Assessment of Potential Zebra Mussel (*Dreissena polymorpha*) Colonization of Smith Mountain Lake, VA.

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BACKGROUND

Zebra Mussels

Zebra mussels (*Dreissena polymorpha*), a native species of Europe, are an invasive species of freshwater bivalve in North America. According to the United States Geological Survey (nas.er.usgs.gov, 6/2/2020), the zebra mussel is a nonindigenous aquatic species, that is identified by the striped pattern of its shell (Figure 1). At maturity, females can release more than 40,000 eggs in a cycle and up to 1 million eggs in a spawning season (www.caryinstitute.org). Spawning occurs from the spring to fall, typically taking several weeks before larvae adhere to a substrate (usbr.gov). Individuals live three to nine years, filtering on average of a liter of water a day for algae, and can grow to an average length of 5 cm (usgs.gov). At dense populations, zebra mussels can cause unnatural clarification of water impacting the ecosystem and native bivalve populations, damage infrastructure (e.g., clogging pipes and water intakes), and can sink navigational buoys and adhere to watercraft (usgs.gov).

Figure 1. Shell patterns of zebra mussels

Notable Growth Requirements

Temperature

There is a discrepancy for temperature tolerance for North American populations of zebra mussels, with optimal ranges for adult survival reported to be 20-25°C (usgs.gov). However, other reports suggest that the species can tolerate 26-33°C as the upper limit for short-term survival (usbr.gov). Reports on zebra mussel populations in the Ukraine show that mortality onset begins at 27-27.3°C, 50% mortality at 28.2-28.4°C and fully open shells at 28.6°C (usbr.gov from Mills et al. 1996).

Calcium

Calcium is a major component of the zebra mussel shell, especially during larval development and growth. In Europe, the threshold of Calcium levels is around 20 mg/L (20 ppm) (usbr.gov). For North American populations, Calcium concentrations of 12-19 mg/L (12-19 ppm) have been suggested as the best range to ascertain a zebra mussel population's potential distribution (usbr.gov).

ASSESSMENT

Project Objectives

The objectives of this snapshot study, from September 2017-March 2019, were to determine if temperature and Calcium levels were conducive to support the growth of a zebra mussel population.

Reports and Projections

Zebra mussels were first discovered in the Great Lakes in 1988 and spread throughout the United States (Figure 2A) (usgs.gov). However, further and more recent surveys indicate that the zebra mussel has not become established in Virginia waters (Figure 2B) (usgs.gov), and one study indicates that Western Virginia and the SML area are categorized at a "very low" or "highly variable" risk for colonization (Figure 2C) (Whittier et al 2008).

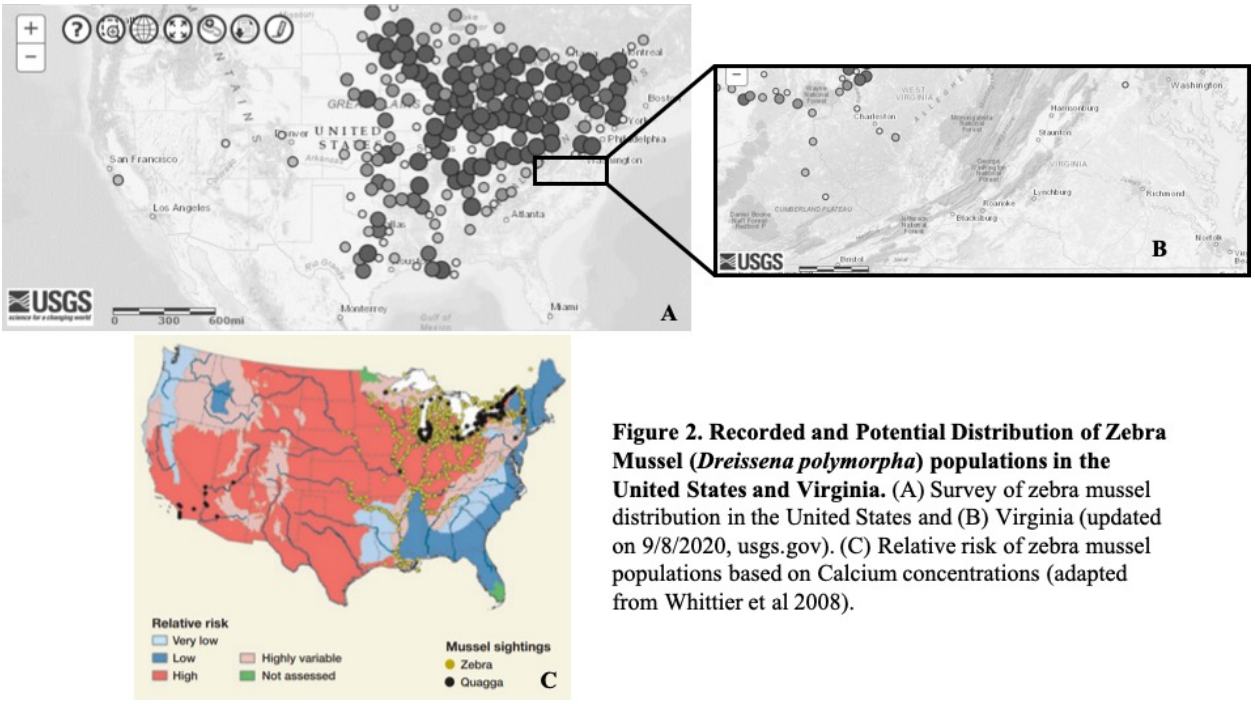

Figure 2. Recorded and Potential Distribution of Zebra Mussel (*Dreissena polymorpha*) populations in the United States and Virginia. (A) Survey of zebra mussel distribution in the United States and (B) Virginia (updated on 9/8/2020, usgs.gov). (C) Relative risk of zebra mussel populations based on Calcium concentrations (adapted from Whittier et al 2008).

Temperature

Although temperature ranges for SML do fall within the optimal ranges for zebra mussel growth, the average temperature during the summer months typically exceeds 28°C, which is the upper limit that supports zebra mussel survival.

Calcium

During the duration of the study, the Calcium concentrations ranged from 4.36 ppm (mg/L) to 22.6 ppm (mg/L), with an average of 13.1 ppm (mg/L) (Table 1). Although this average is within the range for levels conducive for potential zebra mussel colonization it is not definitive. This average value is much lower than the 20 ppm (mg/L) reported to be the minimum level for the more established European populations of zebra mussel. Furthermore, only six of the 12 SML

sampling dates exceeded the minimum concentration of 12 ppm (mg/L), and the lowest concentrations were seen from the spring to fall when shell development should be at its highest (Table 1).

Table 1. Calcium Concentrations in Smith Mountain Lake, VA: Snapshots from 2017-2019

Sample Month	Calcium (ppm)
2017	
September	11.09
October	11.09
November	14.55
2018	
March	22.5
May	7.73
June	6.03
July	4.76
August	4.36
October	22.3
November	20.58
2019	
February	16.41
March	16.38
Average	**13.1**

CONCLUSIONS

Zebra Mussels (*Dreissena polymorpha*) are a highly invasive species that have the potential to drastically alter the aquatic ecosystem and cause extensive mechanical damage to our waterways and infrastructure. To date, surveys have not indicated that zebra mussel populations have accumulated in Virginia waters, including Smith Mountain Lake. Furthermore, analysis of two of the more critical growth factors (i.e., temperature and Calcium concentration) do not appear to be conducive for zebra mussels to become established in SML. This is further supported by the fact that average water temperatures meet or exceed reported optimal temperatures for growth, as well as that the Calcium concentrations are lower than the minimum requirements for shell development during the spring and summer months when spawning and larval development are highest.

At times, the temperature and calcium ranges do meet and/or exceed reported optimal growth conditions for a zebra mussel population during the period that SML was studied. Additionally, one source has reported that the risk is “low” to “highly variable” for the SML area. It is noteworthy that photosynthesis increases pH, which converts bicarbonate (HCO_3^-) to carbonate (CO_3^{2-}) and can lead to precipitation of calcium carbonate ($CaCO_3$). This tends to lower free calcium levels during the growing season, as can be seen in the calcium data for this report. The algae that zebra mussels feed on are in the photic zone where pH and carbonate are relatively high, and the lower free calcium level reduces the risk of zebra mussel colonization. However, it will be prudent to continue monitoring for zebra mussel introductions, and to educate the patrons of SML to be cognizant of potential, future introductions of the species.

SOURCES

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