HUMAN EFFECT ON UNIONID HEALTH AFTER REMOVAL OF *DREISSENA POLYMORPHA* IN DOUGLAS LAKE, MICHIGAN

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Abstract

Zebra mussels (*Dreissena polymorpha*) are an invasive species that is having a negative effect on the native clams (unionids) of Douglas Lake, Michigan, USA. We wanted to test if humans are helping clam fitness by cleaning off attached zebra mussels. We surveyed South Fishtail Bay, North Fishtail Bay, and around Douglas Lake Bar in Maple Bay, taking the percent coverage and mass of zebra mussels on each clam, along with the mass, length, thickness, and species of the clams found. We also built a pen in Douglas Lake with cleaned off clams in it to calculate a reattachment rate of the zebra mussels. Only two clams were found around Douglas Lake Bar, which we did not include in our statistics. However, for South and North Fishtail Bay we found significant differences for the mass of clams and the mass of zebra mussels, South Fishtail Bay having heavier clams with a smaller mass of zebra mussels attached. We concluded that humans are having a positive impact on clam fitness when they remove zebra mussels from the shell of the clam. Zebra mussels are able to reattach themselves quickly, but if we can save the clam population of South Fishtail Bay, we may be able to save the clam population of the entire lake.

Introduction

The zebra mussel (*Dreissena polymorpha*) is an invasive species that was introduced to North America in 1986 in the ballast water from ships coming from Europe (Ludyanskiy *et al.* 1993). It is such a successful invasive species because of its short generation time, wide feeding niche, close association with humans, and its ability to survive in a large range of environments (McMahon 2002). It quickly integrated itself around the Great Lakes because of their low salinity, moderate temperature, hospitable water chemistry, and hard substrate availability, which allow the zebra mussel to thrive (Ludyanskiy *et al.* 1993).

Zebra mussels have external fertilization, allowing their larva to flow down stream and giving them a large distribution area. Within their three to four year lifespan, zebra mussels become sexually mature in the first year and maintain high growth rates for the first two to three years, reaching a shell length of 3.5-5.0 cm. Much of their energy goes into reproduction, which lets them rapidly increase in size and makes them more intraspecifically competitive and less susceptible to predation. This high amount of energy for reproduction and the small egg size of the zebra mussel allows for a very high fecundity rate of 30,000-40,000 to more than 10,000,000 eggs per female per year (McMahon 2002).

With heightened boat traffic and ease of reproduction, the zebra mussel has made its way into many of the lakes around Michigan, including Douglas Lake. There are four species of native clams (unionids) in Douglas Lake, consisting of *Anodonta grandis*, *Lampsilis siliquoidea*, *Ligumia recta*, and *Ligumia nasuta* (Heard and Burch 1966; Hollandsworth personal comm.). Clams are filter feeders, so they burrow down into the sand using a rocking motion and open themselves up slightly to catch passing plankton (Stanley 1975).

Since zebra mussels like to attach to hard substrates, clamshells are the ideal surface. They attach to any part of the clam that is above ground with strong byssal threads (Ram and McMahon 1996; Schloesser *et al.* 1996). They can attach themselves in ways that do not allow the clam to open, close, or move as easily as without the mussels. If the clam cannot open, it cannot eat. If it cannot close, it is susceptible to predators, parasites, and disease (Mackie 1991), and if it cannot move as easily, it is using much more energy to do it than before, leaving less energy for feeding and reproduction. Reductions in energy reserves also make it very hard for clams to survive winter conditions (Ricciardi *et al.* 1996). Because of zebra mussels, clams are the most threatened wildlife group in North America with 60% of their species endangered and 12% extinct (Ricciardi *et al.* 1998).

Along the shore of the University of Michigan Biological Station (UMBS) on Douglas Lake, Michigan, USA, people have been cleaning off clams for approximately five years now, suggesting that these clams should be heartier. However, the clams located along the shore of Camp Knight have had no human contact, leading us to believe that those clams will be much smaller. We will be comparing the two sites to see if humans are having a positive effect on the fitness of the native clam populations, allowing us to save them from extinction.

Methods

We compared the clams of two areas around Douglas Lake, Michigan, USA. One was along the shore of the University of Michigan Biological Station in South Fishtail Bay (**Figure 1**) from Lake Side Lab to the end of Knute Nadelhoffer's property. The other was directly across from UMBS in North Fishtail Bay (**Figure 1**) along the shore of Camp Knight.

The same distance was surveyed at each site. We also surveyed a stretch of beach located close to Douglas Lake Bar in Maple Bay to get a better idea of how clam populations differ in more human inhabited areas.

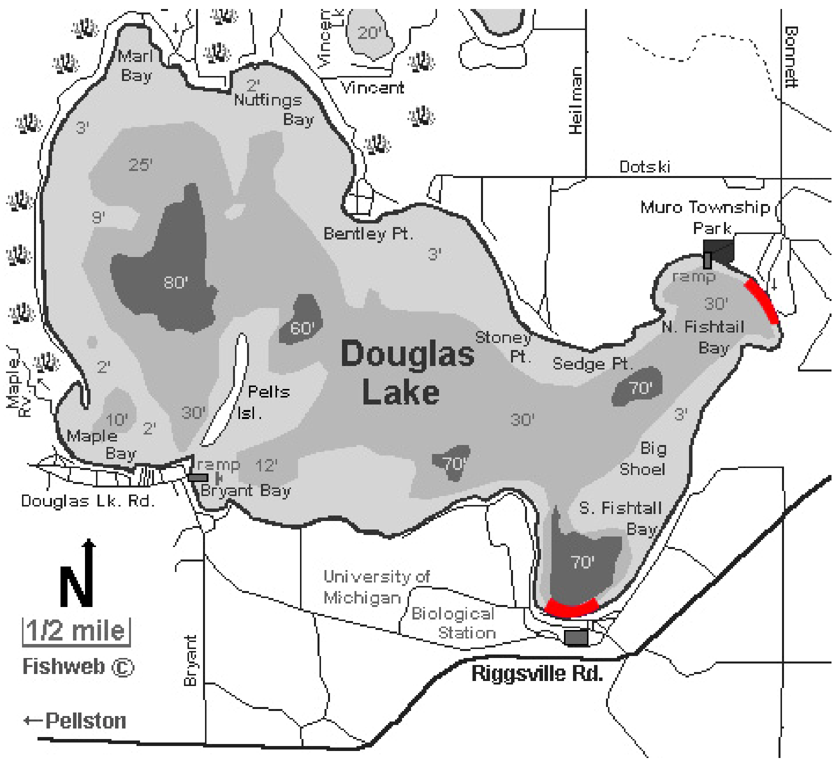

Figure 1: Areas highlighted in red are our testing sites.

The four people in our group walked along the lake from the shore to the drop off, to make sure no clams were missed, and no clams were counted twice. We worked in teams of two, one team using even numbers and one team using odd numbers to record the clams found to keep things organized. Once a clam was found, we looked at how much of it was covered with zebra mussels.

After percent coverage was estimated, we numbered a Ziploc bag and cleaned off the zebra mussels that were on the clam into the bag to be weighed when we were done sampling. To make sure all the clams were measured uniformly, we took measurements of length and thickness using manual calipers, and we took the mass of the clam with 500 and 300-gram spring scales out in the field by attaching a Ziploc bag to the scale, accounting for the mass of the bag, weighing the clam, and subtracting the mass of the bag.

Then we wrote down a description of the clam, and tested for internal teeth by putting it between our hands and moving them back and forth to see if the shell moved at all. If it moved, there were no teeth, and if it did not move, there were teeth.

Once we identified the species of clam, we conducted t-tests comparing the means of clam mass, length, average zebra mussel mass that was on each clam, and the percent coverage of zebra mussels on the clam between the two sites. We used t-tests to make comparisons of each measurement to look at the overall difference in fitness of the clams. We also preformed regression testing to see the relationship between mass and length for each species of clam.

We also wanted to look at how quickly zebra mussels attach themselves to clams, so we created our own environment west of Lake Side Lab. We constructed a 3-meter by 3-meter fenced in area in the lake so the habitat would be as natural as possible. We used chicken wire and wooden stakes to construct the cage, along with flags at the four corners to allow the cage to be visible to people and boats passing by. Nine clams without zebra mussels were collected, lettered A-I by drying off a section and using a permanent marker to mark them, and placed within the fence approximately one meter apart from one another. We collected 200 grams of zebra mussels and dispersed them randomly within the cage to simulate their natural occurrence. One of us checked the clams every two days for two weeks to see if any new growth of zebra mussels was occurring.

Results

Forty-two clams were found along UMBS, four *Anodonta grandis*, 20 *Lampsilis siliquoidea*, and 18 *Ligumia recta*. Thirty-four clams were found along Camp Knight, three *A. grandis*, 19 *L. siliquoidea*, and 12 *L. recta*. *Ligumia nasuta* was not found at either site. The sample sizes for *A. grandis* were too small to get an accurate representation for with a t-test. The relative proportions among clam species were the same between the two sites. Two clams were found on the site located close to Douglas Lake Bar, which we did not include in any of our t-tests or graphs.

A t-test was performed to compare the means of the clam mass for each of the three species between the two sites. Using $\alpha = 0.05$, the one tailed p-value of 0.0496 indicates that there is a statistically significant difference in clam mass between South and North Fishtail Bay for *L. siliquoidea*. South Fishtail Bay had a significantly higher average clam mass for this species (32.85 g compared to 22.74 g). We also preformed a t-test to compare the means of clam mass for *L. recta* between the two sites. The one-tailed p-value of 0.4295 shows that there was not a statistically significant difference in the average mass of this species. South Fishtail Bay had a higher average clam mass, although it was not significantly higher (27.56 g compared to 26.08 g).

We calculated t-tests of the mean length for each species of clam found. Once again using $\alpha = 0.05$ as the level of significance, the one-tailed p-value for *L. siliquoidea* of 0.1678 indicates that there is not a significant difference in average clam length between South and North Fishtail Bay. The one-tailed p-value for *L. recta* of 0.3804 also indicates that there is not a significant difference in average clam length between the two sites for that species.

There is a significant difference in the mass of zebra mussels attached to the clams between the sites. The one-tailed p-value was 0.0070 for *L. siliquoidea*, and 0.0339 for *L. recta*, both of which show a significant difference in the mass of zebra mussels attached to clams between South and North Fishtail Bay. North Fishtail Bay had a significantly higher mass of zebra mussels attached to clams (36.64 g compared to 16.85 g for *L. siliquoidea*, and 39.97 g compared to 17.89 g for *L. recta*).

For both *L. siliquoidea* and *L. recta*, South Fishtail Bay tended to have longer, heavier clams than North Fishtail Bay (**Figures 2** and **3**) as seen by the regression graphs comparing their length and mass. Exponential regression was used because it produced a higher R^2 value than linear regression.

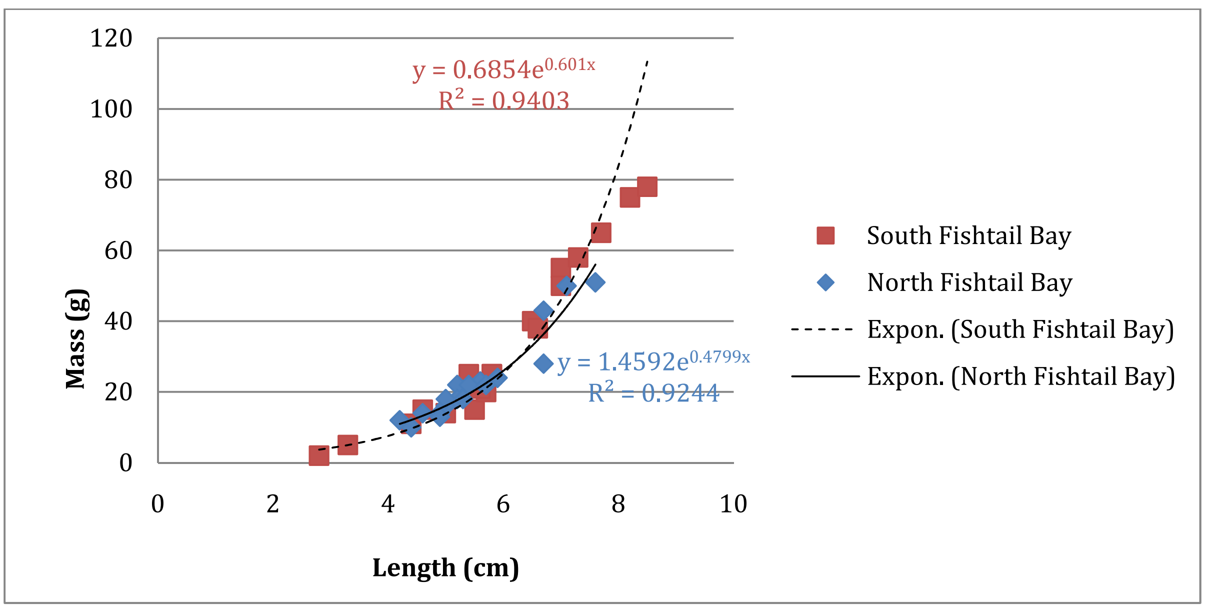

Figure 2: Correlation between length and mass of *L. siliquoidea* in South and North Fishtail Bay.

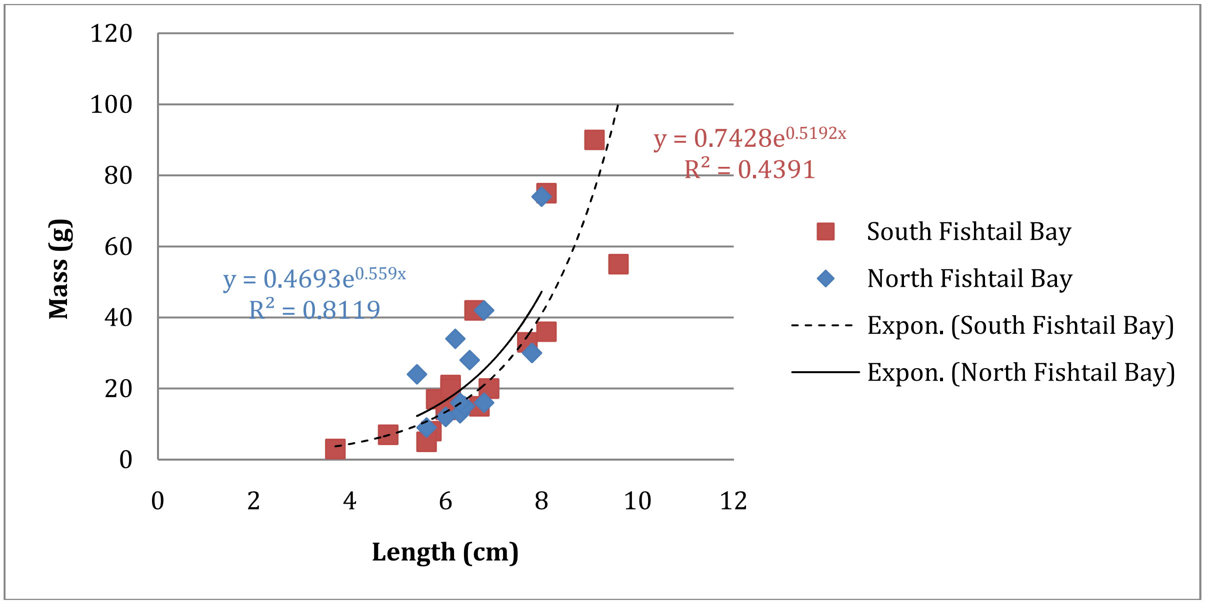

Figure 3: Correlation between length and mass of *L. recta* in South and North Fishtail Bay.

The average rate of zebra mussel attachment can be modeled by the equation y = 0.4034x – 0.1134, where 0.4034 is the slope and 0.1134 is the y-intercept of the line of best fit (**Figure 4**).

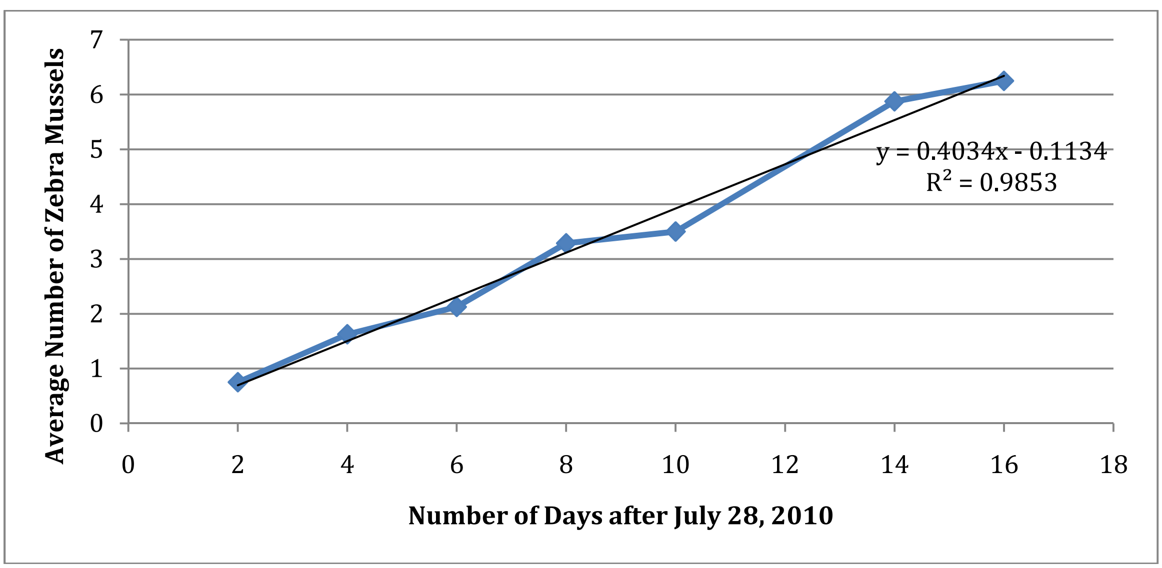

Figure 4: Rate of average zebra mussel attachment, y = 0.4034x - 0.1134.

Discussion

Zebra mussels would not be in the United States without humans, and it is now human effort that is needed to help save native clam populations. This effort of removing attached zebra mussels seems to be having a positive impact on the fitness of the native clams of Douglas Lake. More were found along South Fishtail Bay, and there was a statistically significant difference in clam mass between the two sites for *L. siliquoidea*, concluding that South Fishtail Bay had heavier clams than North Fishtail Bay. Since there was not a significant difference in the length of clams between the two sites, the fact there was a significant difference between masses tells us that South Fishtail Bay has heartier clams for relatively the same size shell as was found in North Fishtail Bay.

To further support that human removal of zebra mussels is helping native clam populations, we found a statistically significant difference in the average zebra mussel mass that was on each clam between the two sites, North Fishtail Bay having a higher average zebra mussel mass per clam. This suggests that, even though every clam we picked up had zebra mussels on it, sporadic removal of them helps reduce their build-up on clams. It is important to slow the build-up of zebra mussels on clams because Ricciardi *et al.* (1996) found that as few as 10 zebra mussels per clam is enough to cause significant declines in clam density. Ricciardi *et al.* (1996) also found that Northern American clams will die if the mass of zebra mussels attached to them is equal to or greater than their own.

Our regression graphs show the comparison between the length and mass for both *L. siliquoidea* and *L. recta* between sites. South Fishtail Bay tended to have longer, heavier clams than North Fishtail Bay, suggesting that physically cleaning the zebra mussels off of the clams is working to improve their fitness.

L. nasuta is an endangered species in Douglas Lake (Hollandsworth personal comm.), leading us to believe that that is why none were found in the sites we surveyed. However, Appledorn and Bach (2007) did a study involving the movement of clams in Douglas Lake in 2005 for which they collected 64 *L. nasuta* along South Fishtail Bay at a depth of 0.5-1.5 m, which was similar to the depths we were surveying. The same study was done using A. grandis of which they found 45 (Appledorn and Bach 2007). We found four *A. grandis* in South Fishtail Bay and three in North Fishtail Bay. These large reductions in two of the four species native to Douglas Lake in five years suggests that it is just a matter of time before clams become extinct in the lake. Ricciardi *et al.* (1998) observed a 4-8 year time interval between the initial colonization of zebra mussels and the time of extinction of clam populations.

However, clams may be able to recover their populations due to their high fecundity rates. One clam has the ability to produce between approximately 80,000 and 1,500,000 eggs within a six-week period. Their eggs are also easily dispersed, allowing them to travel around bodies of water easily (Moles and Layzer 2008). This leads us to believe that if enough effort is put into saving the clams along South Fishtail Bay, those clams would be able to keep the clam population for the entire lake from going extinct.

We wanted to sample a third, more human inhabited site to get an idea of how the presence of humans affects the local populations of clams. We surveyed a site close to the Douglas Lake Bar, in which we found two clams. The site was much different than the other two surveyed in that there were many houses and much more boat traffic around the area, leading us to conclude that increased human presence leads to fewer clams inhabiting the area.

Shucking of zebra mussels has been happening along the shores of UMBS for 5 years (Pillsbury personal comm.), and every clam we found had zebra mussels attached to it. Their reattachment rate is relatively fast (Ludyanskiy *et al.* 1993), and we were able to formulate a rate of reattachment for Douglas Lake from the data we found using the pen we constructed. We noticed reattachment of young zebra mussels to clams that had been cleaned off within two days. The number counted on each clam varied slightly, but increased overall.

We are in a race against time to save the clams of Douglas Lake. Removing the zebra mussels from clams is helping, but more needs to be done to combat the rapid reattachment rate of the zebra mussels. We have seen a major decline in native clam species in just 5 years; another 5 years could see the extinction of all clams in the lake. More surveying of different areas around Douglas Lake needs to occur if we are to get a better idea of total clam populations for the lake. Then we will know how much time we have to save the remaining clams, and the best course of action to take. For now, people need to clean off any zebra mussels on clams they find, and remove as many zebra mussels from the lake as possible to stop their reproduction rate. If enough effort is put into saving the clams of South Fishtail Bay, their reproduction could keep clams present in the entire lake. It is possible to save the clams, but we need to step up our effort if we are to achieve this goal.

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