Freshwater Mussel Reintroduction Research Project 2016: Advancements in Freshwater Mussel Restoration at Longwood Gardens

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Established in 1996, the Partnership for the Delaware Estuary (PDE) is a non-profit 501(c)(3) organization based in Wilmington, Delaware. PDE manages the Delaware Estuary Program, one of 28 national estuaries recognized by the U.S. Congress for its national significance under the Clean Water Act. PDE is the only tri-state, multi-agency National Estuary Program in the country. In collaboration with a broad spectrum of governmental agencies, non-profit corporations, businesses, and citizens, PDE works to implement the Delaware Estuary’s Comprehensive Conservation and Management Plan to restore and protect the natural and economic resources of the Delaware Estuary and its tributaries.
Acknowledgements
The authors are greatly appreciative for the generous funding by Longwood Gardens to support this effort. To enhance lessons learned and logistical efficiency, this mussel relocation effort was completed in tandem with a similar relocation of mussels from the same source (Delaware River) to Green Lane Reservoir, a project led by partners at the Academy of Natural Sciences of Drexel University (ANS). Hence, we are grateful for the collaborative support of Mr. Roger Thomas, Sylvan Klein, Elena Colon and others from ANS who furnished materials, supplies and expertise while they worked side by side with the PDE team. Additional PDE staff who assisted with field tasks were Sandra Demberger and Spencer Roberts, and Nancy Descano and Lorestine Pittman furnished administrative support.

Suggested Method for Citation
Introduction

Importance of Freshwater Mussels

In North America, over 70% of the 297 native species of freshwater mussel species are endangered, threatened, or of special concern (Williams et al. 1993) making them the most imperiled group of aquatic animals nationally (Nobles and Zhang 2011). Freshwater mussels are also considered to be the most imperiled animal locally in the Delaware River basin (PDE 2012a, 2012b). Accordingly, the 12 species of freshwater mussels native to the basin are declining in species richness, population abundance, and geographic range. Despite their decline, there are emerging data suggesting that freshwater mussels are important for water quality and ecological integrity depending on abundance, similar to other filter feeding bivalves (e.g., clams, mussels, and oysters). Due to their imperiled status and potential importance in ecosystem functioning and water quality, there has been a rise in national and local interest in protecting and understanding these animals.

This expanded interest is reflected by the greater diversity of state and federal agencies that are now attentive to freshwater mussel status and trends. In the past, the main groups that focused on mussel conservation and restoration were state heritage programs and a few federal agencies (e.g., United States Fish and Wildlife Service and United States Geological Survey), which focused on biodiversity preservation and the protection of listed species. Now, many other agencies (e.g., United States Environmental Protection Agency) and water supply companies (e.g., Philadelphia Water Department and SUEZ Water) are focused on the water and habitat benefits that are furnished by healthy mussel beds in streams, rivers, and lakes.

As a National Estuary Program, the Partnership for the Delaware Estuary (PDE) is expected to establish and meet measurable goals for sustaining and improving water and habitat conditions in the Delaware River and Bay, thereby working to implement our Comprehensive Conservation and Management Plan (CCMP). PDE has elevated healthy freshwater mussel populations as one of a limited subset of “driver” goals that facilitate ecosystem-based restoration in the Delaware River basin. This goal is based on the observation that mussels are very long-lived (up to 100 years) and sensitive to a variety of suboptimal conditions, ranging from water quality, water quantity, riparian cover, and fish passage. Hence, to achieve multiple goals for water and habitat conditions in any given water body, a simplified focus on achieving healthy assemblages of native freshwater mussels, living in abundance, will drive positive decision-making in support of broader CCMP actions and needs.

The water quality benefits of healthy natural mussel beds are only now being studied, but look to be sizeable. When active, each adult mussel filters gallons of water every day. Many streams that once supported dense populations of freshwater mussels no longer do. This loss of freshwater mussels is thought to contribute to degraded water quality and represents a negative feedback for ecosystem health. In those areas, mussel restoration should promote positive feedbacks to ecosystem health in the form of cleaner water, reduced erosion, and increased habitat complexity. For more information on the ecology and diversity of freshwater mussels in the Delaware River basin, please refer to Freshwater Mussels of the Delaware Estuary: Identification Guide & Volunteer Survey Handbook and other information at the following website: http://www.delawareestuary.org/freshwater-mussels.

Although many current mussel populations appear to be extremely depressed and constricted relative to historic levels, numerous scientists and managers believe that this represents an opportunity to rebuild mussel populations. Countless streams and rivers that were once too polluted to support mussels have since been remediated to the point where mussel populations could again be sustained.
However, blockages to fish passage, slow mussel growth, and other impediments stand in the way of mussels being able to naturally re-disperse and colonize these habitats. Hence, assisted recolonization can directly augment and expedite recovery since the natural dispersal of native populations can be slow or not possible.

**Freshwater Mussel Recovery Program (FMRP)**

The FMRP was launched in 2007 by PDE with the goal of conserving and restoring native freshwater mussels within the Delaware Estuary. This program complements PDE’s comprehensive watershed-based shellfish restoration strategy which also includes saltwater oysters and saltwater ribbed mussels. Together, these shellfish range from the headwaters to the Bay.

The FMRP consists of 8 areas of focus:

- **Surveys** of freshwater mussels (qualitative and quantitative) to identify potential restoration sites and provide data on extant populations.
- **Conservation** of current mussel populations and their habitat.
- **Restoration** of freshwater mussel populations through tactics such as reintroductions to candidate waters.
- **Propagation** using hatchery methods to seed streams for water quality uplift and bolster mussel abundance.
- **Habitat** suitability for freshwater mussels to aid in restoration practices.
- **Research and Monitoring** to understand mussel life history, ecosystem services, and their interaction with future environmental conditions.
- **Remediation** of negative impacts on freshwater mussels and their habitat.
- **Outreach** to educate the public about conservation and restoration of freshwater mussels.

**Project Summary**

The goal of this project was to begin testing the viability of ponds at Longwood Gardens for supporting freshwater mussel populations. Following earlier mussel surveys that confirmed the absence of extant mussels in ponds in Longwood Gardens (Cheng et al. 2015), this project represented the second step in a potential long-term mussel restoration and stocking effort. By testing if 2 native species of mussels can survive and grow within 3 selected Longwood Gardens ponds, results will guide strategic decisions regarding potential broader mussel stocking efforts aimed at enhancing water quality. Mussel restoration and water quality enhancement are goals consistent with the vision of Longwood Gardens to promote environmental sustainability via native species and assemblages, both on the land and in the water. This project also fills important niches in the FMRP (see above) because ponds often support good mussel growth and survival, representing refugia from harsh conditions associated with stormwater impairment in nearby Piedmont streams. If one or more ponds at Longwood are found to support productive mussel populations, these might also serve in the future as nursery areas for juvenile mussels that are propagated in a hatchery. Scientists from PDE with assistance from scientists at the Academy of Natural Sciences of Drexel University (ANSDU) collected mussels from the lower Delaware River, tagged them, and then deployed them into three Longwood Ponds in September, 2016 (Fig. 1). Ponds were chosen based on having suitable depths, bottom conditions, and water quality. Small groups of 12-16 mussels were either placed into off bottom cages, floating baskets, or free-released. Treatments consisted of 3 replicate deployments per tactic per pond, but not all tactics were attempted in every pond. Mussel survival and growth, as well as pond water quality, is currently being monitored, and will continue for at least one year. Results will be compared among ponds and holding tactics to guide future mussel restoration and research efforts at Longwood Gardens and elsewhere.
Figure 1. Spatial distribution of study ponds into which freshwater mussels were reintroduced.
Project Tasks

Freshwater Mussel Reintroduction

To reintroduce freshwater mussels into ponds of Longwood Gardens, two species of freshwater mussels (the eastern elliptio, *Elliptio complanata*, and the alewife floater, *Anodonta implicata*) were collected from the tidal Delaware River on September 21, 2016 and tagged with a unique plastic tag. A subset of mussels was electronically tagged as well for free-release. For an in depth description of collection and tagging techniques, see Cheng and Kreeger 2015.

Mussels were then subdivided and small groups were placed into replicate off-bottom cages and floating baskets on September 22, 2016 (Fig. 2). The electronically tagged mussels were free released near holding structures (baskets or cages) for future monitoring. Each technique had previously been utilized with success by PDE or partners (e.g., United States Fish and Wildlife Service).

The number of mussels deployed, summarized in Table 1, was similar across ponds and techniques. At each pond, mussels were divided among three replicate structures (e.g., Nursery Pond received three cages and three baskets). Efforts were made to keep species composition similar among all treatment groups for all ponds and techniques. The eastern elliptio composed the majority of mussels reintroduced, supplemented with alewife floaters in just baskets and cages. Each set of three cages received seven alewife floaters while eight alewife floaters were divided into the baskets at the Nursery Pond. All electronically tagged and free-released mussels were eastern elliptio mussels.

<table>
<thead>
<tr>
<th>Study Pond</th>
<th>Baskets</th>
<th>Cages</th>
<th>Free-release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery Pond</td>
<td>25</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Wetland Pond</td>
<td>-</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Hourglass Pond</td>
<td>-</td>
<td>24</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1. Number of mussels deployed by technique.
**Water Quality**

Water quality was monitored at each study pond using a YSI Pro+ sonde on October 14, 2016. The sonde was calibrated prior to use. Parameters recorded included dissolved oxygen (mg/L and % saturation), water temperature (°C), specific conductance (uS/cm), and pH. Data gathered during freshwater mussel reintroduction are presented in Table 2.

**Table 2. Summary of water quality data gathered during mussel reintroduction.**

<table>
<thead>
<tr>
<th>Site</th>
<th>Water Temperature (°C)</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>Dissolved Oxygen (Sat%)</th>
<th>Specific Conductance (uS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery Pond</td>
<td>15</td>
<td>10.9</td>
<td>108.5</td>
<td>185.9</td>
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<td>Hourglass Pond</td>
<td>12.7</td>
<td>12.26</td>
<td>115.7</td>
<td>416.1</td>
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<td>Wetlands Pond</td>
<td>14.3</td>
<td>9.87</td>
<td>96.4</td>
<td>110.9</td>
<td>7.97</td>
</tr>
</tbody>
</table>

**Monitoring and Next Steps**

As mussels overwinter, efforts will be made to ensure deployment structures remain undamaged from ice and mussels have the best chance for continued growth and survival. Opportunities will be sought to continue monitoring freshwater mussels at Longwood Gardens and potentially expand both scientific studies as well as outreach opportunities.
**Literature Cited**


