Zebra mussel veliger density monitoring in Pelican Lake, Otter Tail County, MN, 2012-2018

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Introduction

On September 29, 2009, zebra mussels (*Dreissena polymorpha)* were confirmed in Pelican Lake in Otter Tail County by the Minnesota Department of Natural Resources. Zebra mussels are a non-native invasive species that first arrived to the Great Lakes region in 1988 via ballast water in trans-oceanic ships. Since 1988, zebra mussels have spread throughout Minnesota and across much of the United States. Zebra mussels reproduce at alarming rates; an adult zebra mussel can produce up to a million eggs per year that develop into free floating veligers that are able to use byssal threads to attach themselves to any firm surface (USGS 2013).

In 2012-2018, the Pelican Group of Lakes Improvement District (PGOLID) monitored veliger densities throughout the summer on Pelican Lake in an attempt to calculate population dynamics and create a collection of data to be used for comparisons in future years of monitoring. Sample sites in Little Pelican Lake, Bass Lake, and Fish Lake were added in 2017.

Methods

Our methods follow Marsden 1992. In 2012-2016, zebra mussel veligers were collected every two to three weeks between May and September in the same location the mussels were initially found in 2009 (Figure 1). The sample location provides an area for veligers to accumulate when a dominant west or northwest wind is blowing. It also is an area where the Pelican River funnels into the rest of the lake. In 2013, veligers were also collected monthly throughout the winter to compare temperatures and veliger density levels during the ice-on period. In 2017-2018, samples were taken at Pelican Lake site 206 as well as in Fish Lake, Bass Lake, and Little Pelican Lake to monitor veliger population levels in lakes with different sizes (Figure 2).

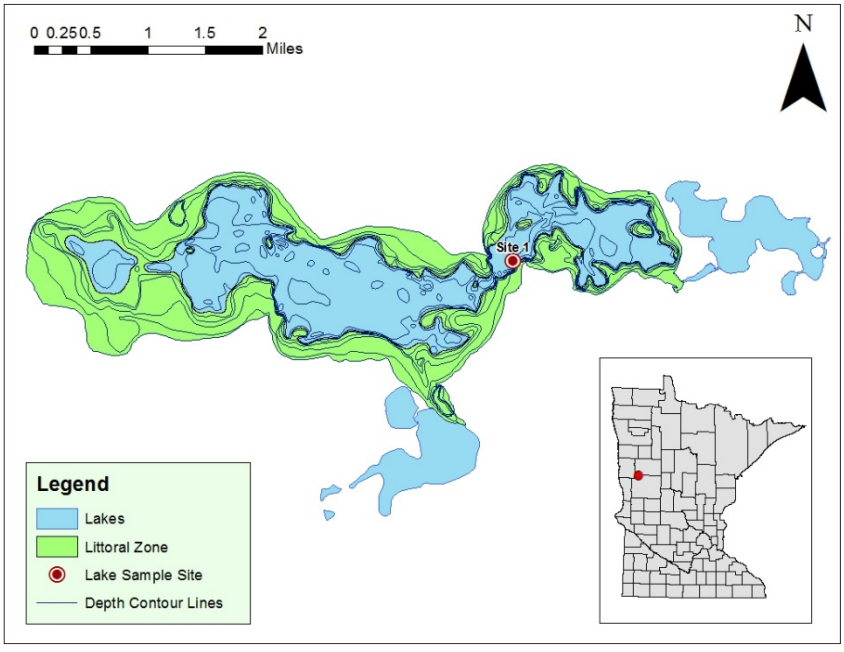

Figure 1. Location of first sighting of Zebra Mussels in 2009 and veliger sampling location in 2012 – 2016 on Pelican Lake, Otter Tail County, MN (-95.990847, 46.702906).

Sampling of veligers was done by conducting a 3 meter vertical tow using a 63 micron mesh net with a detachable cod end to collect the sample along with a rope used for retrieval. The sample was retrieved at a rate of approximately 0.5m/second. The net was then thoroughly rinsed from the outside using gallon jugs of distilled water and a squirt bottle. The cod end of the net was then removed and the mesh screens were thoroughly rinsed to detach any organisms that might remain on the screen. The contents remaining in the cod end were poured into a wide mouth bottle and preserved with 80% ethanol (ethyl alcohol) for transportation to the laboratory for future analysis.

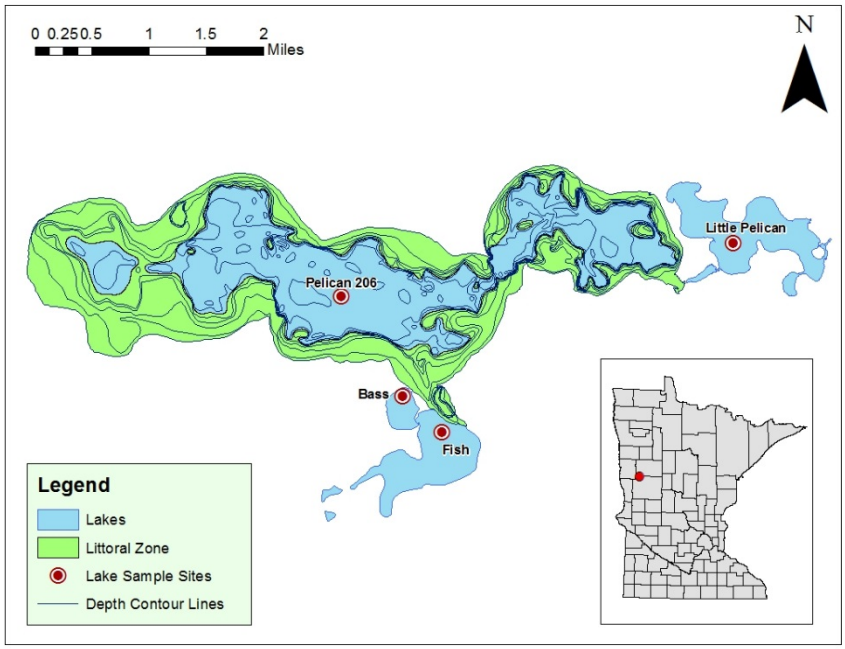

Figure 2. Location of zebra mussel veliger samples sites in 2017 – 2018 on the Pelican Group of Lakes, Otter Tail County, MN.

Zebra mussel veligers were identified using a magnification lens and dissecting microscope with a cross-polarized light filter. The collected sample was filtered by pouring it into an 80 micron sieve and diluting the contents into a beaker with 100 ml of water. The concentrated solution was stirred and a 1 ml subsample was transferred into a Sedgewick Rafter counting slide using a pipette. The cross-polarized light filter was used to identify the veligers, which glow under a dim microscope light. Five to ten - 1 ml subsamples from each sample date were counted. These subsamples were averaged and counts per liter were calculated by taking the average number of veligers per mL, multiplying it by the processing sample volume (100mL) to get a count per tow, and dividing the count per tow by the tow volume (222 L).

2012 Results

On the days spent in the field, PGOLID measured surface water temperatures that ranged from 14.9 to 25.6 degrees Celsius over the 5-month study (Table 1, Figure 3). On July 9, 2012, PGOLID collected veliger densities that reached a high of 53.83 veligers per liter. On the same sample date the water was 25.6 degrees Celsius, the highest recorded temperature in the 10 sample dates. Throughout the summer, zebra mussel veligers were sampled between rates of 0.23 and 53.83 veligers per liter (Table 1, Figure 3).

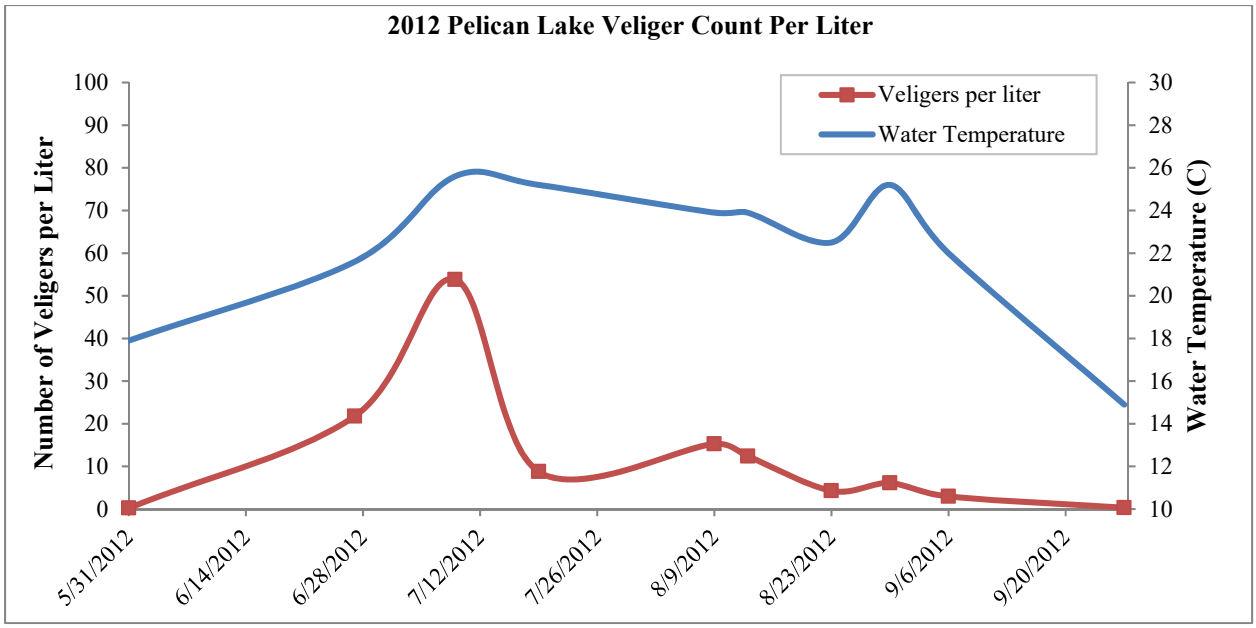

Figure 3. Zebra mussel veliger densities in Pelican Lake, 2012.

Table 1. Zebra mussel veliger densities and corresponding water temperatures, 2012.

Sample Date	Veligers per liter	Water Temp (C)
5/31/2012	0.23	17.9
6/27/2012	21.76	21.6
7/9/2012	53.83	25.6
7/19/2012	8.78	25.2
8/9/2012	15.27	23.9
8/13/2012	12.39	23.9
8/23/2012	4.28	22.5
8/30/2012	6.13	25.2
9/6/2012	2.97	22
9/27/2012	0.32	14.9

2013 Results

In 2013, zebra mussel veliger samples were collected through the ice monthly from January to April to see if any veligers were present. The results showed no veligers present in these samples. The ice came off the lake on May 13, 2013. After ice off, samples were collected every 2-3 weeks to see when veligers began to be present and then to track their densities along with the water temperature. Veligers were first recorded on June 18, 2013, when the water temperature was 19.1 C (66 F). Similar to 2012, the highest veliger densities occurred on July 1 (Figure 4, Table 2). Veliger densities dropped on the July 17, 2013, sample date, but the area received 1.28 inches of rain in the three days prior to the sample and those days were below average air temperature. Overall, veliger densities ranged from 2.7 - 62.8 veligers per liter in 2013 (Table 2, Figure 4).

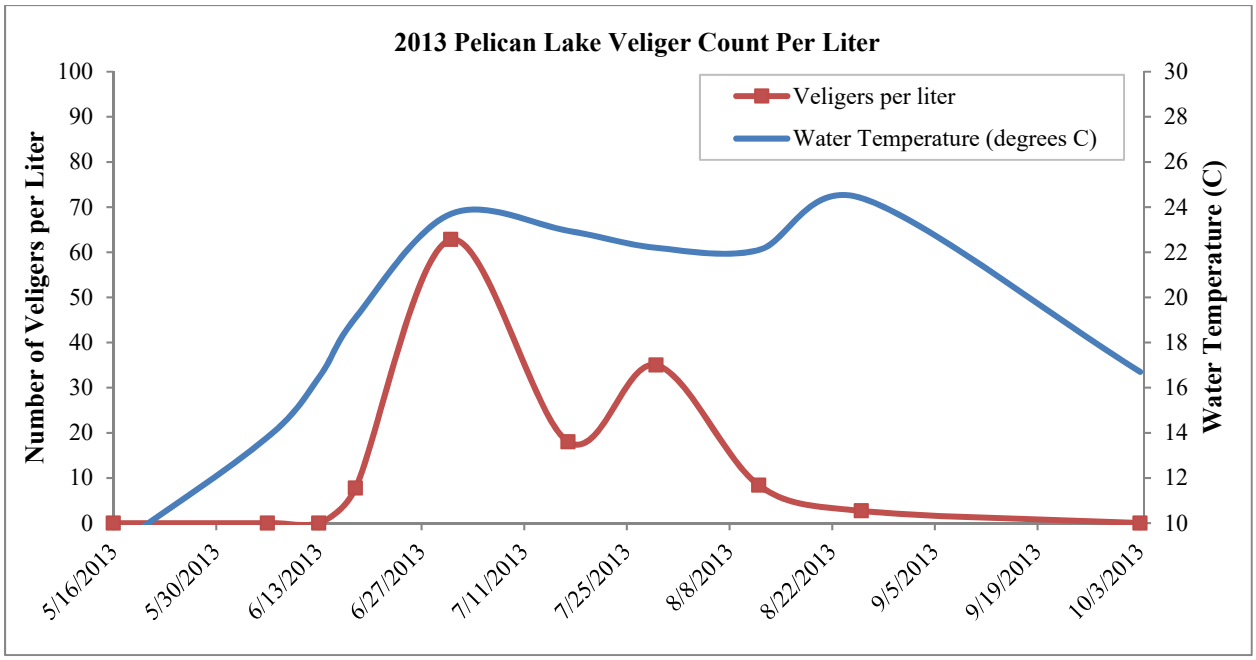

Figure 4. Zebra mussel veliger densities in the ice-off period of 2013.

Table 2. Zebra mussel veliger densities and corresponding water temperatures, 2013.

Sample Date	Veligers per liter	Water Temp (C)
1/16/2013	0	3
2/21/2013	0	3
3/27/2013	0	3
4/19/2013	0	3
5/16/2013	0	8.9
6/6/2013	0	13.8
6/13/2013	0	16.5
6/18/2013	7.75	19.1
7/1/2013	62.80	23.7
7/17/2013	18.00	22.9
7/29/2013	35.00	22.2
8/12/2013	8.38	22.1
8/26/2013	2.70	24.4
10/3/2013	0	16.7

2014 Results

In 2014, the ice-out date was April 27. Veliger samples were collected every 2-3 weeks from May through September. Veligers were first recorded on June 13, 2014, when the water temperature was 19.44 C (67 F). Similar to the pattern in 2012-2013, the highest veliger densities occurred in early July and dropped off by the end of July (Figure 5, Table 3).

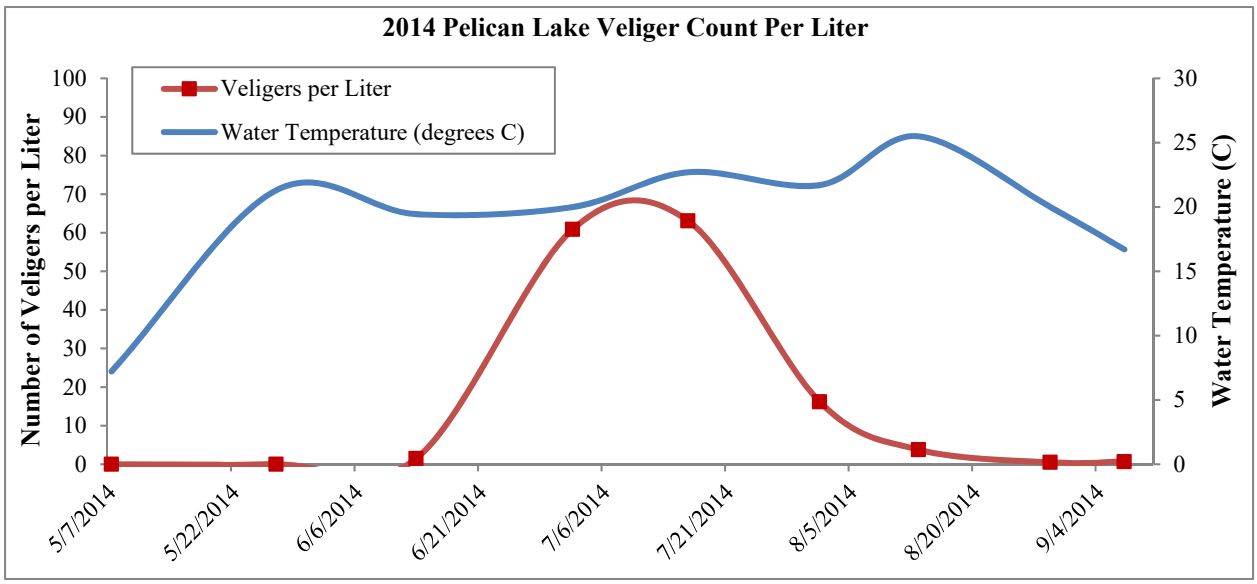

Figure 5. Zebra mussel veliger densities in the ice-off period of 2014.

Table 3. Zebra mussel veliger densities and corresponding water temperatures, 2014.

Sample Date	Veligers per liter	Water Temp (C)
5/7/2014	0	7.22
5/27/2014	0	21.3
6/13/2014	1.49	19.44
7/2/2014	60.90	20
7/16/2014	63.10	22.7
8/1/2014	16.20	21.7
8/13/2014	3.78	25.5
8/29/2014	0.50	20
9/7/2014	0.68	16.7

2015 Results

In 2015, the ice-out date was April 11. Veliger samples were collected every 2-3 weeks from May through September, and veligers were first recorded on May 27, 2015. Similar to the pattern in 2012-2014, the highest veliger densities occurred in early July with 79.2 veligers per liter (Figure 6). Overall, veliger densities ranged from 0.03 – 79.2 veligers per liter in 2015.

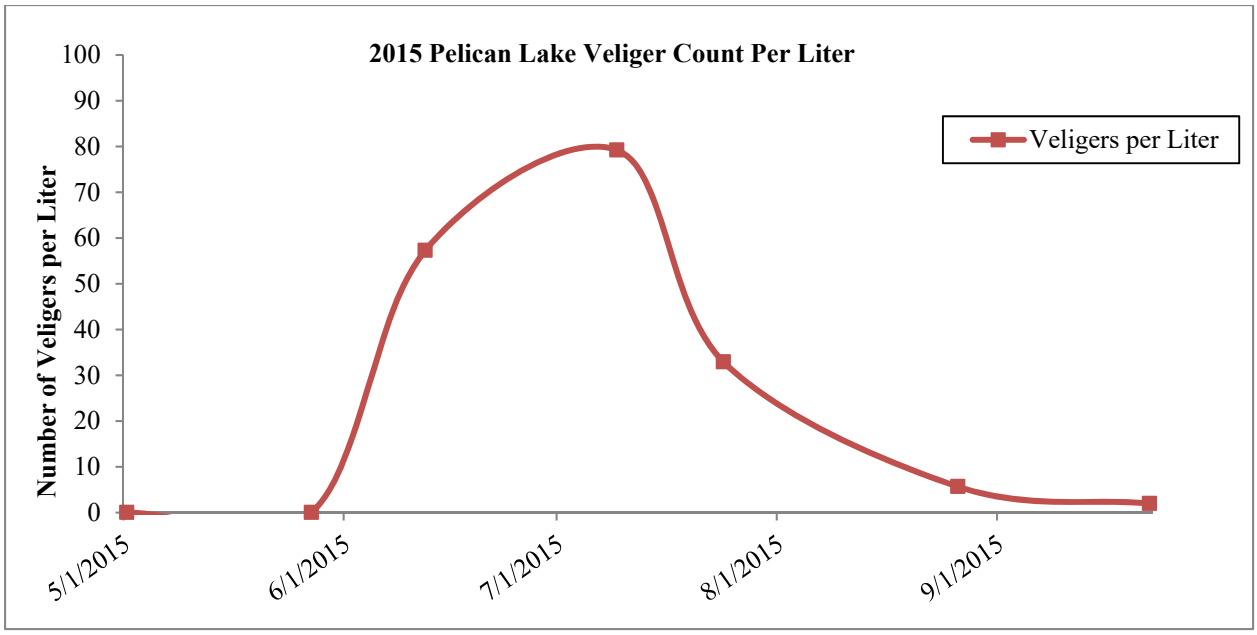

Figure 6. Zebra mussel veliger densities in the ice-off period of 2015.

2016 Results

In 2016, the ice-out date was March 31. Veliger samples were collected once per month from May through September. Veligers were found in the first sample of the year on May 24, 2016. The highest veliger densities occurred in the June sample with 116.12 veligers per liter, which is earlier than in previous years (Figure 7). Veliger densities dropped substantially after the initial peak in June. Overall, veliger densities ranged from 0.45 – 116.12 veligers per liter in 2016. A large die off of adult zebra mussels was observed in 2016 and the algae concentration dropped to 2 ug/L, so they likely ate themselves out of food.

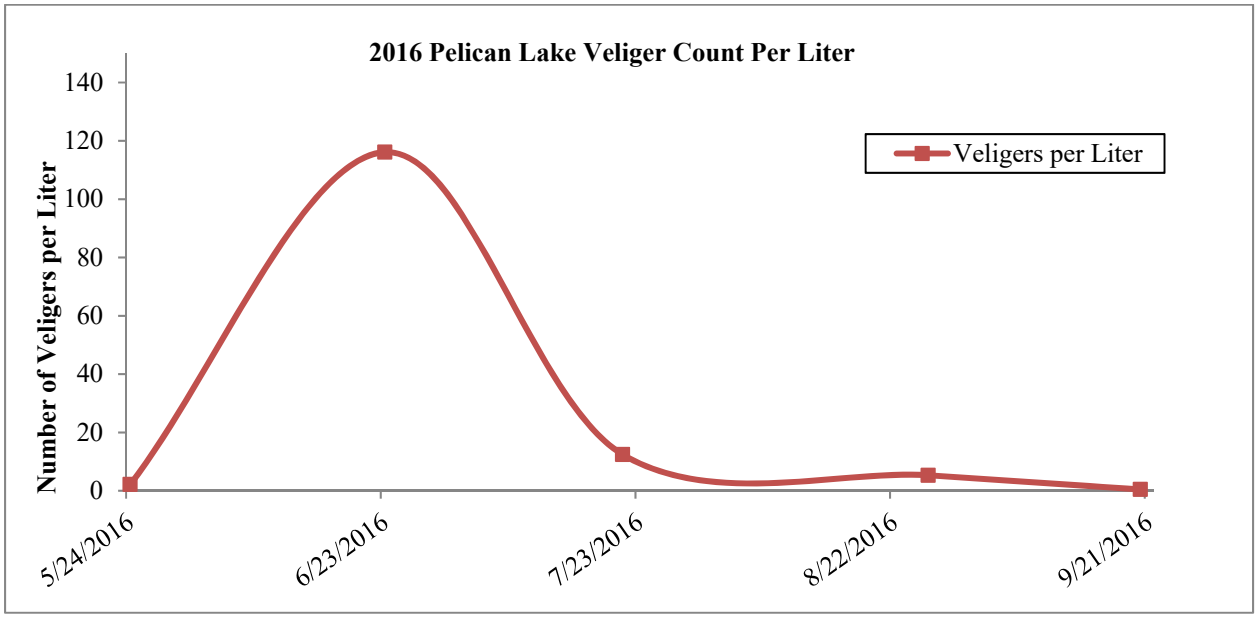

Figure 7. Zebra mussel veliger densities in the ice-off period of 2016.

2017 Results

In 2017, the ice-out date was April 5. Veliger samples were collected in Pelican Lake, Little Pelican Lake, Bass Lake, and Fish Lake once per month from May through September. Veligers were found earliest in Pelican Lake in the first sample of the year on May 18, 2017. The highest veliger densities for most of the lakes occurred in the middle of June, with Pelican Lake having the highest density at 506.37 veligers per liter. This peak density pattern is similar to 2016, but occurred earlier than previous study years. Bass Lake showed an earlier peak than the other three lakes, with the highest density found in the early June sample. However, Bass Lake also had the smallest peak of all the lakes with only 20.86 veligers per liter. Veliger densities in each lake dropped substantially after the initial peak in June (Figure 8). Overall, veliger densities ranged from 0.18 – 506.37 veligers per liter in 2017. After the die off in 2016, the zebra mussel reproduction increased dramatically likely because there was more food available again.

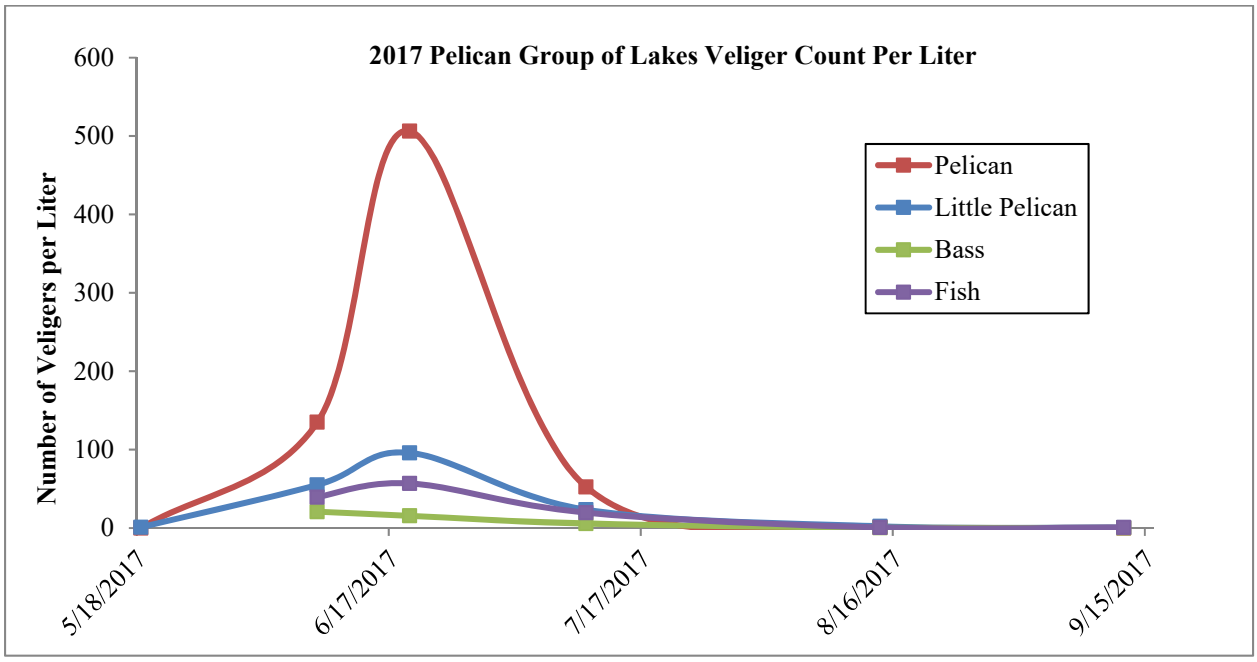

Figure 8. Zebra mussel veliger densities in the ice-off period of 2017.

2018 Results

In 2018, the ice-out date was April 30. Veliger samples were collected in Pelican Lake, Little Pelican Lake, Bass Lake, and Fish Lake once per month from May through September. Veligers were found earliest in Pelican Lake in the first sample of the year on May 23, 2018. The highest veliger densities for all of the lakes occurred in the June sample, with Little Pelican Lake having the highest density at 58.3 veligers per liter. This peak density pattern is similar to 2016-2017, but earlier than previous study years and with much lower peak densities. Bass Lake again showed the smallest peak with only 16.56 veligers per liter, which may be related to the small lake size and mucky substrates compared to the other lakes.

Veliger densities in each lake dropped substantially after the initial peak in June (Figure 9). Overall, veliger densities ranged from 0.07 – 58.3 veligers per liter in 2018.

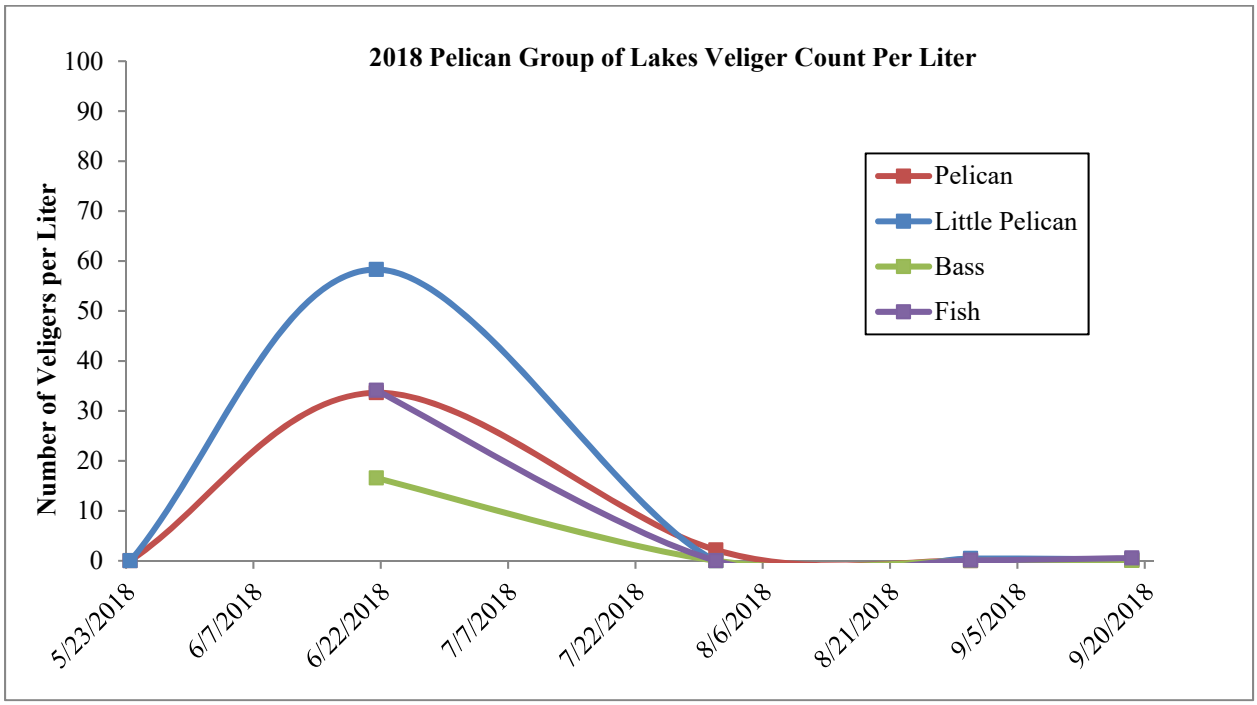

Figure 9. Zebra mussel veliger densities in the ice-off period of 2018.

2012-2018 Comparisons

When graphed together, 2012 - 2018 veliger densities throughout the ice-out season follow a similar pattern in Pelican Lake. The peak veliger density in Pelican Lake in 2012-2014 occurred between July 1 – July 16, while the peak density in 2015-2018 occurred a little earlier in the season (Figure 10). In 2017, the peak density was much higher than all other study years and occurred in the first weeks of June. The 2018 samples showed a peak that was much lower in than most previous years, but also occurred early in June. While invasive species populations tend to stabilize after several years of infestation, natural fluctuations among years like this can happen in relation to changes in temperatures, food sources, predation, and reproductive success. All years show that there is one major peak in reproduction each summer.

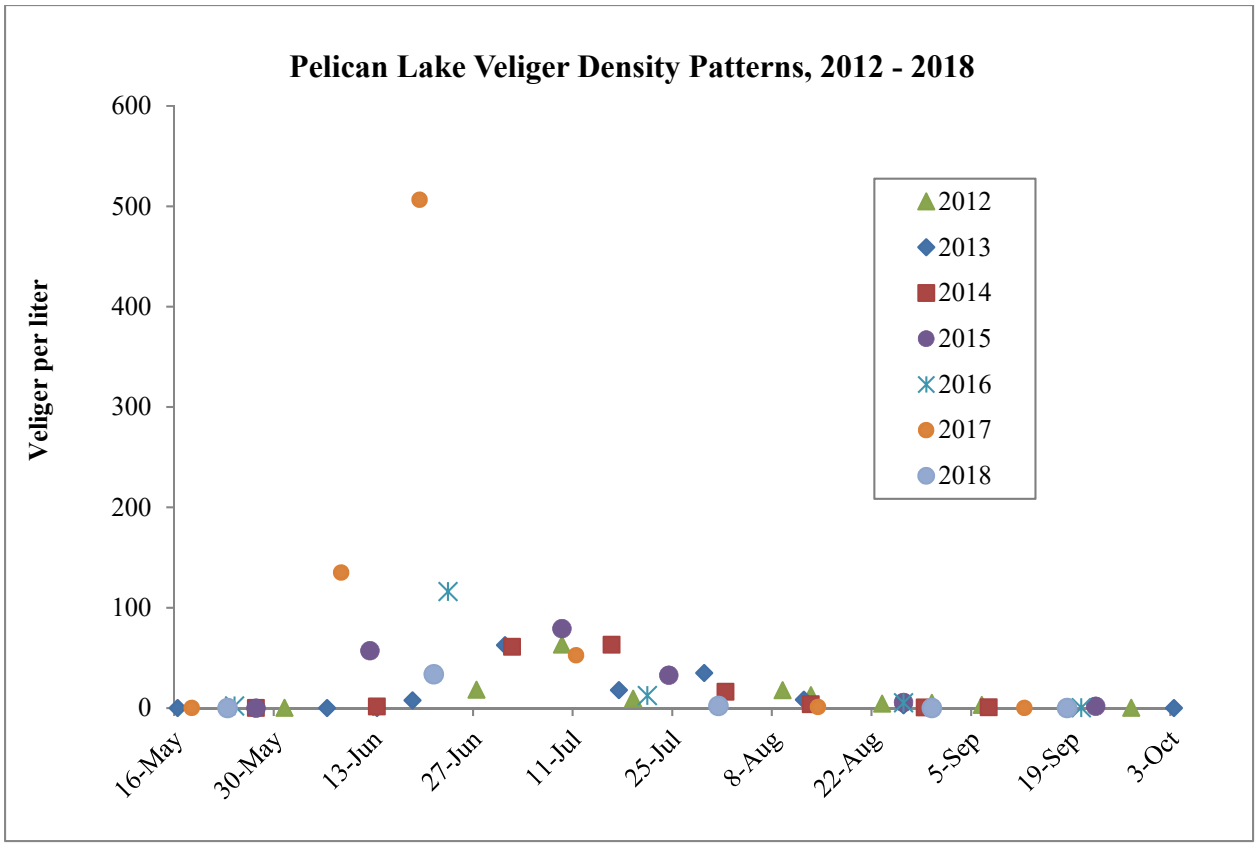

Figure 10. Zebra mussel veliger densities throughout the ice-off period 2012-2018 in Pelican Lake.

Discussion

The zebra mussel veliger densities in Pelican Lake appeared to follow the water temperature at the beginning of the summer, but not later in summer (Figures 3-5). Zebra mussels begin reproduction when water temperature is above 12 C, but ideal reproduction temperature occurs above 17-18 C (McMahon 1996). Veligers first showed up in 2012 when water temperatures reached 18 C (64 F), in 2013 when water temperatures reached 19 C (66 F), and in 2014 when water temperatures reached 19.4 C (67 F) (Tables 1-3). In 2014, water temperatures were cooler overall than 2012-2013, but veliger densities followed similar patterns (Tables 1-3). The data show that water temperatures need to be over 18 C for veligers to be present, but once the water reaches that temperature high veliger production is possible.

The upper thermal limit for North American zebra mussels occurs somewhere around 30 C (86 F) (McMahon 1996), and temperatures in Pelican Lake did not reach that level in 2012- 2018. Peak veliger densities in Pelican Lake in 2012 - 2018 occurred between June 19- July 16 when the water temperature was over 20 C. In all study years, the surface water temperature was very high in late August (24.4 C - 25.2 C, Tables 1-3), but veliger densities were not high like they were in July. There may be some other factor limiting veliger densities or adult reproduction at that time of year. Research into these factors would be helpful in understanding zebra mussel reproduction in Minnesota lakes.

The overall implications of these seven years of data show that the highest risk timeframe for zebra mussel veliger transfer is between early June and mid-July because densities are five to ten times greater during this time than the rest of the ice-free season. More specifically, Pelican Lake zebra mussel veliger densities are highest in early July around the July 4th holiday. Pelican Lake has a very large fireworks show on 4th of July every year that draws crowds from the whole geographic region. Therefore, this is a very high risk time for zebra mussel spread in the region.

The 2013 data show that there were no veligers in the water during the ice-covered season, which shows that ice fishing is likely not a high risk for zebra mussel transfer. However, adult zebra mussels can live underwater through the winter attached to substrates including aquatic plants. All winter fishing equipment like hooks and lines that may have plants caught on them should be cleaned and inspected before leaving the lake.

The 2017 and 2018 seasons included veliger samples taken in Little Pelican, Fish, and Bass Lake in addition to Pelican Lake to observe any major differences among them. All four lakes showed the same seasonal pattern of peak veliger densities occurring in June and starting to decline by the middle of July. In both years, Bass Lake had the smallest peak of all of the lakes, which could be due to the more mucky substrate compared to the others. Without hard substrates like gravel or coarse sand, zebra mussel veligers have more difficulty in finding places to attach and develop. The smaller size, shallower depth, and seclusion of Bass Lake relative to the others may also contribute to the lower number of veligers present.

There were some limitations to this study. The initial study design planned a sample every other week during the ice-free season, but due to weather and schedule interference, there were some 3-4 week gaps in sample time. Later years of this study only had samples taken each month with lake water samples, which caused larger time gaps. This can cause lower data resolution and possibly missing smaller second peaks in veliger production. This study will be repeated again in 2019 with the goals of more finely documenting when the veligers first show up in the spring, when they are at peak densities, and if they are at low densities in late August again despite high temperatures. Additional goals include further monitoring each of the lakes sampled in 2017 and 2018 to evaluate differences among them as well as potential causes for the differences.

Acknowledgements

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References

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