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Short Communication

Zebra mussel (*Dreissena polymorpha*) monitoring using navigation buoys

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Abstract

In the present study, navigational buoys were used to monitor *Dreissena polymorpha* (zebra mussel), an aquatic invasive species in Otsego Lake, New York. Buoys from the north and south sites of Otsego Lake were taken out of the water on December 29 and December 31, 2012, respectively, after being in the water since April 14, 2012. All sampled mussels were frozen until further analyzed; an electronic caliper and compound microscope were used to measure shell lengths. We observed growth, settlement, and density of each colonized buoy and determined that light shielded bottom sides of the buoy had the most colonization whereas the shallowest submersed side had the least. Shell length of mussels from the south site was significantly larger than those from the north site. The mussels from the metal anchor-chain ring at the deepest end of the buoy were the largest, while no difference was found among the rest. Colonization of zebra mussels can be due to specific substrate types and amount of nutrition available in the habitat. Additionally research is recommended comparing buoy designs to determine if buoys without light shielded bottoms will be less colonized.

Key words: zebra mussel, invasive species, Otsego Lake, navigational buoy, growth rate

Introduction

Over the past few decades, at least 36 mollusc species were introduced to Atlantic, Pacific, and Gulf coasts of North America (Johnson and Carlton 1996). Some of these species caused abiotic and biotic changes in inland waterways (MacIssac 1996). One species greatly impacting its surrounding environment is *Dreissena polymorpha* (Pallas, 1771) (zebra mussel). Although not native to the Eastern United States, zebra mussels were first discovered in the Great Lakes in the late 1980s and the St. Lawrence River in 1990 (Carlton 2008; Conn and Conn 2004; Conn et al. 1991, 1992a, b). They were then found in the Hudson River in 1993 and later detected in Massachusetts in 2008 (Strayer et al. 1996; Wong et al. 2012). They now clog water pipelines, attach to boats, colonize dam gates, and foul other substrates (Wong et al. 2012). Zebra mussels are found living on rock surfaces, macrophytes, native molluscs, canal and dock walls, and watercraft and motor outdrives; thus they quickly outcompete the native population and decrease recreational water activities (MacIssac 1996).

Dreissena bugensis (Andrusov, 1897) (quagga mussel) also over-filters water in areas such as Lake Erie where phytoplankton populations decreased. Quagga mussel invasion led to alteration in food webs due to changes in fish and zooplankton populations in Lake Huron (Mueting et al. 2010; Hecky et al. 2004). Zebra and quagga mussels have become serious nonindigenous pests in North America causing environmental harm and associated damage costs (Pimental et al. 2005). Both species are native to Eastern Europe and were first introduced in 1986 into the Great Lakes in North America. They entered the Great Lakes from ballast water dumping by large ocean-going ships from Europe (Hebert et al. 1989; May and Marsden 1992; Mills et al. 1993; Carlton 2008).

Both dreissenid mussels have invaded many lakes and rivers in North America. The spread of dreissenid mussels will presumably continue for many years until their entire potential range is filled (Strayer 2009). Zebra mussels were found

Figure 1. Two buoys from which zebra mussels were collected (top panel) and locations from which samples were collected (bottom panel): 1. Large Side; 2. Large Bottom; 3. Small Bottom; 4. Metal Ring; 5. Small Light Shielded Bottom; 6. Small Side; 7. Large Shallowest Submersed Side.

in Otsego Lake in 2007 (Horvath 2008; Anonymous 2011, 2012). No systematic monitoring program was in place evaluating colonization and growth of these invasive pests in Otsego Lake. Basic biological information is needed for this species such as growth and settlement rate (Wong et al. 2012). Settlement and growth rates of these invasive zebra mussels in Otsego Lake need investigation.

In New York State, buoys are permitted to be deployed to delineate no-wake zones (New York State Navigation Law 2013). The four municipalities bordering the Otsego Lake passed identical laws extending the NY State 100' no-wake zone out to 200' for Otsego Lake (Otsego Lake Association 2013). Navigation buoys have been used to monitor invasive mussels and other benthic invertebrates in St. Lawrence River, Lake Ontario, and the Welland Canal (Conn et al. 1991, 2013; Conn and Conn 2004, 2007); we therefore hypothesize that these buoys can be a good tool for evaluating zebra mussel settlement and growth in Otsego Lake, New York.

Methods

Monitoring buoys were composed with polyethylene (Taylor Made Products 2013). The two navigation buoys we monitored were deployed on April 14, 2012, with one at the Lake Front - (N 42º42.223 W 74º55.237) in the south side of Otsego Lake and the other one at Springfield Landing - (N 42º48.451 W 74º53.022) on the north side of Otsego Lake. The buoys were anchored 2.3 m off the lake bottom. The Springfield Landing and Lake Front buoys were taken out of the water on December 29, 2012 and December 31, 2012, respectively. Colonized mussels (identified with May and Marsden 1992) on these two buoys were used for size analysis and density calculations. All mussels collected from these two buoys are young-of-the-year since the two buoys were mussel free before being deployed. Mussels were taken from seven locations for each navigation buoy (Table 1).

Mussels collected from a specific region of a navigation buoy (Figure 1) were stored in a freezer until analyzed. An electronic caliper (Mitutoyo Absolute digital caliper, 965 Corporate Boulevard Aurora, Illinois 60502) was used to measure mussels with shell lengths larger than 4 mm. Mussels equal to or smaller than 4 mm were measured using a compound microscope (Zeiss compound microscope, Carl-Zeiss-Strasse 2273447 Oberkochen, Germany). Each mussel cohort was estimated using the modal progression of Fish Stock Assessment Tool II. FiSAT is the official program used by United Nations' Fisheries and Aquaculture Department to estimate population dynamics of finfish and shellfish. FiSAT II applies the maximum likelihood concept to separate the normally distributed components of size-frequency samples, allowing accurate demarcation of the component cohorts from the composite polymodal population size of finfish or shellfish (Gayanilo et al. 2005). Densities of mussels (mussels/m^2) on different parts of the buoy were also calculated (Wong et al. 2012). All the statistics were performed using SAS (Version 9.2, SAS Institute Inc. Cary, NC).

Results

The no-wake zone buoys were colonized by zebra mussels. The settlement rate of zebra mussels is shown in Table 1, and length summary is shown in Table 2. The light shielded bottom sides of the buoys had the most colonization whereas the

Table 1. Density of zebra mussels in the two Otsego Lake buoys.

Location	Buoy location	Mussels (#/m^{2})
Lake Front	Large Side	756
	Large Bottom	64,029
	Small Bottom	12,590
	Metal Ring	5,289
	Small Light Shielded Bottom	113,046
	Small Side	14,920
	Large Shallowest Submersed Side	412
Springfield	Large Side	139
	Large Bottom	93,676
	Small Bottom	5,820
	Metal Ring	688
	Small Light Shielded Bottom	106,812
	Small Side	5,296
	Large Shallowest Submersed Side	0

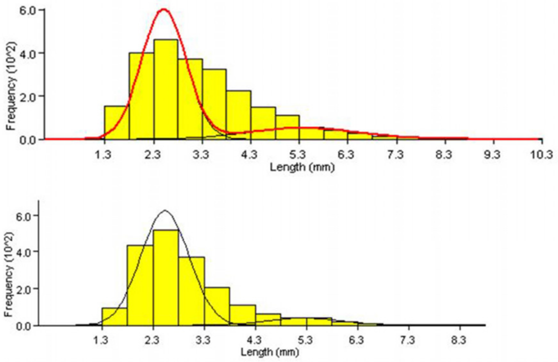

Figure 2. Frequency of zebra mussels on two monitoring buoys in Otsego Lake (Cohort curve presented by FiSAT, Gayanilo et al. 2005).

shallowest submersed side had the least colonization. The computed shell length means of the two identified cohorts were 2.5 mm and 5.3 mm for the Lake Front buoy subpopulation (Figure 2). The means were 2.5 mm and 5.2 mm for the mussels on the Springfield Landing buoy (Figure 2).

After one growing season, the average size of mussels attached to the Lake Front and Springfield Landing buoy were 2.9 mm and 2.6 mm with maximum shell length of 9.8 mm and 8.2 mm, respectively. Shell length of mussels from Lake Front was significantly larger than those in Springfield Landing (Two-way ANOVA; DF = 1; F = 82.11; $p < 0.0001$; $\alpha = 0.05$). The mussels from the metal ring were the largest whereas no difference was found among the rest (Two-way ANOVA; DF = 6; F = 39.45; $p < 0.0001$; $\alpha = 0.05$).

Overall density means for Lake Front and Springfield Landing buoys were 30,148 and 30,347 mussels/m^{2}, respectively; however, there was no significant difference in mussel density between Lake Front and Springfield Landing (T-test; DF = 12; t = -0.01; p = 0.99; $\alpha = 0.05$).

Discussion

Our study demonstrates that no-wake zone buoys can be used to monitor colonization and growth of invasive zebra mussels. Differential settling of mussels was observed on the buoys and those differences were quantitatively described. Karatayev et al. (2006) observed zebra mussel growth increases in water columns above the lake substrate than on the bottom such as buoys, cages, or floating objects. Substantial differences in growth were displayed between lakes and reservoirs – mussels grow faster in reservoirs than lakes (Table 3 in Karatayev et al. 2006).

Larger zebra mussels were found on the Lake Front buoy than the Springfield Landing buoy. One possible reason for this is that there is more suspended silt in Springfield Landing than Lake Front, and zebra mussels do not grow well in an environment with higher sediment content (Schneider et al. 1998). However, the preliminary observations in the present study are only based on two mooring buoys in two experiment locations. A robust future study is needed to expand upon these results, e.g., multiple buoys in Lake Front and Springfield Landing locations should be established to provide data for solid conclusions based on replicates in each site.

The number of mussels from the metal ring was small, but those mussels present were the largest. The number can be explained due to the friction of the metal anchor-chain scraping off mussels caused by rocking from wind and currents in the water. The resulting swaying motion of the buoy decreased colonization around the metal ring. Mussels were larger in the metal ring possibly due to less light exposure.

Settled mussels on the light shielded bottom of both buoys were more abundant than those settling on the shallowest submersed side. This is in agreement with other studies demonstrating that mussels do not like to be exposed directly to light (Marsden and Lansky 2000). Mueting et al. (2010) found substrate preference is based more on the depth of the surface in the water column than the texture or composition of the substrate.

Table 2. Length summary of zebra mussels on the two monitoring buoys in Otsego Lake, from Lake Front and Springfield Landing.

Buoy	Position	Mean	Min	Max	Standard deviation	n
Lake Front	Large Side	2.6	1.2	6.0	1.0	114
	Large Bottom	2.8	1.0	7.4	1.1	622
	Small Bottom	2.6	1.0	6.3	1.0	106
	Metal Ring	3.8	1.2	9.8	1.5	292
	Small Light Shielded Bottom	3.1	0.2	7.9	1.2	780
	Small Side	2.5	0.6	6.9	1.1	431
	Large Shallowest Submersed Side	3.0	1.4	5.2	1.2	16
Springfield	Large Side	2.8	1.6	3.8	0.7	21
	Large Bottom	2.7	1.0	8.2	1.0	910
	Small Bottom	2.5	1.4	3.8	0.5	49
	Metal Ring	2.1	1.2	5.5	0.8	38
	Small Light Shielded Bottom	2.6	0.8	7.4	1.0	737
	Small Side	2.6	1.2	7.8	1.0	153
	Large Shallowest Submersed Side	0.0	0.0	0.0	0.0	0.0

This study and other works documenting zebra mussel settlement and growth rates can help lake managers understand the biology of this invasive species in the Eastern United States (Wong et al. 2012). Based on observations from the present experiment in Otsego Lake, as well as those reports on St. Lawrence River, Lake Ontario, and the Welland Canal (Conn et al. 1991; Conn and Conn 2004, 2007), routine navigation buoys can be used to monitor the settlement of invasive zebra mussels. Therefore, it is suggested that navigation buoys should be able to be used for monitoring zebra mussel colonization and growth in invaded water bodies. It is also recommended that navigation buoys be used for early detection and periodic status monitoring of invasive mussels in water bodies with mussel invasion risk, such as the Upper Chesapeake Bay, where freshwater from the Susquehanna River meets brackish water of the bay. The Maryland Department of Natural Resources initiated such an annual monitoring effort in this area of their state in 2010 (personal communication with R.J. Klauda). Light can minimize zebra mussel colonization; thus, lake managers may be able to avoid settlement of zebra mussels on their property with light (Marsden and Lansky 2000). Another future study should include research comparing the buoys used herein with buoy designs without substantial light shaded areas such as product #46103 Sur-Mark II (Taylor Made Products 2013). Growth rate of dreissenid mussels depends on water temperature, season of the year, location in the water column, trophic conditions, and water velocity (Karatayev et al. 2006). Further studies should be implemented to research different substrates where dreissenid colonies occur to understand differential growth. Diet and nutritional values may also be another factor in settlement and growth rate; mussels are planktivores with phytoplankton as their primary diet (Wong et al. 2012). Wong et al. (2012) hypothesized that natural populations in deeper areas grow slowly due to lower productivity of phytoplankton. In Otsego Lake, future research may help raise awareness on zebra mussel impacts on biotic resources (e.g., fisheries, benthos, and planktonic community), infrastructure (e.g., water quality and water-delivery facilities) and recreational values (unfavorable odors from decaying mussels and boat/propeller contamination).

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