Managing zebra mussels: Developing treatments to eradicate localized populations and evaluating low-dose copper treatments

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Infestation Timeline

Zebra mussels have rapidly expanded throughout Minnesota and the continental U.S. and their spread is likely to continue.
## Minnesota’s Rapid Response actions

<table>
<thead>
<tr>
<th>Lake</th>
<th>Zebra Mussels Detected</th>
<th>Treatment(s)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Marion</td>
<td>2017</td>
<td>EarthTec QZ</td>
<td>TBD</td>
</tr>
<tr>
<td>Lake Minnewashta</td>
<td>2016</td>
<td>EarthTec QZ</td>
<td>1 adult mussel found near access</td>
</tr>
<tr>
<td>Ruth Lake</td>
<td>2015</td>
<td>EarthTec QZ</td>
<td>1 adult mussel found near access</td>
</tr>
<tr>
<td>Christmas Lake</td>
<td>2014</td>
<td>Zequanox, Earthtec QZ, and Potash</td>
<td>mussels found lake-wide</td>
</tr>
<tr>
<td>Lake Independence</td>
<td>2014</td>
<td>Earthtec QZ and Potash</td>
<td>mussels found near access</td>
</tr>
<tr>
<td>Rose Lake</td>
<td>2011</td>
<td>Cutrine Ultra</td>
<td>adult zebra mussels found 2016</td>
</tr>
<tr>
<td>Lake Irene</td>
<td>2011</td>
<td>Cutrine Ultra</td>
<td>mussels found post-treatment</td>
</tr>
</tbody>
</table>
Identified Need for Rapid Response Actions

Treatment protocols are needed to eradicate localized zebra mussel infestations, specific needs include:

1) What molluscide to use?
2) What dose is required to obtain a complete kill?
3) What influence does water temperature have on molluscicide toxicity?
Study Concept

Evaluate four molluscicidal compounds for potential use in zebra mussel rapid response actions.

- Test temperatures - 22, 17, 12, and 7 °C
- Exposure durations - short – long
- Conduct exposures in a controlled environment
- Synthesize results into temperature-specific treatment protocols
Zequanox®

- EPA-registered for dreissenids
- Killed-cell bacteria-based biopesticide
- Selective toxicity
- Breaks down rapidly after hydration
EarthTec QZ®

• EPA-registered for dreissenids
• Copper-based product with demonstrated efficacy
• Copper historically used for algae, biofouling, swimmer’s itch
Potassium chloride

- Known dreissenid toxicity
- Muriate of Potash (MOP, ~99% potassium chloride) was used to eradicate zebra mussels from a highly infested 4.9-hectare, 28-meter deep quarry lake in Virginia
Niclosamide

- Active ingredient of an EPA-registered lampricide (Bayluscide)
- Used as a molluscicide for snails where schistosomiasis is endemic
- Low mammalian toxicity – used to control parasites in animals and humans
Test System

- Climate-controlled environmental chambers
- Heated/chilled well water supply
- Static exposure jars
- Flow-through recovery tanks
- Reed Mariculture Instant Algae® diets
Exposures/Assessments

Static exposures in 3L of water
- 8, 12, and 24 h – Zequanox
- 24, 96, and 336 h – EarthTec QZ, KCl, and niclosamide
- Renewals every 96 h
- 4 replicates (225 jars/temperature)
- N = 20/replicate

Post-exposure holding standardized on daily temperature units (DTU)
- 1 DTU for every 1°C/24 h
- Holding ranged from 216 to 221 DTU’s (10 to 31d)
Water Chemistry

Full suite of water chemistry parameters monitored:

Daily
- Dissolved oxygen
- pH
- Temperature

Periodic
- Alkalinity
- Hardness
- Conductivity
- Ammonia
### Results – Summary Effective Concentrations

Minimum lethal concentration of toxicants required to induce 100% zebra mussel mortality at specific water temperatures (a “>” symbol indicates observed mortality was > 90% and < 100% at the specified concentration; NE = treatment deemed not effective, observed mortality was ≤ 90%).

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>Exposure duration (h)</th>
<th>EarthTec QZ, niclosamide, and KCl</th>
<th>Zequanox</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EarthTec QZ (mg/L)</td>
<td>Niclosamide (mg/L)</td>
</tr>
<tr>
<td>7</td>
<td>24  NE</td>
<td>&gt; 0.552</td>
<td>NE</td>
</tr>
<tr>
<td>12</td>
<td>24  &gt; 58.8</td>
<td>&gt; 0.169</td>
<td>NE</td>
</tr>
<tr>
<td></td>
<td>96  11.3</td>
<td>0.034</td>
<td>&gt; 586</td>
</tr>
<tr>
<td></td>
<td>336 150.4</td>
<td>0.182</td>
<td>NE</td>
</tr>
<tr>
<td>17</td>
<td>24  &gt; 47.6</td>
<td>&gt; 0.200&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&gt; 2,071</td>
</tr>
<tr>
<td>22</td>
<td>24  &gt; 49.6</td>
<td>0.181</td>
<td>&gt; 3,066</td>
</tr>
<tr>
<td></td>
<td>96  21.5</td>
<td>0.137</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>336 5.8</td>
<td>&gt; 0.092</td>
<td>125</td>
</tr>
</tbody>
</table>

<sup>a</sup> Nominal concentration
Results – Summary Effective Concentrations

Treatment options 1
EarthTec QZ: 12.0 mg/L for 336 hours
Niclosamide: 0.06 mg/L for 336 hours

Treatment options 2
EarthTec QZ: 26.0 mg/L for 96 hours or 6.0 mg/L for 336 hours
Niclosamide: 0.10 mg/L for 336 hours or 0.14 mg/L for 96 hours or 0.20 mg/L for 24 hours
Potassium chloride: 165 mg/L for 336 hours

Treatment options 3
EarthTec QZ: 20.0 mg/L for 96 hours or 6.0 mg/L for 336 hours
Niclosamide: 0.10 mg/L for 336 hours or 0.14 mg/L for 96 hours or 0.20 mg/L for 24 hours
Potassium chloride: 150 mg/L for 336 hours

Treatment options 4
EarthTec QZ: 20.0 mg/L for 96 hours or 6.0 mg/L for 336 hours
Niclosamide: 0.10 mg/L for 336 hours or 0.14 mg/L for 96 hours or 0.20 mg/L for 24 hours
Potassium chloride: 125 mg/L for 336 hours or 220 mg/L for 96 hours
Acknowledgements/Disclaimer

Study support:

The data are provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the data. Any use of tradename, product, or firm names in this report are for descriptive purposes only and does not imply endorsement by the U.S. Government.
More information

• Peer-reviewed manuscript:

• MAISRC white paper:
  Minnesota Aquatic Invasive Species Research Center (2018) *Treatment options for the eradication of limited-scale zebra mussel infestations at various water temperatures.* Unpublished manuscript. University of Minnesota, St. Paul, MN.
Evaluating low-dose copper treatments for the management of zebra mussels

- Study planned for 2019
- 10-d low-dose copper treatment (60 ppb) on Lake Minnetonka
Location and timeline

Location:  
St Albans Bay,  
Lake Minnetonka

1st sampler placement:  
May 2019

Treatment:  
July-August 2019

Last sampler removal:  
October 2019
Project rationale

• McCartney (2016) reported 17-h EarthTec QZ concentrations to kill 50% (LC50) and 99% (LC99) of the veligers that were 64 and 18 times lower than what was required for adults exposed to a similar copper-based product (Cutrine Ultra®).

• The EarthTec QZ 17-h LC50 of 18.9 µg/L A.I. for veligers is approximately 53 times lower than what was required for adults (Claudi et al. 2014).

• The potential to manage zebra mussel populations and to curtail their ecosystem and economic impacts through the use of larval suppression techniques warrants further investigation.
Project objectives

The objectives of this project are to comprehensively evaluate the use of low-dose copper treatments for zebra mussel population suppression by targeting early life stages and to quantify short-term impacts of low-dose copper applications to native aquatic animals and algae.
Methodology - application

Application of EarthTec QZ will be completed using a GPS-assisted boat mounted application system

• Every-other day applications (n=5) for 10 days
Methodology — target animals

Evaluate impacts to zebra mussel veligers, juveniles, and adults

- Veliger plankton tows before and after treatment
- Juvenile settlement on sampling plates over the entire season
- Mortality of caged adults
Methodology – nontarget animals and algae

Evaluate impacts to algae, zooplankton, benthic invertebrates, native mussels, and fish

- CLHA and secchi disk measurements before and after application
- Zooplankton tows before and after treatment
- Benthic grab samples before and after treatment
- Mortality of caged native mussels and fish
Copper toxicity is dependent on water chemistry; therefore, data will be collected to allow transfer of results using the EPA’s Biotic Ligand Model. The BLM requires ten parameters:

- pH
- DOC
- Ca
- Mg
- Na
- K
- Cl
- Alkalinity
- Temperature
- SO$_4$
Questions?