Aquatic Invasive Species (AIS) Control Plan:
New Zealand Mudsnail

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: New Zealand Mudsnails (*Potamopyrgus antipodarum*) are diminutive freshwater gastropods, typically attaining adult sizes of only several millimeters (about 1/4th of an inch) in length.

Taxonomy

Common name: **New Zealand Mudsnail**
Family: **Tateidae**
Species: ***Potamopyrgus antipodarum***
Integrated Taxonomic Information System (ITIS) Serial Number **205006**

Morphology: New Zealand Mudsnails (hereafter in this document abbreviated to "NZM") are small freshwater snails which typically attain maximum lengths of only 4-6 mm within invaded portions of North America (Figure 1) but can attain larger sizes in their native range (Levri et al. 2007). NZM contain a "corkscrew" shaped spiraled shell that coils to the right and typically contains 5-8 whorls (Benson et al. 2020). NZM contain a hard operculum which can close to cover the opening in the shell. Shells are typically various shades of grey or brown. Populations within the Great Lakes contain different shell morphologies, such as a keel in the middle of each whorl, which is not typical of populations elsewhere (Levri et al. 2007). Some populations also have small spines on the shell for defense from predators (Benson et al. 2000). NZM can be easily confused with other snail species and so experts are typically required to confirm identification.

Figure 1. Top: Magnified image of New Zealand Mudsnail. Source: USGS. Bottom: New Zealand Mudsnail shells with penny for scale. Source: Tim Throne, Trout Unlimited.

Origin: NZM are native to freshwater environments in New Zealand and several surrounding islands. NZM have spread to numerous localities in Australia, Europe, and North America. In the United States, NZM were first reported from near the

Snake River, Idaho, in 1987 (Benson et al. 2020).

Food Preferences: NZM feed primarily on detritus, periphyton, and organic particles within sediment (Bilka and Levri 2013; Benson et al. 2020).

Reproduction: In their native range, NZM females primarily reproduce asexually via parthenogenesis, although sexual reproduction is known to occur. Invasive populations of NZM within the United States are thought to be exclusively clonal colonies of asexual females (Benson et al. 2020).

Notable Characteristics: NZM can achieve high densities within invaded waters (Figure 2); with some extreme estimates suggesting densities of over 299,000 snails per m^2 (Kerans et al. 2005).

Figure 2. Rock infested with New Zealand Mudsnails from Codorus Creek, Pennsylvania. Credit: Tom Feneniz (Trout Unlimited).

Historic Vectors: NZM are thought to have spread from New Zealand to other parts of the world inadvertently through the global shipping trade. It is speculated that NZM were introduced to the Great Lakes on ships from Europe, and in water with game fish shipped from infested waters and stocked in western North America (Benson et al. 2020).

Current Pathways/Vectors: On smaller geographic scales (i.e., transport between watersheds), NZM are typically unintentionally introduced as "hitchhikers" on fishing, boating, and other aquatic recreational gear (Benson et al. 2020). NZM can close their operculum and can resist desiccation for up to several days outside of water (Richards et al. 2004). In Pennsylvania, the epicenter of most NZM infestations are located at popular trout fishing locations, suggesting waders/fishing gear as a major vector of transport. NZM may also be transported inadvertently via fish stocking and may even survive passage though the digestive system of some fish such as trout (Vinson and Baker 2008). NZM may also disperse on aquatic plants that are transported by humans or on aquatic vegetation moved during high water events (Benson et al. 2020).

Preferred Habitat: NZM are tolerant of a broad range of freshwater habitat characteristics and can even occur in brackish waters (Benson et al. 2020). They may be collected in deeper waters of lakes (Levri et al. 2007). In general, they prefer lentic or slow flowing waters with high nutrient levels, but are tolerant of fast flows, sedimentation, and pollution (Benson et al. 2020). In Pennsylvania, they appear to prefer waters with high conductivity (> 200 $\mu S/cm^2$) and basic (>7) pH levels, likely due to a greater availability of calcium ions required for shell growth at these conditions (Levri et al. 2020). Anecdotally, many of the populations of this species with high densities in Pennsylvania appear to be in coldwater streams with a limestone influence.

Distribution and Status

Distribution: NZM have been reported in at least 21 US States, with populations primarily concentrated in the western US and in the vicinity of the Great Lakes (Benson et al. 2020; Figure 3).

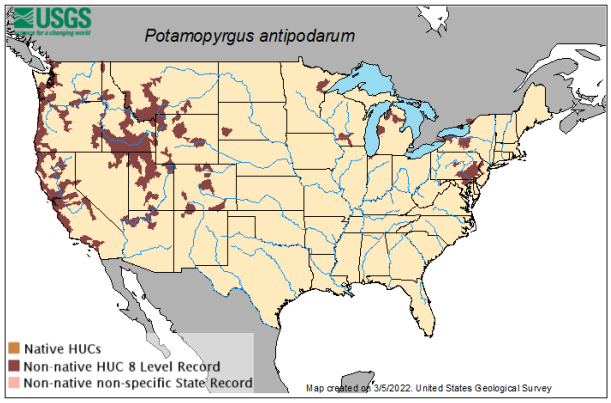

Figure 3. Distribution of New Zealand Mudsnails within the continental United States. Source: USGS.

In Pennsylvania, NZM have been reported from at least 13 counties (Figure 4). NZM were first documented within Pennsylvania in 2005 from Lake Erie in the vicinity of Presque Isle State Park (Levri et al. 2007). In 2013, NZM were discovered in Spring Creek, Centre County (Levri et al. 2020). Since 2018, NZM have also been reported in numerous streams and several rivers, many of which are popular trout waters in southeastern or central Pennsylvania including Bald Eagle Creek (Centre/Clinton Co.), Big Spring Creek (Cumberland Co.), Bushkill Creek (Northampton), Cedar Creek (Lehigh Co.), Codorus Creek (York Co.), East Branch Brandywine Creek (Chester Co.), Falling Spring Branch (Franklin Co.)., Fishing Creek (Clinton Co.), Jordan Creek (Lehigh Co.), Lake Erie (Erie Co.), Lehigh River, (Lehigh/Northampton Co.), Little Lehigh Creek (Lehigh Co.), Monocacy Creek, (Northampton Co.), Perikiomen Creek (Bucks Co.), Pohopoco Creek (Carbon Co.)
Saucon Creek (Northampton Co.), Schuylkill River (Berks, Montgomery, and Philadelphia Co.), Spring Creek (Centre Co.), Trindle Spring Run (Cumberland Co.), Trout Creek (Lehigh Co.), Tuplehocken Creek (Berks Co.), Valley Creek (Chester Co.), Wissahickon Creek (Philadelphia Co.), and Wyomissing Creek (Berks Co.).

Pennsylvania Legal Status: As of August 2022, NZM are presently not regulated in 58 Pa. Code §71.6 and §73.1 but are being evaluated for inclusion in a proposed regulatory code update of these chapters.

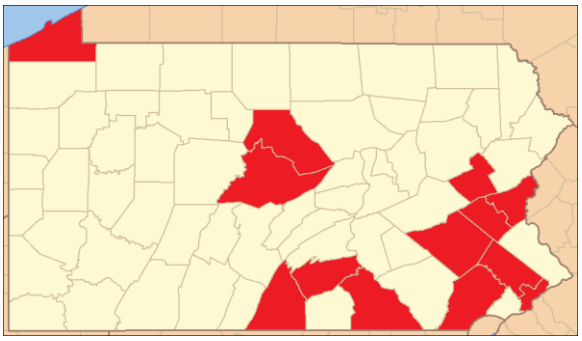

Figure 4. County-level distribution of New Zealand Mudsnails in Pennsylvania (October 2022).

Threats

Ecological: Due to their potential to attain high densities within invaded waters, NZM are competitors with native gastropods and other periphyton-grazing macroinvertebrates such as caddisfly larvae and mayfly nymphs (Karens et al. 2010; Krist and Charles 2012; Larson and Black 2016) and NZM infestations may ultimately result in reductions of macroinvertebrate abundance and biodiversity (Karens et al. 2005; 2010), however, in some areas this impact may be minor (Cada 2004; Karens et al. 2005). Few

studies appear to have been done evaluating the potential impacts of NZM on higher trophic levels (i.e., fish). However, trout will readily consume NZM in both laboratory and natural settings and will lose weight due to the poor nutritional content of NZM as compared to native macroinvertebrates (Vinson and Baker 2008). This suggests trout fisheries may be particularly vulnerable to NZM infestation.

Economic: The economic costs of NZM infestations are primarily speculative and have received little quantitative investigation. Due to their high densities, NZM may cause some degree of economic damage via biofouling structures such as water intake pipes; however, this has not commonly been reported and is likely minor in comparison to other invasive freshwater mollusks such as Zebra Mussels (Proctor et al. 2007).

Likely, the most significant economic cost of NZM invasions is related to fisheries because NZM are known to reduce the weight and quality of game fish species by food web disruption (Poirier 2015) and are of particular concern to trout fisheries (Vincent and Bakker 2008). This impacts the quality of fisheries to anglers, may impair the self-sustainability of fisheries, and thus lead to increased costs devoted to stocking of game fish. Furthermore, NZM infestations can impair fish hatchery function and increase operation costs (Oliver et al. 2021).

Management

Management Goals: NZM presently have an expanding, distribution in Pennsylvania. Therefore, the primary management goal must be to contain infestations.

Containment and Prevention Actions:

- Coordinate with Federal and Pennsylvania state agencies, watershed associations, and volunteer groups (e.g., Trout Unlimited) to conduct surveys/monitoring within invaded watersheds to determine the extent of NZM infestations, and initiate surveys of waters at-risk of infestation.
- Initiate a public education effort to acquaint the populace with the threat of and measures to prevent the spread of NZM. Because the spread of NZM in Pennsylvania appears to be primarily on fishing gear (waders), specifically target anglers for education/awareness through presentations and/or literature.
- Routinely monitor fish hatcheries at-risk of NZM contamination due to the presence of this species in nearby waters. Continue following established PFBC biosecurity protocols for fish rearing and stocking and incident response plans as needed.
- Support or initiate research in Pennsylvania further evaluating the impacts of NZM on native species and coldwater fisheries, and the habitat preferences of this species in order to predict areas of high risk for invasion.
- Continue installing NZM-specific signage developed by PFBC and PA Sea Grant at locations infested by NZM and consider the installation of wader cleaning stations at infested sites. Established gear disinfection protocols

include the following: freezing gear for a minimum of six hours, soaking gear in hot (>120°F) for at least five minutes, or soaking gear in a 1:1 solution of Formula 409 Degreaser Disinfectant and water. Other typical aquatic invasive species disinfection methods and other 409 brand products are not effective in killing NZM.

- Evaluate inclusion of NZM within the invasive species lists in 58 Pa. Code §71.6 and §73.1.

- Encourage the incident reporting of aquatic invasive/nuisance species such as NZM 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

- Keep informed with research concerning the use of biological/chemical controls (see Rapid Response Options below).

Rapid Response Options:

- Several physical or chemical treatment options have been evaluated for killing or preventing the dispersal of NZM within fish hatcheries; however, these are largely ineffective against NZM control due to the ability of this species to seal its shell during adverse chemical conditions (Oplinger et al. 2009). Copper sulfate-based treatments were recently demonstrated to be effective at eradicating NZM but required long-term (weeks) of treatment to be effective within hatchery raceways (Oliver et al. 2021). No effective methods of control appear to have been demonstrated for streams, rivers, large ponds, or lakes.

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