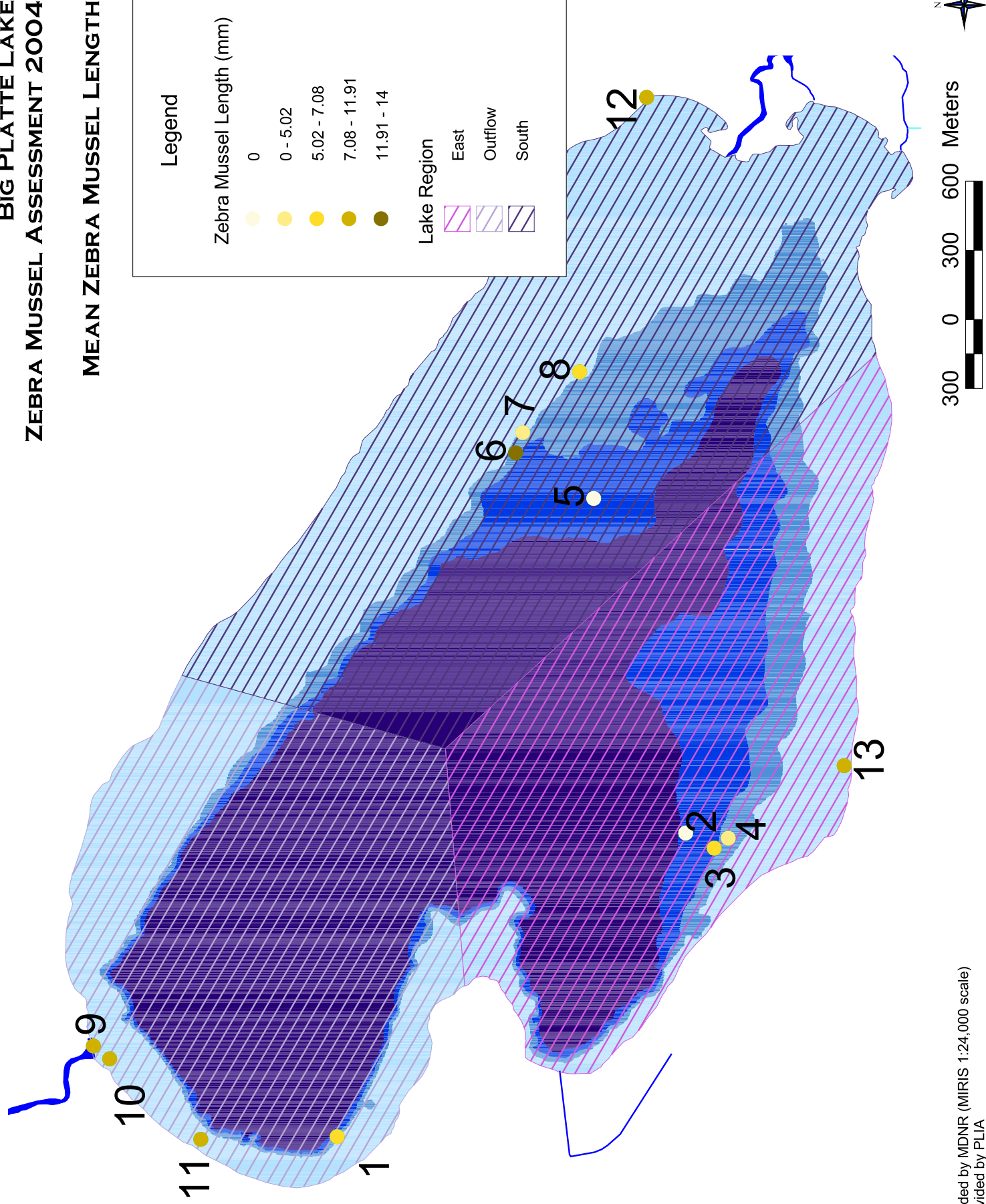
ZEBRA MUSSEL DENSITY



Source:
Hydrology provided by MDNR (MIRIS 1:24,000 scale)
Bathymetry provided by PLIA

BIG PLATTE LAKE ZEBRA MUSSEL ASSESSMENT 2004

MEAN ZEBRA MUSSEL LENGTH



BIG PLATTE LAKE

ZEBRA MUSSEL ASSESSMENT 2004

ZEBRA MUSSEL FILTERING CAPACITY

