Zebra mussel monitoring in Otsego Lake: Applications for municipal use of lake water

FINAL REPORT TO VILLAGE OF COOPERSTOWN ZEBRA MUSSEL TASK FORCE COMMITTEE

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Introduction:

Zebra mussels are unique in freshwater habitats in North America in that they produce a truly planktonic larva. Spawning by adult mussels is synchronous. Females release eggs into the water column and shortly afterwards, males release sperm. Fertilization then takes place in the water column. The zygotes formed will float passively in the water during early development (this is the Trochophore stage). Shortly afterwards, the trochophores form a vellum which allow them to maintain position in the water column. These so called *veligers* continue to develop over the next 2 to 4 weeks feeding on suspended particles such as algae, bacteria, and other microscopic organisms. Development stages of immature mussels are typically divided into groups based on shape. Trochophores (80-100 microns) are mostly rounded; D-staged or straight-hinged veligers (90-120 microns); umbonal (120-320 microns) characterized by the appearance of the umbo; and finally pediveligers (250-450 microns) characterized by the presence of a foot. Pediveligers secrete a trailing byssal thread that helps them remain in the water column until they finds a suitable substrate to settle on. Once settled, pediveligers undergo metamorphosis to become juvenile mussels. Juveniles continue to secret byssal threads to firmly attach. Pediveligers, juveniles and even adults can detach themselves and move along the substrate before adults again attach themselves. Juveniles and adults feed by siphoning water into their shell and filter suspended particles from bacteria to filamentous algae size. This filter-feeding activity has changed the function of many invaded lakes - the so called benthification of lakes, whereby energy in the form of food is shifted from the water column to the lake bottom.

Zebra mussels were first reported in Otsego Lake in 2007, and adult mussels were more commonly found in the north end of the lake. Data from the 2009 and 2010 studies indicated that veligers were distributed throughout the lake (north to south, east to west, shallow to deep) but that distinct spatial and temporal patterns existed. This was somewhat unexpected because the paradigm in Otsego Lake is that the circulation patterns would evenly distribute veligers because they are essentially passive swimmers. Veliger abundances were generally higher in the northern end of the lake in both years. There was no distinct east to west pattern in 2009, and this sampling was discontinued in 2010. Veligers were most abundant near the thermocline in 2009, and accepted practice became to sample just above this point in 2010 and 2011. This is expected as the density gradient could cause accumulation of settling particles, and in this case veligers. We were somewhat limited in the end of year sampling dates, but veligers were present through August. Maximum abundances occurred in late July-early August. Based on these data, a modified sampling regime was established for 2010 and followed again in 2011.

Objectives:

Spawning events and the length of veliger development are dependent on environmental conditions (temperature, pH, etc.) and availability of quality food. Thus, zebra mussel populations vary in their development from lake to lake. This is the third year of veliger sampling and the continuation of an established protocol for long-term monitoring of this invasive species. This project remains non-hypothesis driven. It does, regardless, provide important practical information in a scientifically sound manner. Objectives include:

1) monitor the spatial and temporal aspects of larval zebra mussels in Otsego Lake

2) provide continued information to support a management plan that will dictate when control measures can be effectively deployed.

Methods:

The following procedures and protocols are recommended in all future monitoring efforts for zebra mussel veligers.

Sampling should begin no later than the first week of June, and ideally by mid-May, and continue

through the month of September. Sample sites should cover the entire north-south axis of the lake. It does not matter where samples are collected along any east-west axis. Samples should be collected on at least a weekly basis during this period. This allows for estimates of veliger growth rates to be made if desired.

It is recommended to pump at least 50 liters, but no more than 75 liters of water from June through August. In September, it is recommended that the volume of water collected increase up to 100 liters. In 2011, I sampled between 20-100 liters of water by running a centrifugal pump with the hose end at 20 ft (6.1 m) for a time between 30-90 seconds. The pump rate was about 1.06 liters per second with the hose at that depth. The volume sampled is modified to make the counting more accurate (higher volume sampled when veliger numbers are low, and a lower volume sampled when the veliger numbers re high). Water was pumped through a 63-µm mesh plankton net, and the contents were preserved on the spot with ethanol. End volume of concentrated water and ethanol was between 50 and 100 ml. I sampled 10 east-west transects covering the north-south axis of the lake (Figure 1). The Hyde Bay site was dropped in 2011 because no unusual patterns were observed in 2010. Within each transect, I haphazardly chose a site often based on the spot least interfering with other lake users (canoers, anglers, etc).

Veligers were later quantified using a cross-polarizing light microscopy technique. This technique allows veligers to be easily distinguished from other plankton, with the exception of Ostracods (pea shrimp). These can be distinguished from zebra mussel veligers by closer inspection of internal and external morphology. Three subsamples were quantified in 1-ml aliquots, and averages of subsamples were used as the sample density. For all statistical analyses, true replicates were based on the sites sampled in the lake and not the subsamples in order to avoid pseudoreplication errors.

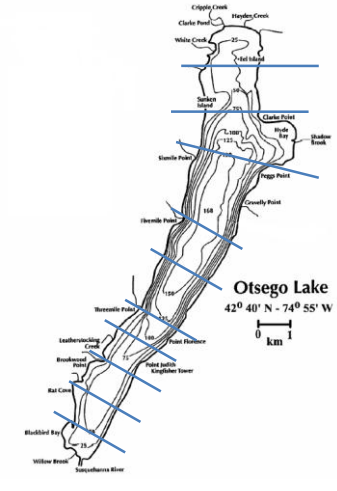

Figure 1. Sampling transects for veliger monitoring. Transect positions are approximations. Lake image from BFS Annual Reports.

Results for 2011:

The first sampling date for 2010 was 8 June and veligers were already present but in low numbers. This is

evidence that sampling should begin as early in June as possible or optimally in late May. This is necessary in order to capture the onset of reproduction. As experienced in previous years, distribution of veligers is bimodal through time. A strong peak was observed in July, and another smaller peak occurred in August (Figure 2). However, the magnitude of the peaks represents a change from previous years. In 2010 a first peak was evident in mid-July, with a second stronger peak in mid-August. By September, veliger abundances are usually 1 per liter or less. Even though veligers are still present in late September (figure 2), their numbers are certainly low enough that no further appreciable settlement can be expected. The propagule pressure by that time is likely too low. This has been a consistent pattern across years.

The exact timing of these spawning events is most likely temperature driven. Analysis of a correlation between water temperature and veliger presence in the water column isn't feasible with this data set because water temperatures vary spatially with depth and so do adult mussels. Additionally, a lag exists between the time of spawning and the time of detection of veligers in the samples.

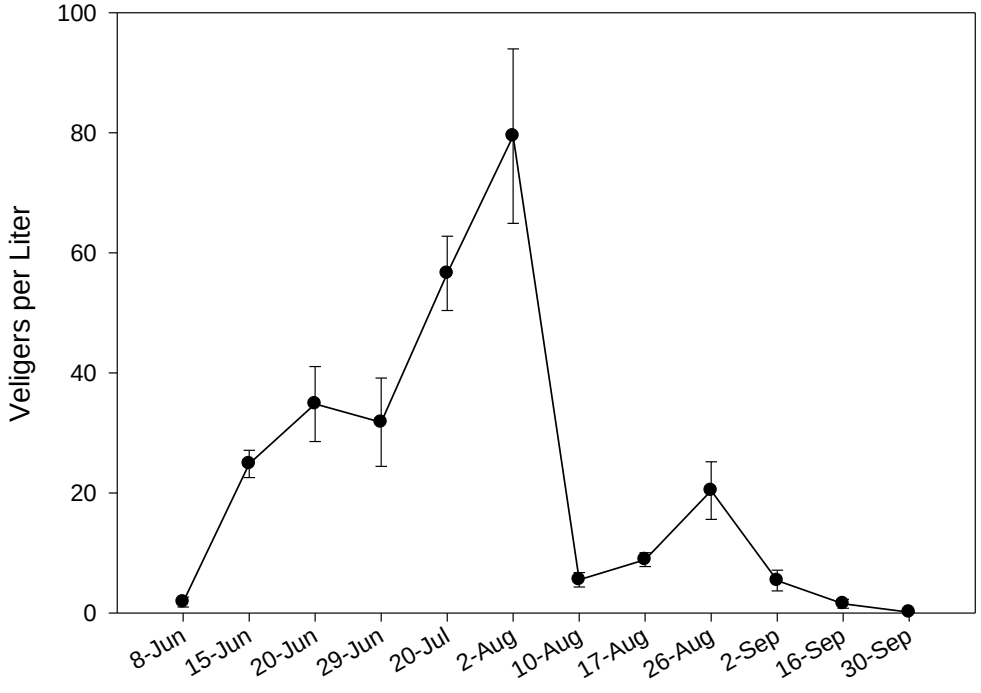

Figure 2. Veliger abundances through the 2010 reproductive season. Each point is the lake-wide mean from the 11 sites sampled. Error bars represent standard error of the mean.

In previous years there was a statistically significant difference in veliger abundances between the 5 northern sites and the 5 southern sites. The dividing line between these two groups is 3 Mile Point. The division is arbitrary, but allows for a balanced statistical model. The density of veligers was almost twice as high in 5 northern sites. However, this year there is no statistically detectable difference between the two ends of the lake. We may be experiencing the completing of the colonization of the entire lake, thus reducing even further the differences in the reproduction potential among areas of the lake.

When veliger abundance is parsed into three basic stages of development, interesting patterns appear (Figure 3). It appears that development of veligers in Otsego Lake still takes about 4 weeks from early post-trochophore stages to veligers close to settlement stage (pediveligers).

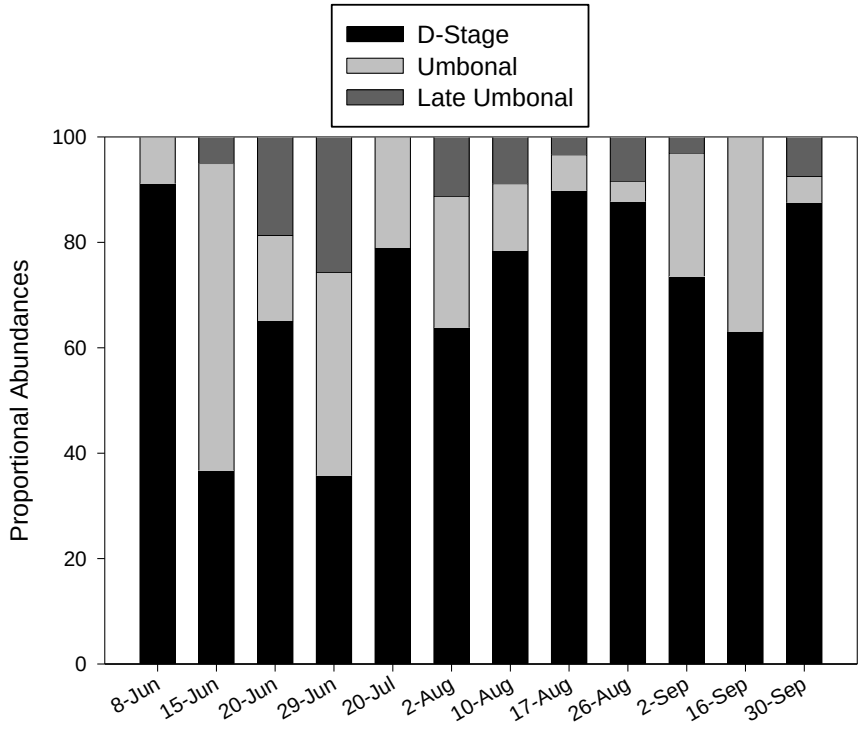

Figure 3. Stacked bar indicating the 3 development stages of veligers. The red bars are the D-stage (earliest), the blue bars are umbonal, and the green bars are late umbonal veligers.

Late-stage veligers were at their highest proportion in late June heading into July. This indicates that settlement rates are likely at their highest at some period in July. The samples from 20 July showed a much reduced proportion of late-stage veligers, likely due to the loss via previous settlement. The number of late-stage veligers remains fairly constant through most of August, and then mostly disappear by September. Settlement rates are likely unappreciable by mid-September. Although late-stage veligers were present in the last sampling in September, the actual numbers were very low. Also of note is that the veligers from greatest peak in veliger abundance (early August) may not be as important as the earlier abundances in terms of settlement. It may be that mortality in this late cohort is higher (possible due to temperatures or algal community changes) than in earlier cohorts. Thus although there are high numbers of veligers in August, they may not contribute as much to the adult population as the earlier veligers.

Recommendations:

One of the objectives of the project was to be able to provide some guidance for the Village of Cooperstown as it begins to address how they will deal with the introduction of zebra mussels into Otsego Lake. Because the Village has raw water intakes in the lake, they will certainly have to deal with biofouling of external structures and within the intake pipeline. This has not changed. I believe the Village will need to maintain regular cleanings of their intake infrastructure.

The Town's water board has been debating whether to install a chemical treatment system that would prevent settlement of veligers in the intake pipes by dripping potassium permanganate at the intake site. The current practice has been no chemical treatment and regular pigging of the line. If chemical treatment is started, that would reduce the need to clean the water intake physically with the pig. As part of these continued monitoring efforts, I have agreed to sample the intake water at the water treatment plant for evidence of effectiveness of the chemical treatment. I have developed methods that allow distinguishing between live and dead veligers. These methods would allow for a cost-effective determination of effectiveness of the chemical in killing potential settlers. However, it may be prudent to visually inspect the intake pipes at some point to ensure that adult mussels are not establishing in the pipes.

The natural variability of zebra mussels in Otsego Lake also demands some regular monitoring efforts. This population is in a state of change, and the worst impacts usually occur during the initial or exponential phase of an invasion. The impact of zebra mussels on lake users and the ecology of the lake can't be predicted without further data on the mussel population. The protocols outlined in this report provide an effective means by which to continue yearly monitoring. There is always room for more detailed studies as funding is available. As before, I will continue to solicit funds from many sources in order to increase our understanding of the impacts that zebra mussels (and other invasive species) will have on Otsego Lake's community and its lake users.

A companion study report is forthcoming that will provide results from an intensive adult mussel survey. At this time we have sampled over 155 sites throughout the lake, counted and measured over 10,000 mussels, and have started to build a theoretical model to predict the impacts that zebra mussels will likely cause in Otsego Lake.

Acknowledgements:

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