Aquatic Invasive Species (AIS) Control Plan: Dreissenid Mussels

This control plan is a living document and will be updated, as needed, to reflect the status of the species within Pennsylvania.

Natural History

Description: The term "Dreissenid mussels" is typically used collectively to describe invasive mussels in the genus *Dreissena* which were introduced into the Great Lakes basin and have subsequently spread to other waters in North America. This includes the Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena rostriformis bugensis*) which are both small freshwater mussels native to Eurasia.

Taxonomy

Common Name: **Zebra Mussel**
Family: **Dreissenidae**
Species: ***Dreissena polymorpha***
Integrated Taxonomic Information System (ITIS) Serial Number**: 81339**

Common Name: **Quagga Mussel**
Family: **Dreissenidae**
Species: ***Dreissena rostriformis bugensis***
ITIS Serial Number: **567514**

Morphology: Zebra Mussels (Figure 1) are small (up to 3 cm) freshwater bivalves with a flat ventral surface, forming a "D" shape if oriented flat on the ventral surface. They typically possess striated pattern, although this may not be present in all individuals or populations (Benson et al. 2022a). Adults are sessile and attach to surfaces by byssal threads.

Figure 1. Adult Zebra Mussel (*Dreissena polymorpha*) with dorsal side facing up. Photo curtesy of the Smithsonian Institution.

Quagga Mussels (Figure 2) are freshwater bivalves generally similar in appearance to Zebra Mussels but are typically larger (up to 4 cm) and typically have a rounded ventral surface (Benson et al. 2022b). However, morphological characteristics may not be completely reliable to distinguish between these species (Beggel et al. 2015). Like Zebra Mussels, adults are sessile and attach to surfaces by byssal threads.

Figure 2. Adult Quagga Mussel (*Dreissena rostriformis bugensis*) with dorsal side facing up. Photo curtesy of the U.S. Geological Survey.

Origin: Zebra Mussels are native to the Black, Caspian, and Azov Sea basins (Benson et al. 2022a). Quagga Mussels are native to portions of the Black Sea basin (Benson et al. 2022b).

Food Preferences: Both species are suspension filter feeders which selectively consume phytoplankton (Tang et al. 2014; Karatayev et al. 2015; Benson et al. 2022a; 2022b) and facultatively consume zooplankton, although feeding on zooplankton has received less study (Karatayev et al. 2015). Zebra Mussels filter feed both diurnally and nocturnally (Hogan and Mills 1997) and can filter significant volumes of water per day (Benson et al. 2022a; 2022b). Both species can effectively filter feed in turbid environments by the production of pseudofeces, in which non-organic particles captured are expelled prior to digestion (Roditi et al. 1996; Benson et al. 2022a; 2022b).

Reproduction: Both Zebra and Quagga mussels are dioecious (i.e., individuals of sperate sexes occur) and reproduce by the release of gametes into the water column where fertilization occurs (Benson et al. 2022a; 2022b). Release of gametes typically occurs in the spring and summer. After fertilization, juveniles of both species become planktonic veligers for several weeks before settling on substrate or other surfaces and becoming sessile. Natural dispersal of veligers is typically passive by drift. Female Zebra Mussels typically become sexually mature after one year and may produce up to a million eggs during a reproductive season (Benson et al. 2022a). Hybridization between Zebra Mussels and Quagga Mussels may occur, but hybrids are expected to be rare (Benson et al. 2022b).

Notable Characteristics: Recent observations and research have demonstrated that Quagga Mussels can outcompete and displace Zebra Mussels in contained environments. While Zebra Mussels typically colonize hard surfaces in the littoral zone, Quagga Mussels can also colonize soft sediments in the profundal zone (Balogh et al. 2018). Due to this advantage, Quagga Mussels typically first colonize the profundal benthos and subsequently colonize and displace most Zebra Mussels over a period of years in ecosystems where both species are introduced (Karatayev et al. 2015; Balogh et al. 2018). However, populations of Zebra Mussels may still persist in shallow bodies of water (Karatayev et al. 2015).

Historic/Current Vectors: Both species were initially introduced into the Great Lakes basin of North America by the release of ballast water from trade ships originating from Eurasia (Benson et al. 2022a; 2022b). Subsequent spread of both species into inland waters of North America is primarily attributed the overland movement of recreational boats between waterbodies with either have live mussels attached or veligers in live well, motor, ballast water which is not drained completely prior to transport (Johnson and Carlton 1996; Dalton and Cottrel 2013). Other potential mechanisms of dispersal include transport on fishing gear, diving gear, or by wildlife such as birds. Additionally, Zebra Mussels were found in contaminated “moss ball” pet products in many U.S. states during March 2021, suggesting the aquarium trade could be an incidental dispersal pathway for

Dreissenid mussels (Benson et al. 2022a). It is thought that Zebra Mussels are more likely to be dispersed by overland dispersal on watercraft than Quagga Mussels, given both species were introduced into the Great Lakes basin at approximately the same time, but Zebra Mussels have colonized relatively more inland waters than Quagga Mussels (Karatayev et al. 2015).

Preferred Habitat: Zebra Mussels prefer to colonize hard surfaces within the littoral zone of lakes, impoundments, and slow-moving waters (Karatayev et al. 2015). Quagga Mussels occupy similar habitats but can also colonize soft sediments in the profundal zone of invaded waters (Karatayev et al. 2015; Balogh et al. 2018). Chemical characteristics of the waterbody, such as low dissolved calcium, may limit the establishment of introduced populations (Karatayev et al. 2015).

Distribution and Status

Distribution: Following their introduction in the late 1980s, Zebra Mussels spread throughout much of the Great Lakes basin and have subsequently spread into many inland waters of the eastern and central United States, with occasional introductions in the western U.S. (Figure 3).

In Pennsylvania (Figure 4), Zebra Mussels are known from 22 counties, with records predominantly occurring in the Lake Erie and Allegheny/Ohio River basins in the western part of the Commonwealth. However, records are also known from several locations in the Susquehanna River basin and from one quarry in the Delaware Basin (Northampton County).

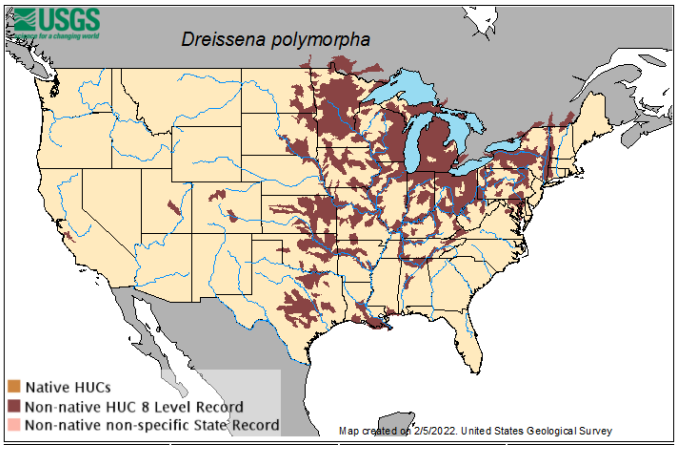

Figure 3. Distribution of Zebra Mussels in the United States. Source: USGS. (April 2022)

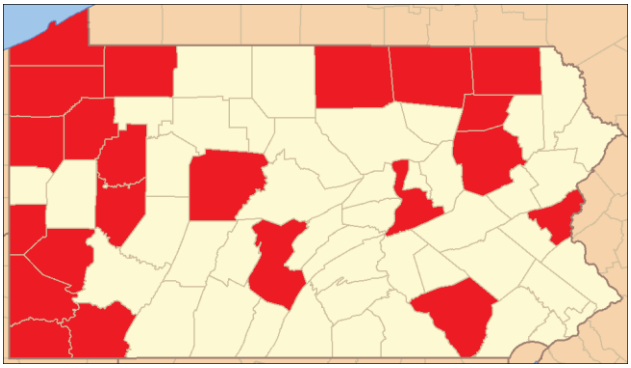

Figure 4. County-level distribution of Zebra Mussels in Pennsylvania (as of April 2022).

Relative to Zebra Mussels, Quagga Mussels have a more limited distribution in the United States (Figure 5), despite both species being introduced around the same timeframe (late 1980s). Quagga Mussels are prevalent in parts of the Great Lakes basin and occur in scattered localities in the Mid-Atlantic, Midwestern, and western United States.

In Pennsylvania (Figure 6), Quagga Mussels are known only from Lake Erie (Erie County) and from quarries in Blair, Lancaster, and Northampton counties.

However, they may have been eliminated from Lancaster County via copper treatment of a lake (Hammond and Ferris 2019).

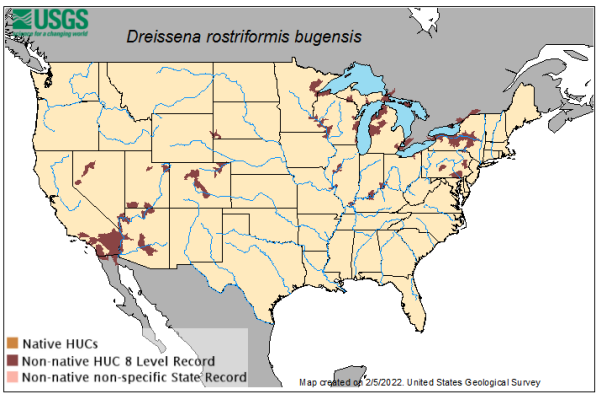

Figure 5. Distribution of Quagga Mussels in the United States. Source: USGS. April 2022.

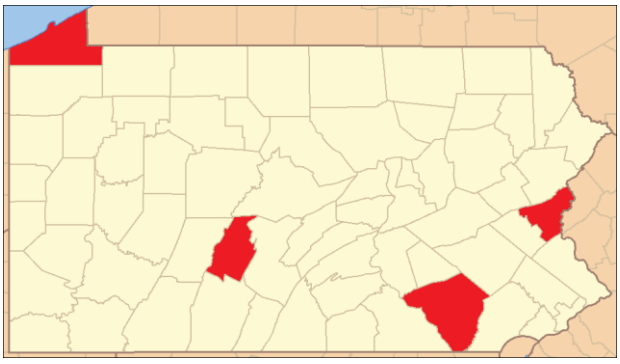

Figure 6. County-level distribution of Quagga Mussels in Pennsylvania (as of April 2022).

Pennsylvania Legal Status: Live Zebra Mussels and live Quagga Mussels are unlawful to possess, transport, or introduce in Pennsylvania under 58 Pa. Code Title 58 § 71.6 and § 73.1.

Threats

Ecological: Zebra and Quagga Mussels can have similar, significant impacts on invaded aquatic ecosystems (Karatayev et al. 2015; Benson et al. 20222a; 2022b). High densities of both species can create “reef like” habitats which may shelter certain benthic macroinvertebrates while excluding others, contributing to shifts in macroinvertebrate abundance and biodiversity (Karatyev et al. 2015). Because both species can filter feed large volumes of phytoplankton, they can shift the trophic status of invaded aquatic ecosystems towards oligotrophic conditions. Dreissenid mussels may consume most of the available energy produced by primary producers, depriving other native primary consumers (Karatayev et al. 2015; Benson et al. 2022a; 2022b). These trophic effects may also affect higher trophic levels. For example, Walleye (*Sander vitreus*) may exhibit diminished sizes in habitats invaded by Zebra Mussels (Hansen et al. 2020). Additionally, because of selective filter feeding by Dreissenid mussels on certain phytoplankton groups, establishment of these species has been attributed to increased risk of harmful algal blooms (Knoll et al. 2008). Furthermore, Dreissenid mussels may create habitat or serve as a food source for other aquatic invasive species, such as the Round Goby *Neogobius melanostomus* (Ray and Corkum 1997; Wilson et al. 2006).

In addition to broader ecosystem impacts, a major concern associated with Dreissenid mussel invasion is the potential negative effects on native freshwater mussels (Unionidae), particularly because many native mussels are of conservation concern (Karatayev et al. 2015; PGC-PFBC 2015). Zebra Mussels are known to encrust native mussels, which can cause direct mortality (Schloesser et al. 1996). Additionally, Zebra

Mussels compete with native mussels for food resources and habitat (Karatayev et al. 2015; Benson et al. 2022a). While the impacts of Quagga Mussels on native Unionid Mussels are less well studied than those of Zebra Mussels, it is anticipated that the impacts of Quagga Mussels may be generally similar but less severe (Karatayev et al. 2015)

Economic: The economic impacts of Zebra Mussels are well-known, and this species is considered among the most economically costly aquatic invasive species in North America (Pinmental et al. 2005). Due to their occurrence in high densities and attachment to hard substrates, Zebra Mussels can foul any hard manmade structures that are immersed in water, such as docks, boats, barges, and buoys, causing these structures to degrade or sink (Benson et al. 2022a). This species can quickly clog industrial freshwater intake pipes and filtration systems, contributing to over an estimated 1 billion U.S. dollars in annual costs (Pinmental et al. 2005). Hard, empty shells can foul beaches, which can exclude recreation unless removed at a cost. The economic impacts of Quagga Mussels are less well-known; however, they are anticipated to be generally similar to Zebra Mussels (Pinmental et al. 2005; Benson et al. 2022b).

Management

Management Goals: Both Zebra and Quagga Mussels are already present in Pennsylvania. Therefore, the primary management goals should be to continue, initiate, or enhance efforts to contain or slow the spread of existing populations into novel waters.

Containment and Prevention Actions:

- Coordinate with Federal and Pennsylvania state agencies, and non-government organization partners to conduct surveys and monitoring for Dreissenid mussels when feasible, especially in high-risk waterways (i.e., waters in close geographic proximity to invaded waters or those highly used by boaters). Consider the use of eDNA technology in monitoring if feasible and cost-effective (Amberg et al. 2019).

- When feasible, coordinate with Federal and Pennsylvania state agencies, and non-government organization partners to perform status assessments of Dreissenid mussels within known invaded waters.

- Encourage the incident reporting of aquatic invasive species such as Dreissenid mussels within Pennsylvania. Online reporting can now be conducted at the following PFBC web site: https://pfbc.pa.gov/forms/reportAIS.htm as well as PA iMapInvasives at: https://www.paimapinvasives.org and at the national level, USGS Nonindigenous Aquatic Species website: https://nas.er.usgs.gov/SightingReport.aspx

- Install signs at invaded waters informing the public on how to clean boats and fishing gear to prevent the spread to other waters. When feasible, install AIS disposal boxes or boat cleaning stations at high use waters infested with Dreissenid mussels or considered to be of high risk for introduction. Education and boat inspections may be done by launch steward programs, where feasible, in addition to, or in lieu of, signage and cleaning stations.

- Strictly enforce Dreissenid mussel regulations within 58 Pa. Code § 71.6 and § 73.1 and promote awareness among Law Enforcement Staff to conduct inspections at areas within known Dreissenid mussel infestations.

- Keep informed with research concerning the use of control options (see Rapid Response Options below) and support research needs related to the control of Dreissenid mussels in Pennsylvania, particularly to mitigate impacts towards native freshwater mussel species of conservation concern.

Rapid Response Options:

- Several control methods for Dreissenid mussels are available; however, the cost and effort required for effective elimination or control in invaded waterbodies is likely prohibitive, especially for larger waterbodies or connected systems. Drawdowns of infested impoundments during the winter months may be done to help control populations; however, total elimination of populations by this method is unlikely (Grazio and Montz 2002). Benthic barriers (which smother mussels) have also been utilized as a control option to varying degrees of success (Culver et al. 2013). Chemical controls have been effective or partially effective at removing Dreissenid mussels from relatively smaller (i.e., < 12 ha) bodies of water (Lund et al. 2017; Hammond and Ferris 2019), including a small quarry in Lancaster County, Pennsylvania in which Quagga Mussels may have been eliminated (Hammond and Ferris 2019).

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