

Requested information on the Pennsylvania distribution, status, and threats to the Salamander Mussel (*Simpsonaias ambigua*) and its host, the Mudpuppy (*Necturus maculosus*) for the U.S. Fish and Wildlife Service's Species Status Assessment.

Prepared for:

Jessica Pruden
U.S. Fish and Wildlife Service
Michigan Ecological Services Field Office
East Lansing, MI

Prepared by:

Nevin Welte
Pennsylvania Fish and Boat Commission
Natural Diversity Section
Centre Regional Office
Bellefonte, PA

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The following is an up-to-date summary of Pennsylvania Salamander Mussel (*Simpsonaias ambigua*) distribution, biology, and regulatory status, along with stream-specific statuses and threats.

Pennsylvania distribution

The distribution of the Salamander Mussel (*Simpsonaias ambigua*) in Pennsylvania has recently been reviewed and summarized by Bogan and Locy (2009) and updated by Schwegman and Welte (2019). Arnold Ortmann's baseline freshwater mussel surveys in the early 1900s did not detect Salamander Mussels in Pennsylvania despite having "hunted for it in vain" but he surmised that "...it might have once existed here, or else it accidentally may have escaped detection" (1919; p. 136-137). Pennsylvania's first known Salamander Mussel records appear in 1969 from the Allegheny River (Bogan and Locy 2009) but given the species' habitat (beneath shelter rocks), the Salamander Mussel may have always existed in the Pennsylvania portion of the Ohio River basin.

Currently, extant occurrences are known from the Allegheny River navigational pools (3 – 8), French Creek, and Cussewago Creek (a tributary to French Creek) (Bogan and Locy 2009; Schwegman and Welte 2019). Salamander Mussels were known from Dunkard Creek, but a toxic event destroyed the Dunkard mussel population in 2009 (PFBC 2010). Conneaut Creek (Lake Erie drainage) has an occurrence in Ohio less than 1 km from the Pennsylvania border, although this species has not been detected in the Pennsylvania portion of Conneaut Creek despite recent survey efforts (WPC 2011, unpublished data; PFBC 2018, unpublished data).

Notes on biology and habitat

The specific gravid period for Pennsylvania's Salamander Mussels is unknown, but gravid females were collected from the Allegheny River on May 7, 2019 (David Foltz, personal communication).

The majority of Pennsylvania's Salamander Mussel habitat is associated with structure, typically shelter or slab rock habitat suitable for both the Salamander Mussel and its host, the Common Mudpuppy (*Necturus maculosus*: hereinafter referred to as "Mudpuppy"). Salamander Mussels have been observed under rocks that were safely overturned by surveyors, so there may be larger shelter rock features that have been under-surveyed for Salamander Mussels. Salamander Mussels have also been observed beneath artificial structures, as noted by the presence of four individuals under a manhole cover in French Creek (Schwegman and Welte 2019) and a Salamander Mussel observed beneath an artificial Mudpuppy "hut" structure placed into Allegheny River Pool 5 (Doug Locy, personal communication).

In the navigational pools of the Allegheny River, the primary habitat beneath these shelter rocks is described as a silty-clayey substrate with a "cake-like" consistency (Doug Locy, personal communication). Similar fine silt and clay substrates were observed beneath shelter structures in French and Cussewago creeks (Schwegman and Welte 2019). Elsewhere in the Allegheny River navigational pools Salamander Mussels have been observed under rocks with clean swept gravel (Pool 7) and in the absence of a shelter rock in a bed of water willow (*Justicia americana*) (Pool 7; Doug Locy, personal communication).

Regulatory status

The Salamander Mussel was initially proposed for state listing in 2008 along with four other mussel species (38 Pennsylvania Bulletin (Pa.B). 6617). After extensive public comments (39 Pa.B. 1074) the listing of two species, Salamander Mussel and Rayed Bean (*Villosa fabalis*) were deferred pending additional survey information (for Rayed Bean) and negotiations with the regulated community (i.e., commercial sand and gravel dredging industry) regarding Salamander Mussel (39 Pa.B. 3442).

The 2009 negotiations with the sand and gravel dredging industry led to development of a “Pre-dredging Protocol for Sampling and Relocating Live Salamander Mussels July 2009,” which established numeric Salamander Mussel “triggers” in which dredging could be authorized, authorized with relocation, or not authorized (39 Pa.B. 5031). Upon completion of these negotiations and the establishment of the above-referenced protocol, the Salamander Mussel was listed as state endangered in January 2010 (40 Pa.B. 620).

Current regulatory protection

Like other Pennsylvania state-listed species, Salamander Mussel occurrence records are included in the Pennsylvania Natural Diversity Inventory (PNDI) environmental review system. The Salamander Mussel’s presence in Pennsylvania occasionally generates conflicts with proposed development projects and triggers the need to avoid, minimize, or mitigate for projects that may directly impact the species. The PFBC has developed a biological opinion process in which PFBC authorizes incidental take under certain circumstances (i.e., instances where take cannot be avoided). The following projects have been recently permitted by PFBC, via a biological opinion and issuance of a Special Permit for taking a limited number of Salamander Mussels: a bridge replacement over French Creek (Cambridge Springs; PFBC 2019), a proposed discharge pipe to the Allegheny River Pool 6 (PPG; PFBC 2019), and Allegheny River maintenance dredging (U.S. Army Corps of Engineers (USACE); PFBC 2018). All three PFBC biological opinions included avoidance and minimization measures (e.g., standard best management practices, erosion and sedimentation controls, etc.) and a requirement to conduct pre-construction mussel salvages.

The Salamander Mussel host, the Mudpuppy, has no state or federal protected status, although the Pennsylvania Biological Survey has ranked it as Vulnerable (S3) and the species is included in the State Wildlife Action Plan as a Species of Greatest Conservation Need (PGC-PFBC 2015, p. 687).

There are currently no state provisions for designating critical habitat for state-listed species or for establishing permanent, i.e., in perpetuity, set-aside areas for the protection of aquatic organisms.

Pennsylvania species recovery status

A PFBC Species Action Plan was prepared and published for Salamander Mussel in 2015 (PFBC 2015). This plan outlines initial steps for species recovery and habitat restoration. The following subheadings describe some recent conservation and recovery actions undertaken towards meeting the objectives outlined in the 2015 Species Action Plan:

Assessment

To date, three Pennsylvania Department of Conservation of Natural Resources (DCNR) Wild Resources Conservation Program grants have been awarded to the Western Pennsylvania Conservancy (WPC) and the Mid-Atlantic Center for Herpetology and Conservation (MACHAC) to begin gathering baseline data that will help implement PFBC’s Species Action Plan. The two WPC grants were designed to assist PFBC in determining the status and distribution of the Mudpuppy in the navigable Allegheny and Ohio rivers and to document new occurrences of Salamander Mussels using acquired Mudpuppy occurrence data. The MACHAC grant focused more broadly on the distribution of Mudpuppies in Pennsylvania.

Propagation

Circa 2015 – 2016, the Pennsylvania Department of Environmental Protection (PADEP) directed commercial sand and gravel mitigation monies to the U.S. Fish and Wildlife Service’s (USFWS) White Sulphur Springs National Fish Hatchery (WSSNFH) to rear Salamander Mussels for Dunkard Creek

recovery efforts. The Salamander Mussel effort was substantial and consisted of ~20 total Mudpuppies being trapped from the Allegheny and Ohio rivers by WPC and transported to WSSNFH in the spring and fall of 2018 and again in the spring 2019. Twelve Salamander Mussels were collected on May 7, 2019 from Allegheny River Pool 5 by Environmental Solutions and Innovations, Inc. under contract to USFWS to provide broodstock for the WSSNFH propagation efforts (David Foltz, personal communication). Ten of these mussels, ranging in length from 22.5 – 37.3 mm, were sent to WSSNFH and the remaining two were returned to the river due to their small size (David Foltz, personal communication). Some of the mussels were gravid females but others had a very thin shell and were not checked (David Foltz, personal communication). Unfortunately, no propagation of these mussels occurred, and these mussels died in captivity. This propagation effort, while unsuccessful, demonstrates some of the inherent challenges associated with the culture and production of Salamander Mussels.

PFBC's Union City State Fish Hatchery (UC), located in the French Creek watershed, has undergone major renovations (2019 – 2020) while converting part of the hatchery into a mussel propagation hatchery. The focus of the mussel hatchery will be on Ohio River basin species conservation and stream and river restoration. Currently there are four species on station (~1,800 mussels total) with initial *Lampsilis* production trials slated for February 2020. The initial focus of the hatchery will be the propagation and production of mussel species lost from Dunkard Creek, including Salamander Mussel. UC Salamander Mussel propagation activities are not anticipated in 2020 but may commence in 2021 or in subsequent years.

Artificial Salamander Mussel habitats

Hanson Aggregates, in 2018 (PADEP E02-1752), agreed to conduct a Salamander Mussel study in the Allegheny River (Pool 5) as part of mitigation for their commercial sand and gravel dredging activities in the Ohio River's Dashields Pool. Doug Locy (Aquatic Systems), is leading this mitigation project which includes the construction, placement, and monitoring and comparison of artificial habitats ("huts") and natural rock structures to determine whether Mudpuppies and Salamander Mussels will use these structures. These structures were monitored one-year post-placement (structures placed in 2018, monitored in 2019) and one live Salamander Mussel was observed under an artificial structure (Doug Locy, personal communication – see Appendix). No Mudpuppies were observed, but silt may have obscured escaping Mudpuppies during monitoring (Doug Locy, personal communication, report pending). Additional monitoring of these structures will continue.

Bathymetric mapping

In June 2019 PFBC and PADEP reached out the U.S. Environmental Protection Agency (Region 3) for assistance in developing fine resolution side scan sonar imaging of the navigable Ohio and Allegheny rivers. This information, when collected, will help PFBC ascertain the amount of potential Mudpuppy habitat in the rivers and allow PFBC to: 1) refine methodology for selecting potential Salamander Mussel stocking sites using PADEP- and PFBC-reared mussels, and 2) conduct spot check dives for the presence of Salamander Mussels and their hosts. Given downriver Ohio River Salamander Mussel occurrences (e.g., Morrison 2012), PFBC seeks to determine the extent of available and potentially available Salamander Mussel and Mudpuppy habitat and restore, if possible, habitat and connectivity between Allegheny and Ohio River Salamander Mussel populations.

Status and threats to known occurrences

Allegheny River status

The status of the Allegheny River population is under review but presumed stable pending additional survey information. Currently, Salamander Mussels are known from Allegheny River pools 3 – 8 (Bogan and Locy 2009; Lewis Environmental Consulting 2016). Lewis Environmental Consulting (2016) expanded the Salamander Mussel's extant distribution in the Allegheny River navigational pools downstream to include Pool 3. Mudpuppies have been confirmed from Allegheny River pools 4 – 6 (Ryan Miller, unpublished data), and from Pittsburgh to Kinzua dam and generally throughout the Ohio River basin (Brandon Ruhe, personal communication).

Allegheny River threats

Other than stochastic events, the Allegheny River continues to be at long-term risk for resumption of commercial sand and gravel dredging (see Appendix for a brief permitting history). Commercial sand and gravel dredging involves the wholesale removal of multiple feet of sand and gravel from the river bottom (up to 50-60 feet in substrate depth; Rick Spear, personal communication). Dredged navigational pools in Pennsylvania generally remain in their altered state because they have few natural sources of sand and gravel replenishment and substrate movement or redistribution is restricted by nine locks and dams on the Allegheny River and three locks and dams on the Ohio River. With few exceptions (e.g., portions of Pools 8 and 9), all the navigational pools in the Allegheny have been extensively dredged. Some habitat in these pools remains protected by regulatory buffers that protect islands, buried utility lines, pipelines, bridges, water intakes, etc.

Habitat alterations in dredged areas appear to have an affect on fish populations due to shifts in water flow, nutrient dynamics, and sediment flow that resulted after flows were diverted away from the banks and towards the center of the river (Freedman 2010, 2012). Decoupling of mussels and their host fish – or Mudpuppies - would also be anticipated after riverine habitats were altered. No studies have been conducted to compare the pre- and post-dredging mussel communities.

Maintenance of lock and dams have led to unintentional dewatering of the Emsworth (“Pittsburgh”) Pool (Welte and Urban 2019) and future maintenance – or lock and dam failure – carry risks for Salamander Mussels in the form of direct mortality or habitat alteration. Presently there are no commercial lockages upstream of Allegheny River Lock and Dam (L&D) 4 and USACE operates the upstream locks and dams (i.e., L&Ds 5 – 9) by appointment only. The structural condition of these locks and dams are unknown. Temporary and permanent impacts associated with construction of pipelines, bridges, sewer and industrial discharges and associated mixing zones continue to be potential threats to the persistence of Pennsylvania's Allegheny River population.

French Creek status

The status of the French Creek population is under review but presumed stable pending additional survey information. Currently, live Salamander Mussels are known from French Creek near Cambridge Springs (Schwegman and Zimmerman 2015) and from Cussewago Creek near its confluence with French Creek (Dunford 2019). Salvage work at Cambridge Springs by EnviroScience in 2019 documented 17 individuals under one 1 x 1 m rock with a total of 27 salvaged from the work area (Ryan Schwegman, personal communication; report pending).

French Creek threats

The latest threat to French Creek mussels, including Salamander Mussel, is the bait bucket introduction of the Round Goby (*Neogobius melanostomus*). This species is a known unionid molluscivore (Bradshaw-Wilson et al. 2019) and was introduced into the French Creek watershed (Lake LeBoeuf) circa 2014. Lake LeBoeuf, a natural glacial lake, drains via its outlet (LeBoeuf Creek), to French Creek. The Pennsylvania Governor's Invasive Species Council (PISC) has developed a Round Goby workgroup that consists of a variety of state, NGO, and academic aquatic biologists. This workgroup is currently focused on the assessment of the Round Goby in French Creek (and other invaded areas) and are working towards development of management options. Other general threats to French Creek mussels include excess sedimentation from agricultural practices, contaminants, and invasive species such as Zebra Mussels (*Dreissena polymorpha*) and Asian Clams (*Corbicula fluminea*) (Smith and Crabtree 2010).

Dunkard Creek status

The status of the Dunkard Creek Salamander Mussel population is presumed extirpated. A 2009 toxic event – a discharge of brine followed by an invasive golden algae bloom (*Prymnesium parvum*) – destroyed the Dunkard Creek freshwater mussel population (PFBC 2010). The last known live Salamander Mussel was observed October 3, 2008 (PFBC, unpublished data; see Appendix). In addition to freshwater mussels, the 2009 Dunkard Creek aquatic life kill included an estimated 6,447 Mudpuppies (PFBC 2010).

PFBC settled with Murray Energy in 2015. Since then, PFBC has developed an internal Dunkard Creek mussel restoration plan and PFBC and its partners have been conducting Dunkard Creek restoration efforts. To date, nearly 15,000 mussels salvaged from Allegheny River projects or propagated by WSSNFH have been stocked into Pennsylvania's portion of Dunkard Creek. No Salamander Mussels have been stocked. The initial goal is to stock and establish a community of common mussel species and augment host species (e.g., Mudpuppy; Flathead Catfish, *Pylodictis olivaris* (host for Pistolgrip *Tritogonia verrucosa*) prior to reintroducing or augmenting state endangered species (e.g., Salamander Mussel, Pistolgrip) or federally endangered species (Snuffbox, *Epioblasma triquetra*) (PFBC unpublished data).

PFBC surveyed Dunkard Creek for Mudpuppy during 2016 and 2018 to assess the status of population. These surveys resulted in the detection of one Mudpuppy in the Pennsylvania Fork of Dunkard Creek and one Mudpuppy in the Dunkard Creek mainstem, a male collected near the confluence of Little Shannon Run. No other Dunkard Creek Mudpuppy trapping efforts, including those by West Virginia Department of Natural Resources, have documented Mudpuppy occurrences (Mike Everhart, email dated January 7, 2020). PFBC plans to augment the Dunkard Creek Mudpuppy population via trap-and-transfer from the Monongahela River starting in 2020.

Dunkard Creek threats

The recovery of Dunkard Creek continues to be limited, in part, by historical mining degradation near Dunkard Creek's confluence with the Monongahela River (see Milacevic 2009). This pollution barrier remains a potential obstacle for the dispersal of some host fish (e.g., Flathead Catfish, *Pylodictis olivaris*) and Mudpuppies that could potentially move from the Monongahela back into Dunkard Creek. Mudpuppies are known to be extant in the Monongahela River (PA Amphibian and Reptile Survey, unpublished data).

The treatment and removal of water from the Dunkard Creek watershed following the 2009 pollution event has the potential to exacerbate poor water quality conditions given the creek's already low gradient nature. The Blacksville #2 mine formerly pumped mine water into the West Virginia Fork of Dunkard Creek, but now this water is being pumped, treated, and then released into the Buffalo Creek watershed (in Marion County, West Virginia). The short- and long-term ramifications of this decision are unknown but may render the mussel and Mudpuppy population in an already low gradient stream more susceptible to dissolved oxygen swings, occlusion, desiccation, further golden algae blooms, or other adverse effects associated with water management or global climate change (see Galbraith and Vaughn 2010).

Conneaut Creek status

The status of the Conneaut Creek Salamander Mussel population in general (e.g., Ohio) is unknown. There are no known records of Salamander Mussel from Pennsylvania's portion of Conneaut Creek, despite recent surveys (WPC 2011, unpublished data; PFBC 2018, unpublished data). Additional mussel survey work in Pennsylvania's portion of the creek is anticipated in 2020. Mudpuppies are known to be present in Conneaut Creek although no Pennsylvania Mudpuppy population-level data is available. Recent trapping efforts by MACHAC on Conneaut Creek did not detect mudpuppies; however, dead mudpuppies were observed by PADEP following a 2018 3-trifluoromethol-4-nitrophenol (TFM) kill (Brancato 2018).

Conneaut Creek threats

The continued application of lampricide to this Lake Erie tributary by USFWS is likely to depress populations of both the Salamander Mussel and its host, the Mudpuppy (Brancato 2018; Matson 1990, 2013). The spring timing of TFM application approximately coincides with the discharge and inoculation of Mudpuppies by Salamander Mussel glochidia (note gravid Pennsylvania mussels collected in May 2019). TFM applied prior or immediately after to Mudpuppy inoculation may result in direct mortality or a poor Salamander Mussel recruiting class. Adverse effects associated with TFM would be expected along the entire stream length in both Pennsylvania and Ohio. Continued USFWS TFM application and mussel and Mudpuppy non-target mortality is likely to conflict with any USFWS species conservation goals set for Great Lakes populations of Salamander Mussel or result in inadequate regulatory protection by USFWS under the Endangered Species Act.

Miscellaneous notes

Recovery potential in the Ohio River

The Ohio River in Pennsylvania harbors Mudpuppies and shelter rock habitat throughout the watershed, but Salamander Mussel habitat appears to be limited, in part, due to the presence and extensive coverage of the river bottom by Zebra Mussels (Ryan Miller, personal communication). The water quality and species recovery of the Ohio River makes this river a candidate for future Salamander Mussel recovery efforts. Not unlike the Allegheny River, threats such as Zebra Mussels, potential invasion of molluscivorous non-native fishes (e.g., Black Carp, *Mylopharyngodon piceus*), combined with existing and continued commercial sand and gravel dredging operations in the Ohio River in both West Virginia and Pennsylvania may limit or be threats to the Salamander Mussel dispersal or recovery.

303(d) impaired waters

USFWS should consider Clean Water Act 303(d) impaired waters and reason for impairments of various known Salamander Mussel streams.

Summary

The Salamander Mussel is an exceedingly rare freshwater mussel in Pennsylvania. As an example of its rarity, the known occurrences in French Creek range from a single shell specimen collected in 1985 and 1995 (both Charles Bier, WPC) to multiple live animals collected in 2015. The other populations are highly fragmented (e.g., French Creek, Allegheny River pool 6, Dunkard Creek), and may suffer from genetic isolation, further hampering recovery efforts.

The threats to the Salamander Mussels in Pennsylvania are considerable and range in severity from probable extirpation (e.g., Dunkard Creek), recent habitat destruction by commercial sand and gravel dredging operations (Allegheny River), to potential non-targeted mortality in Conneaut Creek. The French Creek and Cussewago are probably the least vulnerable to human perturbations, but the French Creek population is currently under new threat by the molluscivorous Round Goby.

Acknowledgements

Thanks to Rick Spear and Jamie Detweiler (PADEP) for review, providing a permitting history of dredging in the Allegheny and Ohio Rivers, and for providing an update on current permits and permit conditions. Thanks to Doug Locy for providing an update on the status of Salamander Mussel mitigation project in the Allegheny River and for his photos and descriptions of Allegheny River Salamander Mussel habitat. Thanks to Ryan Schwegman for updated information on French Creek occurrences of Salamander Mussel. Thanks to Ryan Miller for updated information on the distribution of Mudpuppies in the Ohio and Allegheny rivers and for his observations of Salamander Mussel habitat at trapping locations. Thanks to David Foltz for providing additional information regarding the Salamander Mussel brood stock collection effort. Thanks to Chris Urban and Kathy Gipe (PFBC) for their review and for providing comments and edits.

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Contact information

Doug Locy

Aquatic Systems, Inc.
4621 Baptist Road
Pittsburgh, PA 15227
Phone: (412) 427-2758
Email: aquatic.systems@comcast.net

David Foltz

Environmental Solutions & Innovations, Inc.
1341 Old Freedom Road, Suite 202
Cranberry Township, PA 16066
Phone: (304) 479-3268
Email: dfoltz@envsi.com

Ryan Miller

Pennsylvania Natural Heritage Program
Western Pennsylvania Conservancy
800 Waterfront Drive
Pittsburgh, PA 15222
Phone: (412) 586-2348
Email: remiller@paconserve.org

Ryan Schwegman

EnviroScience, Inc.
5070 Stow Road
Stow, OH 44224
Phone: (330) 688-0111
Email: rschwegman@enviroscienceinc.com

Rick Spear

Department of Environmental Protection
Southwest Regional Office
Clean Water Program
400 Waterfront Drive
Pittsburgh, PA 15222
Phone: (412) 442-5874
E-mail: rspear@pa.gov

Nevin Welte

Pennsylvania Fish and Boat Commission
Centre Region Office
595 E. Rolling Ridge Dr.
Bellefonte, PA 16823
Phone: (412) 586-2334
Email: c-nwelte@pa.gov

Appendix 1. A brief history of recent commercial sand and gravel dredging permitting (2008 – 2018) as it relates to Pennsylvania’s Salamander Mussels.

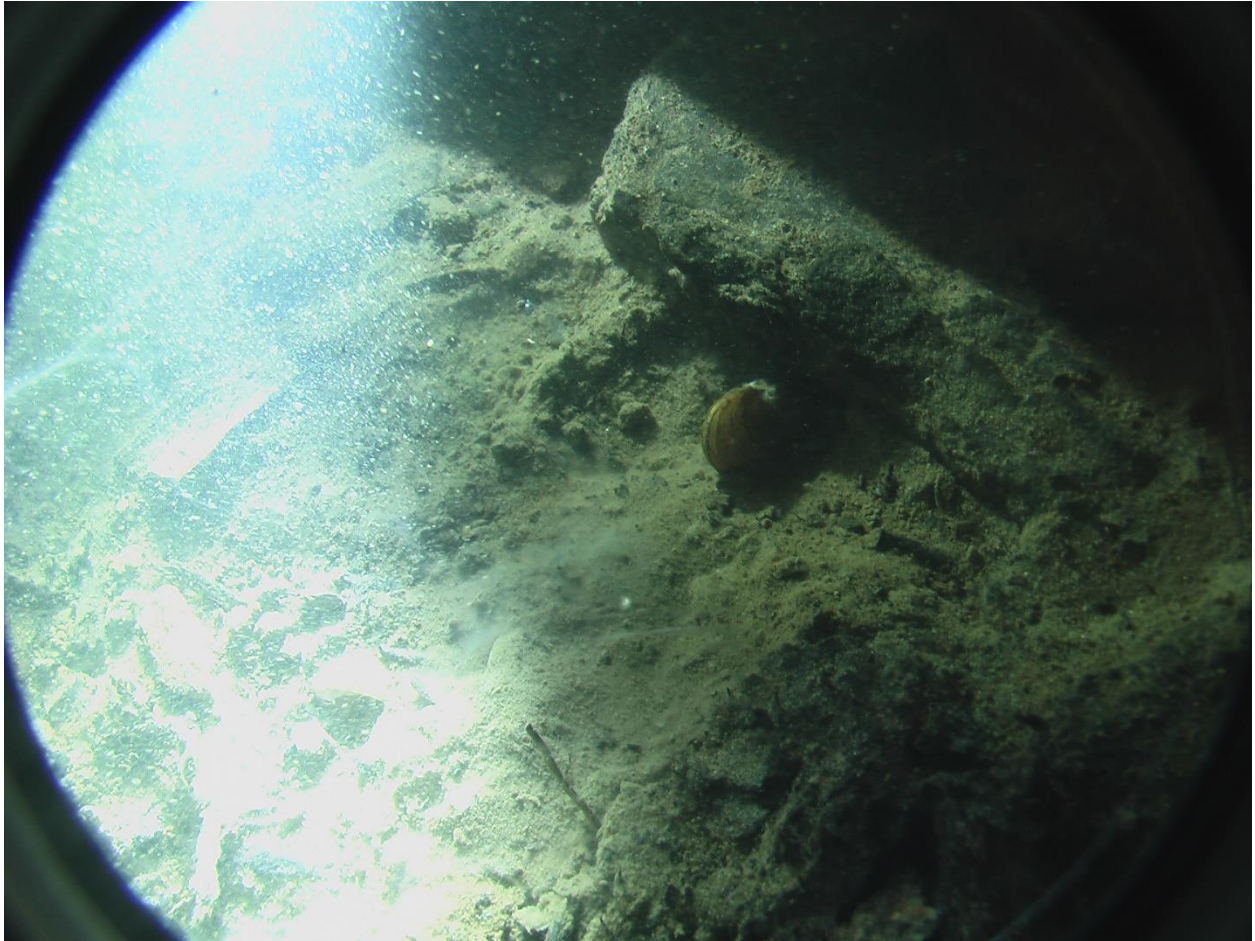
Until recently, commercial sand and gravel permitting in the Ohio and Allegheny River was conducted under an adaptive management framework led by U.S. Army Corps of Engineers (USACE) and the Pennsylvania Department of Environmental Protection (PADEP). This Adaptive Management Group (AMG) was formed in 2006 following 2005 litigation between PADEP, PFBC, and the commercial sand and gravel industry with the general purpose of allowing commercial sand and gravel dredging while avoiding damage to state and federally protected mussel and fish species.

Shortly after the Salamander Mussel became listed in 2009, one of the primary Allegheny River sand and gravel dredgers (Glacial Sand and Gravel; PADEP permit E02-1326) abandoned its Allegheny River operations (2011). Of the two remaining operators, only Hanson Aggregates operated in the Allegheny River until ~2012-2013.

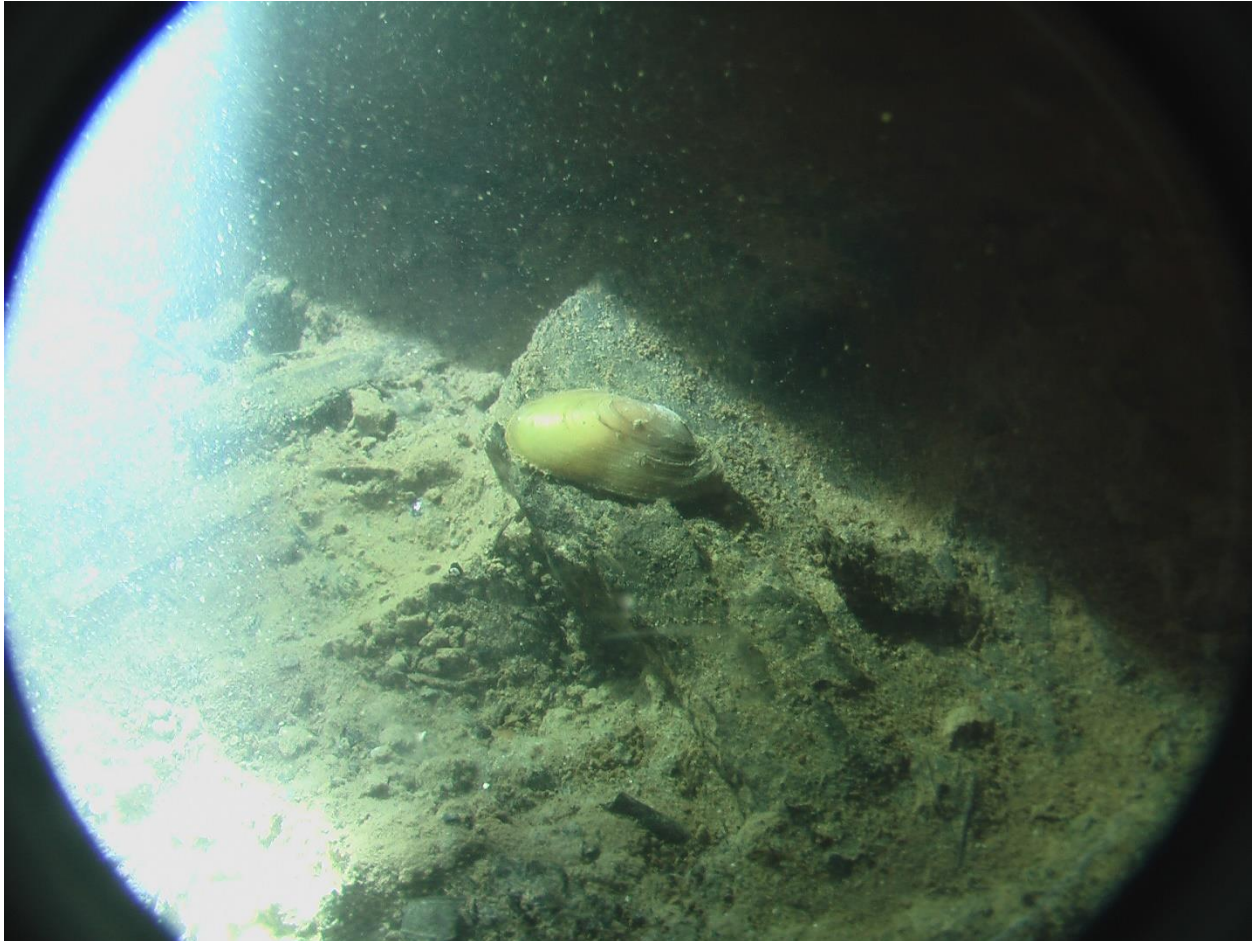
In the 2012-2016 PADEP permit cycle, Hanson Aggregates and Tri-State (Ohio River) agreed to “set-aside” or avoid dredging in the majority of the Allegheny River as an avoidance measure (Hanson finished dredging operations in Pool 5 during this permit cycle). All Allegheny River pools were “set aside” areas incorporated into the state permits that began in 2018 (PADEP E02-1752; E04-361, E04-363) and federal permits (USACE 2002-1005; 2002-1006). The state permits expire in 2023 and corresponding federal permits expire in 2029. Short of a new dredging operation, additional Allegheny River commercial sand and gravel operations are not likely prior to the 2023 or 2029 permit expiration dates. There are no known mechanisms for establishing permanent (in perpetuity) set-aside areas for freshwater mussels.

With the abandonment of the Adaptive Management Group in 2018 and the cessation of Allegheny River sand and gravel dredging operations, the former Salamander Mussel sampling protocol was replaced by the standard environmental review process.

Appendix 2. Allegheny River (Pool 5) Salamander Mussel beneath artificial shelter (Mudpuppy hut), note habitat (photo courtesy of Doug Locy).



Appendix 3. Allegheny River (Pool 5) Salamander Mussel (same mussel as Appendix 1) beneath artificial shelter (Mudpuppy hut), note habitat (photo courtesy of Doug Locy).



Appendix 4. Allegheny River (Pool 5, near Murphy's Island) two live Salamander Mussels (photo courtesy of Doug Locy).



Appendix 5. Same mussels as in Appendix 3, but different view. Allegheny River (Pool 5, near Murphy's Island) two live Salamander Mussels (photo courtesy of Doug Locy).



Appendix 6. Allegheny River (Pool 5, near Murphy's Island) live Salamander Mussels. Note presence of live Zebra Mussels (photo courtesy of Doug Locy).



Appendix 7. Dunkard Creek Salamander Mussel collected by PFBC October 3, 2008.

