Species Action Plan:
Pistolgrip
(*Tritogonia verrucosa*)

Purpose: This plan provides an initial five-year blueprint for the actions needed to attain near-term and, ultimately, long-term goals for the conservation and recovery of the state endangered Pistolgrip. Given the complexity of managing and recovering this species, this plan will be continually updated to reflect progress toward the identified goals, and to incorporate new information. This SAP also includes a description of the species natural history, its distribution, and threats that have led to its rarity or imperilment.

Goals: The goal of this plan is to provide guidance for the maintenance, augmentation, and protection of extant populations of Pistolgrip in the Commonwealth and to ensure sufficient distribution and to adequately secure the species' Pennsylvania range.

Natural History

Taxonomy: Class Bivalvia, Order Unionoida, Family Unionidae (unionids), Pistolgrip (*Tritogonia verrucosa*, Rafinesque, 1820). Nomenclature follows Williams et al. (2017) et seq.

Description: Parmalee and Bogan (1998) described the Pistolgrip's shell characteristics as "solid, elongate and rhomboid in outline, rather compressed but with a distinct, elevated, and rounded posterior ridge. Shells of old males may reach a length of 160 mm, while those of females may reach 120 mm." The shell is covered in tubercles and is distinctly differentiated from similar-looking Pennsylvania species by its dark periostracum, sculpturing, and shape.

Figure 1. Pistolgrip (*Tritogonia verrucosa*), photo credit: PFBC (CM 61.3577, Mahoning River, Edinburg, PA, collected by A.E. Ortmann, 1908)

Habitat: The Pistolgrip is found in a variety of stream and river substrates including sand, gravel, and mud and may be found at variable depths (Parmalee and Bogan 1998). Watters et al. (2009) indicated that the Pistolgrip occupies streams with high water quality and can be found on top of the substrate, or unburied, near the water's edge during the summer. PFBC staff have similarly noted gravid female mussels on top of the substrate surface from late April to June.

Life History: Pistolgrip longevity in Pennsylvania is unknown. The maximum age of Pistolgrip in the upper Ohio River basin can exceed 10 years (Watters et al. 2009) although greater longevity has been observed in southern populations (e.g., Sipsey River, Alabama females 21 years, males 37 years; Haag and Rypel 2010). The Pistolgrip is a short-term brooder (tachytictic) and releases its glochidia (larvae) during the late spring / early summer (Hove et al. 2011; PFBC unpublished data). Hove et al. (2011) documented the Flathead Catfish (*Pylodictis olivaris*) as the primary host for the Pistolgrip. Other, more pelagic members of the catfish family (Yellow Bullhead, *Ameiurus natalis*; Brown Bullhead, *A. nebulosus*) are documented secondary hosts. The Pistolgrip diet is unknown, but presumed to be bacteria, detritus, phytoplankton, and zooplankton.

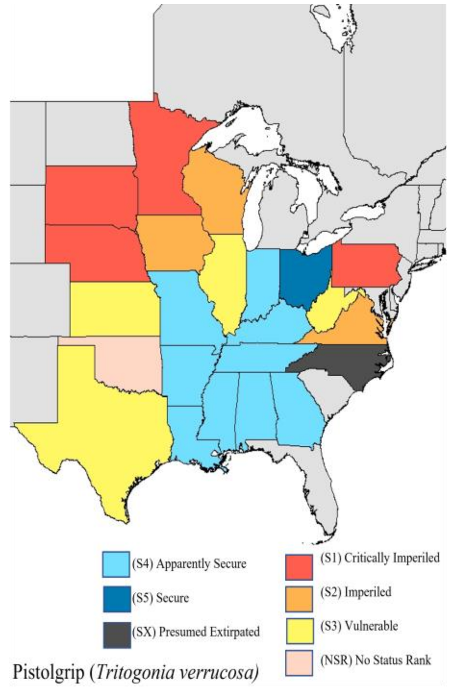

Figure 2. Pistolgrip national range and conservation status

Distribution and Status

National Distribution: The Pistolgrip is restricted to North American streams and rivers in the Great Lakes, Mississippi, and Ohio River basins of the following states: Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin (NatureServe 2022) (Figure 2).

Pennsylvania Distribution: Ortmann (1919) reported this species from the following Pennsylvania streams and rivers: Ohio River, Beaver River, Mahoning River, Shenango River, Pymatuning Creek, Allegheny River, Monongahela River, and Dunkard Creek (Figure 3).

The Pistolgrip occurred in Dunkard Creek prior to a 2009 toxic event, which destroyed the Dunkard Creek mussel fauna (Zeto 1982; Wood 1994; PFBC unpublished data). Presently, the only known extant Pistolgrip populations occur in the Shenango River (Nelson and Villella 2010) and the Ohio River (Bogan and Locy 2014).

Pennsylvania Legal Status: Endangered (58 Pa. Code §75.1).

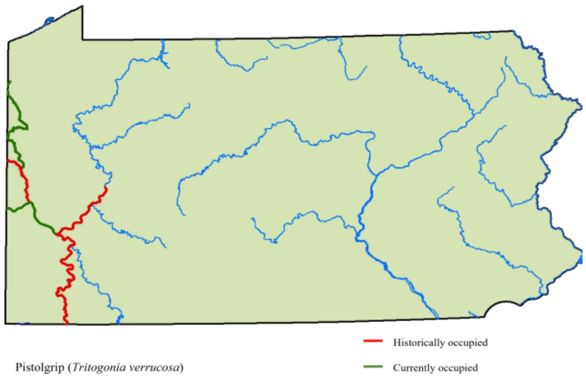

Figure 3. Pistolgrip historic and extant occupied watersheds in Pennsylvania.

State Rank: S1 – Critically Imperiled (assessed 2014)

Global Status: G4G5 – Apparently Secure / Secure (assessed 2009)

The Pistolgrip will be considered for delisting when 80% of the historically occupied streams contain three distinct naturally reproduced year classes (PABS Bivalve Committee listing criteria) and a minimum number of individuals in each stream. A minimum number will be determined after analysis of occupied streams. Historical populations can include yet-undiscovered populations. Populations that contain at least three distinct year classes and a minimum number of individuals will be considered viable. A viable population is defined as a naturally reproducing population large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural environmental changes (Soule 1980).

Management Status

The Shenango River, Ohio River, Allegheny River, and Dunkard Creek have all been surveyed within the past 25 years although, due to its size and extent, the Ohio and Allegheny rivers within Pennsylvania remain relatively unexplored compared to other streams such as the Shenango River and Dunkard Creek.

Population trends:
In the absence of other information, the status of the Shenango River population is presumed stable. The status of the Ohio River population is unknown, with only two observations (2013, 2018) since Ortmann's surveys of the early 1900s. The Allegheny River population was augmented in 2022. The Dunkard Creek mussel population was destroyed by a 2009 toxic event and augmented in 2022 with propagated juveniles. Contemporary surveys are needed at these streams to determine population trends.

Threats

Historical threats have resulted in a decline of Pennsylvania's Pistolgrip populations, e.g., Ortmann (1909). Due to the historical and recent distribution of Pistolgrip over a broad swath of western Pennsylvania's landscape, qualitative uncertainty ranges were used to measure the scope of threats facing this species. The following broad threats categories follow Salafsky et al. (2008). Existing and possible future threats to the Pistolgrip include the following:

1) Agriculture and aquaculture:
   Non-point source pollution from agricultural activities, particularly the introduction of nitrogen and phosphorus that contribute to stream and river eutrophication and sedimentation, has the potential to adversely affect mussel habitat or alter biological functioning within the stream or river. Sediment can clog the gills of mussels, affect filter-feeding of mussels, and decouple host fish from mussels during critical life stages (see Brim Box and Mossa 1999). For example, excessive sedimentation may reduce visibility of Pistolgrip's mantle lure or displays that facilitate an ictalurid's detection of gravid females.

2) Energy production and mining:
   Commercial sand and gravel dredging and navigational channel maintenance dredging activities in the Allegheny and Ohio River have historically resulted in the wholesale physical removal and loss of river habitat available for both the Pistolgrip and their Flathead Catfish hosts. Mining activities in the Dunkard Creek watershed, particularly near its confluence with the Monongahela River, may contribute to or limit host fish movement into and out of Dunkard Creek (Milavec 2009).
3) Transportation and service corridors
   a. Roads and railroads: Bridge projects on streams and rivers with Pistolgrip populations (e.g., Shenango and Ohio rivers) may result in temporary or permanent habitat alteration, mussel mortality via direct impacts (e.g., crushing) or indirect impacts (e.g., sediment deposition), and mortality associated with relocating mussels out of harm's way.
   b. Utility and service lines: the threats associated with pipeline crossings could be locally severe; however, severity is reduced when stream crossings are accomplished using directional boring methods. Directional boring is preferred where feasible despite some risk of bentonite spills associated with directional bores. These inadvertent returns can result in smothering of mussels or the choking of interstitial spaces or Flathead Catfish habitat. Consultations for other state and federally threatened and endangered species in Pistolgrip-inhabited portions of the Shenango River may also help limit or reduce the potential

adverse effects of river crossings on freshwater mussels.

4) Natural systems modifications- Dams and water management/use**:** There are multiple flood control and navigational locks and dams within the Pistolgrip's historical and extant range. Dams block mussel population movement and natural recovery of the species. Depending upon management objectives, Pistolgrip may be vulnerable to or benefit from changes to existing dam operations that may affect this species.

   Extant populations of Pistolgrip occupy the Allegheny and Ohio River navigational pools at low abundance. Maintenance dredging for the approaches to these locks, hydropower facilities placed on these dams, and the risk of outright failure of the locks and dams are ongoing threats to the persistence of this species and limit species recovery. Hydropower facilities alter the river's flow patterns and affect the best available Pistolgrip habitat that remains in the upper portion of each navigational pool. Hydropower facilities alter the previous run-of-the-river function of these locks and dams by constricting flows to one side of the river causing downstream scour on one side and fine particle deposition on the other. Previously, water flowed evenly across the top of these run-of-the-river dams providing uniform potential mussel habitat in the pool downstream of the dam.

5) Invasives and other problematic species and genes
   a. Invasive non-native/alien species**:** French Creek and tributary populations are at risk due to the spread of the non-native, molluscivorous Round Goby (*Neogobius melanostomus*) (Clark et al. 2022). The extent or magnitude of this threat is still under study and may represent a threat to species recovery in the Allegheny and Ohio rivers. There are presently no known occurrences of the Round Goby (*Neogobius melanostomus*) in the Shenango River; however, there is a risk of the spread of the Round Goby by anglers from the Lake Erie watershed, which abuts the Shenango River drainage. The correlation between North American enigmatic mussel declines and the non-native Asian Clam (*Corbicula fluminea*), is also under study. The combined effects of increased salinity and the invasive Golden Algae (*Prymnesium parvum*) has had a deadly effect on the Dunkard Creek mussel population. The well-documented adverse effects of dreissenid mussels (e.g., Zebra Mussel, *Dreissena polymorpha*) continue to be a concern throughout large river or slow-moving portions of the Pistolgrip's historical and extant range.
   b. Problematic native species**:** The extent to which freshwater mussels, including Pistolgrip, are

vulnerable to native molluscan and non-molluscan diseases or pathogens is becoming better known (e.g., Richard et al. 2022).

6) Pollution
   a. Industrial and military effluents:
      Risks associated with industrial accidents or spills exist although the scope and severity of this particular risk is unpredictable. A single catastrophic pollution event could destroy a Pennsylvania stream or river population. Mussels in general are particularly vulnerable to pH alterations, sodium, chlorides, ammonia, nickel, and other constituents with varying life stages (e.g., glochidia, juveniles) being particularly sensitive. The scope and severity of these constituents may vary throughout the Pistolgrip's range depending upon the nature of the effluent.
   b. Agricultural and forestry effluents:
      Increased sedimentation remains a threat to mussels, host fish, substrate integrity, and overall water quality. Mussels that depend upon direct interactions with the host, or the host and their conglutinates, risk being decoupled during this critical life stage. Host fish that rely on clean swept substrates for critical life stages are also at risk in streams that suffer from excess sedimentation.
7) Climate change and severe weather:
   a. Habitat shifting and alteration
      Major shifts or alteration of water quantity, quality, and temperature can have severe effects on freshwater mussels (PFBC 2022). Abnormally high or low flows that disrupt mussel reproduction at key periods, such as fertilization and glochidia release, are likely to decouple male-female gamete interactions or result in host fish behavioral changes that decouple the transfer of larvae to hosts. Habitat alterations are anticipated with predicted increasing storm intensities and associated flooding or via fluctuations in wetted widths associated with drought conditions. These oscillations are likely to result in increased channel instability and bank failure contributing to habitat loss or degradation.
   c. Droughts:
      As aquatic animals, mussels are extremely sensitive to drought conditions which lower water levels, dewater formerly wetted channels, desiccate mussels, increase water temperatures, occlude mussels, and contribute knock-on effects such as toxicity via low dissolved oxygen levels, elevated temperatures, and concentrated pollutants.
   d. Temperature extremes:
      Extreme temperatures are anticipated to have a direct effect on freshwater mussel communities (e.g., Galbraith and Vaughn 2010). Mussels rely on thermal cues for feeding and reproduction and disruptions to these cues can result in decreased fecundity, brood abortion, increased

parasite loads, or asynchronous timing of larval release with the presence of obligate host fish (PFBC 2022).

8) Policy
   Climate change policy that calls for drainage "improvement" or flood control measures have the potential to further altered flow patterns during the year, (flooding and drought), contribute to stream bank failure and riverbed destabilization, erratic temperatures, and perhaps demands to alter reservoir flow discharges to maintain downstream sport fisheries needs in direct competition with endangered species management.

Conservation and Recovery

Conservation and Recovery Goal: The goal of this plan is to implement actions that maintain, augment, protect, and enhance extant populations of Pistolgrip in the Commonwealth and ensure sufficient distribution to adequately secure the species and allow its removal from the Pennsylvania list of endangered, threatened and candidate species (58 Pa. Code §75.1). The location of PFBC's Union City Aquatic Conservation Center's mussel propagation facility to brood stock sources may allow PFBC to actively restore Pistolgrip populations via population augmentations.

In general, PFBC encourages the use of the online Pennsylvania Conservation Explorer environmental review tool and Conservation Opportunity Areas tool to restore degraded habitats and facilitate watershed-level water quality enhancements. Habitat conservation and protection in the form of riparian restoration via tree-plantings, land acquisition, or easements are encouraged; however, instream habitat management for Pistolgrip – unless Flathead Catfish oriented – is generally discouraged.

Shenango River

1) Protect, conserve, and enhance existing Pistolgrip population between Pymatuning Reservoir Dam and Shenango River Lake and from Sharpsville downstream to Sharon
   a. Manage Shenango River flows from Pymatuning Dam to benefit the species
   b. Provide Pennsylvania Department of Conservation of Natural Resources (DCNR) with minimum streamflow recommendations.
2) Continue to gather baseline information
   a. Characterize Pistolgrip populations
   b. Collect the following quantitative population demographic information:
      i. Age structure (e.g., shell thin-sectioning)
      ii. Shell lengths
      iii. Determine specific gravidity period, ratio of gravid/nongravid individuals using non-lethal methods
      iv. Number of individuals/sex-ratio
      v. Collect non-lethal genetic samples
      vi. Density
   c. Quantitatively and qualitatively characterize physical habitat
      i. Measure streamflow, water chemistry at known locations
   d. Characterize host (Flathead Catfish) population

Dunkard Creek

1) Restore Dunkard Creek Pistolgrip population
   a. Continue implementing PFBC Dunkard Creek mussel restoration plan
   b. Restore native mussel community, including Pistolgrip (see *Long-term Monitoring*, below)
   c. Maintain water volume and flow
      i. Work with USEPA, PADEP, WVDEP and WVDNR to develop flow recommendations that are protective of the Dunkard Creek mussel population
2) Ensure protection from pollution and invasive species
   a. Work with partners to monitor TDS and osmotic pressure
   b. Work and communicate with partners to monitor golden algae (*Prymnesium parvum*) levels in Dunkard Creek including sampling for residual spores, as feasible

Allegheny and Ohio River

1) Protect, conserve, and enhance the Allegheny and Ohio River populations,
   a. Gather baseline quantitative information
      i. Conduct comprehensive surveys in area where Pistolgrip observed
      ii. Characterize Pistolgrip population
      iii. Collect the following quantitative population demographic information:
         a. Age structure (e.g., shell thin-sectioning)
         b. Shell lengths
         c. Determine gravidity period for Pennsylvania
         d. Ratio of gravid/nongravid (using non-lethal methods)
         e. Number of individuals
         f. Density, if practical

Beaver River

1) Conduct additional surveys for Pistolgrip and Flathead Catfish
2) Consider potential for fishways around dams or dam removal

Long-term Monitoring

1) Begin long-term monitoring of Shenango and Allegheny River populations
2) Establish sentinel monitoring sites to provide population trend information

Threat Mitigation

1) Identify and mitigate microscope threats to Pistolgrip (e.g., disease, pathogens)
2) Conduct DNA testing to address genetic concerns
3) Maintain existing habitats and facilitate genetic connectivity, where feasible

Propagation, Augmentation, Reintroduction, and Habitat Restoration

1) Propagation
   a. Determine feasibility of establishing a Pistolgrip propagation program at PFBC's Union City Aquatic Conservation Center
   b. Develop Pistolgrip propagation techniques
2) Augmentation

   a. Augment Ohio and Allegheny rivers
   b. Restore Dunkard Creek populations
3) Reintroductions
   a. Due to the general widespread nature of the host fish (Flathead Catfish), PFBC does not anticipate the need for a reintroduction program at this time. Natural dispersal via host fishes is eventually anticipated to other streams within the species historical range.
4) Habitat Restoration
   a. Using existing data and tools (e.g., Conservation Opportunity Areas tool), identify areas where habitat restoration efforts would benefit Pistolgrip
   b. Determine need for creating spawning/nesting habitats for Flathead Catfish.

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