Clubshell
(*Pleurobema clava*)

5-Year Review:
Summary and Evaluation

Photo credit: Kevin Cummings, Illinois Natural History Survey

2019

U.S. Fish and Wildlife Service
Pennsylvania Field Office
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5-YEAR REVIEW

Species reviewed: Clubshell (*Pleurobema clava*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Region 5, Martin Miller, 413-253-8615

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Cooperating Field Offices:

Alabama Field Office, Jeff Powell, 251-441-5858
Illinois Field Office, Kristen Lundh, 309-757-5800
Indiana Field Office, Lori Pruitt, 812-334-4261
Kentucky Field Office, Mike Floyd, 502-695-0468, x102
Michigan Field Office, Jessica Pruden, 517-351-8245
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Ohio Field Office, Angela Boyer, 614-416-8993
Tennessee Field Office, Warren Stiles, 931-525-4977
West Virginia Field Office, Barbara Douglas, 304-636-6586, x19

Cooperating Regional Offices:
Region 3, Laura Ragan, 612-713-5292
Region 4, Matthew Dekar, 404-679-4127

1.2 Methods used to complete the review

Public notice was given in the Federal Register (83 FR 39113) requesting new scientific or commercial data that have become available since the previous 5-year review was completed in 2008. Pertinent data were obtained from the previous 5-year review, from recent reports of freshwater mussel surveys, and from data submitted by U.S. Fish and Wildlife Service (Service) Field Offices and State natural resource agencies within the range of the species. This 5-year review was completed by Robert Anderson and Melinda Turner, Assistant Field Office Supervisor and Fish and Wildlife Biologist, respectively, with the Pennsylvania Ecological Services Field Office. The purpose of this 5-year review is to review new information since the last review of the species' status in 2008 and consider whether any of this information indicates that a change in the listing status of the clubshell may be warranted.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review

83 FR 39113 (August 8, 2018): Notice of Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Reviews of 19 Northeastern Species: Roseate tern (*Sterna dougallii dougallii*), Roanoke logperch (*Percina rex*), Virginia big-eared bat (*Corynorhinus* [=*plecotus*] *townsendii virginianus*), Dwarf wedgemussel (*Alasmidonta heterodon*), Northern riffleshell (*Epioblasma torulosa rangiana*), Clubshell (*Pleurobema clava*), Purple bean (*Villosa perpurpurea*), Puritan tiger beetle (*Cicindela puritana*), Northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*), Flat-spired three-toothed [=Cheat] snail (*Triodopsis platysayoides*), Chittenango ovate amber snail (*Novisuccinea chittenangoensis*), Bog turtle (*Glyptemys* [=*Clemmys*] *muhlenbergii*), Sandplain gerardia (*Agalinis acuta*), Peter's Mountain mallow (*Iliamna corei*), Furbish's lousewort (*Pedicularis furbishiae*), Northeastern bulrush (*Scirpus ancistrochaetus*), American hart's-tongue fern (*Asplenium scolopendrium* var. *americanum*), Knieskern's beaked-rush (*Rhynchospora knieskernii*), and Virginia sneezeweed (*Helenium virginicum*).

1.3.2 Listing history

Original Listing

FR notice:	58 FR 5638-5642
Date listed:	January 22, 1993
Entity listed:	Species
Classification:	Endangered, Entire Range; except where listed as Experimental Populations

1.3.3 Associated rulemakings

66 FR 32250-32264 (June 14, 2001) – Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free-Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL

1.3.4 Review History: Last 5-year review completed in 2008.

1.3.5 Species' Recovery Priority Number at start of 5-year review

Recovery Priority Number: 5 (indicating that the clubshell is taxonomically categorized as a species, has a high degree of threat, and low recovery potential)

1.3.6 Recovery Plan

Name of plan: Clubshell (*Pleurobema clava*) and Northern Riffleshell (*Epioblasma torulosa rangiana*) Recovery Plan
Date issued: September 21, 1994
Dates of previous revisions: None

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? The species is an invertebrate; therefore, the DPS policy is not applicable to this listing.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes; however, see section 2.2.3.

2.2.2 Adequacy of recovery criteria

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? No.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? No.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

1994 Recovery Plan Criteria

In order to ***reclassify*** the clubshell as threatened from endangered, this criterion must be met:

1. Viable populations must be documented in 10 separate drainages for this species. A viable population consists of sufficient numbers of reproducing individuals to maintain a stable or increasing population. These populations should include as many subpopulations as possible to maintain whatever fraction of the original genetic variability that remains.

   The following drainages are identified as necessary to achieve recovery: Tippecanoe River (Indiana), East Fork West Branch St. Joseph River (Michigan/Ohio), Fish Creek (Indiana/Ohio), Green River (Kentucky), Little Darby

Creek (Ohio), Elk River (West Virginia), French Creek (Pennsylvania), Allegheny River (Pennsylvania), and two additional as yet unidentified drainages.

This criterion is partially met. There appear to be reproducing populations in 7 of the 10 listed waterways (*i.e.*, surveys found a range of sizes, including smaller individuals that likely resulted from recent recruitment) occur in 7 of the 10 listed waterways (see Table 1): Tippecanoe River (Indiana), East Branch of the West Fork St. Joseph River (Michigan/Ohio), Green River (Kentucky), Little Darby Creek (Ohio), Elk River (West Virginia), French Creek (Pennsylvania), and Allegheny River (Pennsylvania). Reproduction has also been documented in the Shenango River (Pennsylvania). Living clubshells are still occasionally found in several other streams, but recent reproduction has not always been documented (see section 2.3.1.2). The viability of remaining populations, including those showing some evidence of reproduction, is unknown. Viability is a function not only of population characteristics (*e.g.*, size, structure, fecundity, distribution), but also of threats, some of which do not appear to be fully understood or controlled for the clubshell.

In order to ***remove*** the clubshell from the Federal list of threatened and endangered species, the following additional criteria must be met:

2. Each of the 10 populations in Criterion 1 must be large enough to survive a single adverse ecological event. Most populations at this time are localized and susceptible to such impacts. Therefore, the extent of most populations must be increased, either naturally or through translocation.

3. The populations and their drainages from Criteria 1 and 2 must be permanently protected from all foreseeable and controllable threats, both natural and anthropogenic.

   The recovery criteria have not been met; furthermore, they are vague in that: (1) population viability is not defined, (2) the separation distance (between sub-populations) necessary to ameliorate catastrophic events is not identified, (3) population protection is not well defined, and (4) habitat protection is not well defined. Several recovery tasks are intended to address habitat and population protection, but the needs of this species, including its environmental tolerances, are not well understood (see section 4.0).

   Adult clubshells were relocated to a number of streams required to achieve species recovery between 2014 and 2018, including in New York, Pennsylvania, West Virginia, Ohio, Kentucky, Indiana, and Illinois. As of 2019, no juvenile clubshells have been found that demonstrate that reproduction of augmented or reintroduced anmals has occurred; however, due to slow growth of the species recruitement may not be observed for several years (see section 2.3.1.2 and table 1 for additional information).

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

We have no new information on the biology and life history of this species since the last 5-year review.

2.3.1.2 Abundance, population trends, demographic features, and/or demographic trends:

The clubshell was listed as endangered in 1993. Historical and/or current clubshell records are known from Alabama, Illinois, Indiana, Kentucky, Michigan, New York, Ohio, Pennsylvania, Tennessee and West Virginia. See *Table 1. Historical (H) and present (P) occurrences of the clubshell and northern riffleshell* in the Recovery Plan for a detailed list of stream locations. In addition to its presence in the streams detailed in the Recovery Plan, the clubshell has also been observed in Cassadaga Creek, New York, and Muddy Creek and Tionesta Creek, Pennsylvania.

At the time of listing, the clubshell was thought to be extant in 12 streams: the Tippecanoe River, Kosciusko, Fulton, Pulaskia, and Tippecanoe Counties, Indiana; Fish Creek of the St. Josephs River, Williams County, Ohio, and DeKalb County, Indiana; West Branch of the St. Josephs River, Williams County, Ohio, and Hillsdale County, Michigan; Walhonding River, Coshocton County, Ohio; East Fork of the West Branch of the St. Josephs River, Hillsdale County, Michigan; Little Darby Creek, Madison County, Ohio; Allegheny River, Warren and Forest Counties, Pennsylvania; French Creek, Crawford, Venango, and Mercer Counties, Pennsylvania; Conneauttee Creek of French Creek, Crawford County, Pennsylvania; LeBoeuf Creek, Erie County, Pennsylvania; Elk River, Braxton and Clay Counties, West Virginia; and Green River, Edmonson and Hart Counties, Kentucky.

The current status of each clubshell population is discussed below, and extant populations are summarized in table 1. Note, the streams and locations shown in bold below are listed in the Recovery Plan as areas where stable clubshell populations are necessary to achieve recovery:

Allegheny River System

- In the **Allegheny River, Pennsylvania**, clubshells have been documented to occur in abundance at several locations, but the species' distribution is discontinuous (*i.e.*, localized to areas of suitable habitat). The conditions of these populations range from those exhibiting successful reproduction to those with apparently depressed vigor and a predominance of older adults (U.S. Geological Survey 2004). Clubshell

populations are known from scattered locations in the middle Allegheny River (*e.g.*, near the towns of Kennerdell, Foxburg, Oil City, Parker and East Brady), downstream to river mile 58, which includes the two upper Navigation Pools (Pools 7, 8 and 9). In many of these locations, mussel population data are based solely on qualitative surveys, and the clubshell appears to be relatively less abundant than the other more common species with which it co-occurs in the Allegheny River, such as muckets (*Actinonaias ligamentina*) and spikes (*Elliptio dilatata*).

Quantitative sampling has occurred at a few locations on the Allegheny River. For example, approximately 3,025 clubshells were estimated to occur in 100-meter-wide river sections located 200 and 300 meters downstream of the existing West Hickory Bridge (USGS 2000). The total population of clubshells in the upper 52 kilometers of the Allegheny River sampled by USGS may exceed 1,100,000 individuals (Villella 2007).

- Between 2015 and 2017, bridge construction on the Allegheny River prompted a salvage operation to remove thousands of clubshells from the impacted area and relocate them to suitable habitat to reestablish or augment existing populations throughout their historical range, including streams in Pennsylvania, West Virginia, Ohio, Kentucky, Indiana, Illinois, and New York. The Federal Highway Administration, in conjunction with the Pennsylvania Department of Transportation Engineering District 1-0, proposed to replace the State Route 62, Section B01 Bridge, known locally as the Hunter Station Bridge, over the Allegheny River in Tionesta Township, Forest County, Pennsylvania. As part of the Hunter Station Bridge Replacement Project, a salvage plan was developed to reduce mussel fatalities and promote clubshell recovery. In total, 68,539 clubshells were salvaged and translocated between 2015 and 2017 (EnviroScience 2019).

- Between 2015 and 2018 the Seneca Nation relocated 1,017 clubshells to the upper Allegheny River (above Kinzua Dam/Allegheny Reservoir) on the Seneca Nation Territory, New York (Titus 2019). Between 2015 and 2017, the translocated mussels were from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania; in 2018, the translocated mussels were from the Allegheny River, Warren County, Pennsylvania (from the location of a proposed pipeline crossing). The Seneca Nation is currently seeking funding to do a comprehensive mussel survey on the entire Seneca Nation Territory (Titus 2019).

- In 2017, two live clubshells and a couple of weathered dead shells were discovered in Tionesta Creek/Tionesta Lake, Forest County, Pennsylvania (Chapman 2017). Additional mussel surveys are planned for approximately 20 sites upstream of Tionesta Lake to determine more about the clubshell's current distribution in Tionesta Creek.

- The clubshell population is discontinuously distributed in approximately 15 miles of the upper portion of **French Creek, Pennsylvania**, from near the confluence with LeBoeuf Creek, downstream to the vicinity of the State Route 6 Bridge at Mill

Village. Within this reach, clubshell abundance ranges from relatively common to rare or absent at sites that have otherwise diverse mussel communities. Of 31 sites investigated along the length of French Creek in 2003, clubshells were documented alive at only 3 sites. The size distribution ranged from 17 millimeters (mm) to 81 mm, indicating that successful reproduction is occurring. In 2004, population estimates at these sites ranged from less than 10 to over 800 individuals per site (Smith and Crabtree 2005). In the French Creek watershed, the clubshell populations have a relatively small range that has little overlap with that of the federally listed, endangered northern rifffleshell.

Clubshells have also been found in the reaches of four French Creek tributaries: Conneaut Outlet, Conneauttee Creek, and Muddy Creek in Crawford County and LeBoeuf Creek in Erie County, Pennsylvania. Documentation of these tributary populations is often based on small numbers of individuals in highly restricted reaches of these streams. The population in Conneaut Outlet is isolated, does not appear to be reproducing, and is restricted to less than a mile of stream immediately below a wastewater treatment plant.

- Two clubshells were documented in Cassadaga Creek, New York in 2005. The extent of this population, beyond the single known site, and its reproductive status are not known at this time (Smith and Horn 2006). *No new information since last 5-year review.*

Wabash River System

- The Indiana Department of Natural Resources has seen changes in the **Tippecanoe River, Indiana**, population in the last 15 to 20 years. The Tippecanoe River clubshell population can be split into three distinct subpopulations (Fisher 2019):
    - Lower section (Tippecanoe and Carroll Counties; below Lake Shafer/Norway Dam and Lake Freeman/Oakdale Dam): since 2008, only a couple older live individuals have been observed; reproduction in this section of the Tippecanoe River is questionable.
    - Middle section (White [upstream from Lake Shafer], Pulaski, Starke, and part of Fulton [downstream of Rochester] Counties): the last live clubshell was seen in this section in 2003 even though there has been significant survey effort.
    - Upper section (part of Fulton [upstream of Rochester], Marshall, and Kosciusko Counties): clubshell is doing very well in this area; live adults and juveniles have been collected at multiple locations since 2008.

- Between 2015 and 2016, 3,147 clubshells (449 passive integrated transponder [PIT] tagged and 2,698 glitter tagged) were collected from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, and translocated to habitat at three locations on the Eel River, Miami and Cass Counties, Indiana (Fisher 2018). As of September 2018, less than 1 percent (n=4) are known dead, and 8 percent

(n=37) are unaccounted for. Of the 2,698 glittered clubshell placed in July 2016, only 1 is known dead (Fisher 2018).

- In 1998, a live clubshell was collected in the Middle Branch North Fork Vermilion River, Illinois. The small size of the specimen (4.5 centimeters) suggests that the clubshell has successfully reproduced in the Middle Branch in the last decade (Szafoni *et al*. 2000). Also, Illinois Natural History Survey still occasionally find pair valves of the clubshell in the Middle Branch North Fork Vermilion River (Tiemann 2019).

- Staff from the Illinois Natural History Survey participated in a joint project with the Illinois Department of Natural Resources and the Service to reintroduce the clubshell to Illinois. A total of 4,166 clubshells have been collected from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, and translocated to suitable habitat at 8 sites in the Vermilion River basin (Middle Fork Vermilion River and Salt Fork Vermilion River) in Champaign and Vermilion Counties, Illinois (Tiemann *et al*. 2019). A total of 1,766 clubshells were PIT-tagged to allow monitoring to determine success of the project. Annual survival of translocated adult clubshells appears to have been successful in some locations with individual survival on par with other wild populations (Stodola *et al*. 2017). Survival varied among translocation sites, likely a result of local scale habitat differences such as substrate or gradient. Also, high discharge events posed the greatest threat for the long-term success of this project, as survival was significantly decreased following periods of abnormally high flows. It is too early to tell if clubshell reintroductions into Illinois have successfully recruited. Repeated translocations of individuals over a period of several years across several sites could be implemented to reduce the overall risk of failure due to high discharge events or local-scale differences (Stodola *et al*. 2017; Tiemann *et al*. 2019).

Maumee River System

- In 2004 and 2005, six living clubshells were found in an extensive qualitative and quantitative survey of 26 miles of **Fish Creek, Indiana/Ohio**, albeit with no evidence of recent reproduction (Brady *et al.* 2004; Brady *et al.* 2005). Since then, the Indiana Department of Natural Resources collected a single live adult clubshell in 2012 from Fish Creek, Dekalb County, Indiana, but still doubts the population is reproducing (Fisher 2019). Numerous dead clubshells were found in 2009, 2010, 2011, and 2012 at sites on Fish Creek, Williams County, Ohio, and at the mouth of Fish Creek in the St. Joseph River, Williams County, Ohio (Ahlstedt 2009; Ahlstedt 2010; Ahlstedt 2011; EnviroScience 2012).

- A clubshell population occurs in **East Fork West Branch St. Joseph River, Michigan/Ohio**, but is likely declining (Zanatta 2019). Shells of the clubshell are common, but few live mussels have been observed; however, there is some evidence of recruitment. Five live clubshells, including one juvenile, were observed in 2014,

and two live juvenile clubshells were observed in 2017 (Zanatta 2019). Mussel surveys were conducted in 2018, and only shells of the clubshell were observed at 5 of the 18 surveyed locations (Badra 2018).

Licking River

- Between 2012 and 2016, the Kentucky Department of Fish and Wildlife Resources reintroduced 19,479 clubshells collected from the Alleghey river to 7 locations in the Licking River, Kentucky (McGregor 2017). According to the Recovery Plan, historical clubshell records are known from the Licking River (U.S. Fish and Wildlife Service [USFWS] 1994). In 2016, multiple live clubshells from previous (*i.e.*, before 2016) releases were observed (McGregor 2017).

Green River System

- Since 2000, living clubshells have been reported from the **Green River, Kentucky** from about 6 to 25 miles downstream of the Green River Reservoir (James Layzer, Tennessee Technological University, 2007, personal communication). This population shows evidence of periodic success in reproduction, apparently related to discharge rates from Green River Reservoir, and hatchery-produced juveniles were released back to this population in 2007 (James Layzer, TTU, 2007, personal communication). *No new information since last 5-year review.*

Scioto River System

Living clubshells can be found in a 13-mile stretch of **Little Darby Creek, Ohio,** where the species is reproducing and appears to represent a stable population (Tetzloff 2000; G. Thomas Watters, Ohio State University, 2007, personal communication). Twenty-nine clubshells were found during a 2014 survey for a bridge replacement project in Madison County. Several clubshells were also found during a 2014-2015 Big Darby Creek system survey at multiple sites.

- In 2006, a single, 5-year-old clubshell was reported from Big Darby Creek, Ohio, which may have recruited from Little Darby Creek following the removal of a low-head dam (Michael Hoggarth, 2007, Otterbein College, personal communication).
- A freshdead clubshell was found in the 2014-2015 system survey, and 4 live and 1 freshdead clubshell were found in 2015 by John Tetzloff.

Kanawha River System

- The clubshell still occurs in localized areas of the **Elk River, West Virginia**, between Sutton Dam to within about 42 miles of the confluence with the Kanawha River (a distance of approximately 52 stream miles), where the species appears to be successfully reproducing (Barbara Douglas, USFWS, 2007, personal communication; Janet Clayton, West Virginia Division of Natural Resources [WVDNR], 2007, personal communication). In 2014, 56 live clubshells were

observed at the long-term monitoring station on the Elk River at Sutton, Braxton County, West Virginia (WVDNR 2014).

Monongahela River System

- In the 1990s, a small population of clubshell was documented in Hackers Creek, West Virginia. Hackers Creek is a tributary of the West Fork River, which joins the Tygart Valley River in Fairmont, West Virginia, to form the Monongahela River. The clubshell population in Hackers Creek is the last remaining population within the Monongahela watershed (WVDNR 2018b). Monitoring in 2004, 2009, and 2014, revealed the population was declining. In coordination with the WVDNR Mussel Program and the Service's West Virginia Field Office, captive propagation was believed to be the best option to save this genetic population. In 2018, 69 clubshells were salvaged from Hackers Creek. Salvaged mussels were transported to White Sulphur Springs National Fish Hatchery for long-term captive propagation and restoration activities. Most of the salvaged mussels have died while in captivity. Poor condition and potential disease transmission have hampered propagation efforts or stocking to new locations (Clayton 2019).

Beaver River System

- Twenty-four living clubshells were found in quantitative sampling at one site related to a bridge replacement project on the Shenango River, Mercer County, Pennsylvania (EnviroScience 2002). This study provided a population density estimate of 0.33 clubshell per square meter (m^2), and a population estimate of 41 to 155 individuals in the 13,191 m^2 sampling area. The size range of clubshells at this site ranged from 37 mm to more than 60 mm, indicating the population is successfully reproducing. The full extent of the Shenango River population is unknown due to a lack of sampling, but potential habitat extends from at least Pymatuning Reservoir to Shenango Reservoir and perhaps below into Lawrence County.

- In 2006, only a single, large adult clubshell was found in Pymatuning Creek, Ohio, along with several deeply buried, dead shells (Michael Hoggarth, Otterbein College, 2007, personal communication). In 2013, 6 weathered dead clubshells were observed during spot surveys of 31 sites (EnviroScience 2013). In 2015, 50 clubshells were translocated from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, to Pymatuning Creek. In June 2016, all 50 translocated clubshells were located during monitoring of PIT-tagged individuals (EnviroScience 2016a). In August 2016, an additional 1,000 clubshells were translocated from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, to Pymatuning Creek.

Muskingum River System

- In 1987, a single, freshly dead clubshell (with adductor muscle tissue still attached) was reported from the Walhonding River, Ohio (Michael Hoggarth, 2007, Otterbein College, personal communication). In 2015, 50 clubshells were translocated from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, to the Walhonding River (Boyer 2019). Forty-eight PIT-tagged individuals were detected in 2018 surveys (USFWS 2018).

Ohio River System

- Between 2013 and 2016, 15,196 clubshells were translocated from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, and released at 3 sites in the Ohio River: Muskingum Island and Buckley Island, Wood County, West Virginia, which are located within the Belleville Pool; and Ohio River Mile 284 in the Greenup Pool, Mason County (WVDNR 2014; Clayton 2019). A summary of each restoration site follows:

    - A total of 4,619 clubshells were stocked into the Belleville Pool at Muskingum Island. Mortality has been low with only seven clubshells recovered dead (Clayton 2019).

    - A total of 4,917 clubshells were stocked into the Belleville Pool at Buckley Island. Mortality has been low with only one dead clubshell recovered (Clayton 2019).

    - A total of 5,660 clubshells were stocked into the Greenup Pool (Ohio River Mile 284). Only five dead individuals have been recovered, and all indications are that the mussels are doing well (Clayton 2019).

- Between 2014 and 2016, 6,571 clubshells were translocated from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, to Middle Island Creek near Falls Mills, Tyler County, West Virginia (WVDNR 2018b; Clayton 2019). Only 22 clubshells have been reported dead since 2017 monitoring (Clayton 2019).

- A few scattered individual clubshells have been documented during spot surveys in Meathouse Fork of Middle Island Creek, West Virginia; however, because no systematic surveys have been completed, the status and range of clubshells in Meathouse Fork is unknown (Barbara Douglas, USFWS, 2007, personal communication). *No new information since last 5-year review*

Little Kanawha River

- Prior to 1983, four clubshell records were documented from the Little Kanawha River, West Virginia (Clayton 2019). Clubshell restoration began in 2013 near

Annamoriah, Calhoun County (WVDNR 2018a). To date, 2,505 clubshells have been translocated from the Hunter Station Bridge Replacement Project, Allegheny River, Pennsylvania, and placed in the Little Kanawha River at Annamoriah (Clayton 2019). The augmentation appears to be successful, and mortality remains low (only five dead individuals have been reported) (Clayton 2019). In 2016 and 2017, one live clubshell was observed at two other locations (*i.e.*, in addition to the reintroduction site) from the Little Kanawha River, including one at Creston, Wirt County, West Virginia (WVDNR 2018a; Clayton 2019).

- Clubshells have been found in the South Fork of the Hughes River, a tributary of the Little Kanawha River, West Virginia. In 2013, the first live clubshell in recent years was observed in the South Fork of the Hughes River upstream of Berea, Ritchie County and in 2014, a single live clubshell was observed downstream of Berea (WVDNR 2014). In 2018, WVDNR Mussel Program staff conducted 16 qualitative timed surveys within the Little Kanawha River watershed. These surveys were conducted at 1 site on the Hughes River, 2 on the North Fork Hughes River, 12 on the South Fork Hughes River, and 1 on Leading Creek. A single freshly dead clubshell was observed from the South Fork Hughes River, Ritchie County, West Virginia, during 2018 surveys (WVDNR 2018b).

Tennessee River and Cumberland River

- The status of the clubshell in Tennessee remains uncertain. Numerous surveys have been conducted since the last 5-year review in 2008 within the clubshell's historical range in the Tennessee River and Cumberland River drainages. Surveys have failed to detect any specimens (Hubbs 2019).

In summary, clubshells appear to be restricted to 13 populations in the Ohio River and Lake Erie Basins (table 1). Portions of 21 streams support, or might still support, the species. Evidence of recent successful recruitment has been reported in 10 streams: the Allegheny River, French Creek, LeBoeuf Creek, Muddy Creek, Tippecanoe River, Middle Branch of the North Fork Vermilion River, Green River, Elk River, Little Darby Creek, and Shenango River. In several streams, clubshell populations appear to comprise only older adults, and the populations are in decline and possibly extirpated: East Fork of the West Branch St. Joseph River, Fish Creek, Hackers Creek, Walhonding River, Cassadaga Creek, Pymatuning Creek, Conneaut Outlet, and Conneauttee Creek.

Clubshells have been moved from the Allegheny River to several streams in the historical range of the species to augment existing populations or reintroduce the species to increase redundancy and species recovery. These relocations occurred from 2014 to 2018, and no evidence of successful recruitment has been documented; however, juvenile clubshells take several years to reach a size that is likely to be detected.

Table 1. Currently extant clubshell populations.

Basin	Population	Stream	Approximate Range	2019 Status and notes
Lake Erie (St. Lawrence River system)	St. Joseph River	East Fork West Branch St. Joseph River	Scattered over ~10 mile reach	Shells are common, but few live individuals observed; some evidence of recruitment: 5 live clubshells observed in 2014, including one juvenile; 2 live juveniles observed in 2017; declining
		Fish Creek (isolated from other populations)	7-mile reach	6 live individuals found during extensive survey of 26 miles of Fish Creek in 2004 and 2005; single live adult found in 2012 from Fish Creek, Dekalb County, Indiana; numerous dead shells found in 2009, 2010, 2011, and 2012; no recruitment documented; declining.
Ohio River	Wabash River	Tippecanoe River	Lower section (Tippecanoe and Carroll Counties; below Lake Shafer/Norway Dam and Lake Freeman/Oakdale Dam)	Since 2008, only a few older live individuals observed; reproduction is questionable.
			Middle section (White [upstream from Lake Shafer], Pulaski, Starke, and part of Fulton [downstream of Rochester] Counties)	The last live clubshell was seen in this section in 2003 even though there has been significant survey effort.
			Upper section (part of Fulton [upstream of Rochester], Marshall, and Kosciusko Counties)	Recruitment documented; stable.
		Middle Branch, North Fork Vermilion River	1 site	1 live young individual found in 1998; shells still occasionally found.

		Eel River	Reintroduction of 3,147 clubshell to 3 locations in Miami and Cass Counties, Indiana	Reintroduction of 3,147 clubshells between 2015 and 2016. As of September 2018, less than 1 percent (n=4) are known dead, and 8 percent (n=37) are unaccounted for.
		Vermilion River	Reintroduction of 4,166 individuals at 8 sites in the Vermilion River basin (Middle Fork Vermilion River and Salt Fork Vermilion River) in Champaign and Vermilion Counties, Illinois	Reintroduction between 2010 and 2016. The clubshell appears to have been successful; some variability in survival between sites; survival was significantly decreased following periods of abnormally high flows; no recruitment documented.
	Green River	Green River	Scattered over ~20 miles	Recruitment documented; stable.
	Licking River	Licking River	Reintroduction of 19,479 individuals at 7 locations on the Licking River, Kentucky	Reintroduction between 2012 and 2016. In 2016, multiple live clubshells observed.
	Scioto River	Little Darby Creek	12-mile reach	Recruitment documented; declining.
		Big Darby Creek	1 known site prior to reintroductions; Reintroduction of 6,539 individuals at 11 locations.	Reintroduction between 2012 and 2016. Totals of 179 live and 25 dead observed during 2017 monitoring of reintroduced individuals.
	Shenango River	Shenango River	1 site	Recent recruitment; status unknown.
		Pymatuning Creek (isolated from the Shenango River)	4 sites	Prior to 2015, no recruitment documented, likely declining. In 2015, 50 clubshells translocated to Pymatuning Creek from Hunter Station for pilot study. In 2016, all 50 located during monitoring; In 2016, an additional 1,000 clubshells translocated to Pymatuning Creek from Hunter Station.

	Muskingum River	Walhonding River	In 2015, 50 individuals were released.	1 freshly dead individual in 1987. 48 PIT-tagged individuals detected during 2018 surveys
	Allegheny River	Allegheny River (PA)	Scattered over 66 miles	Successful recruitment at multiple sites; stable
		Tionesta Creek	One site in Tionesta Creek/Tionesta Lake, Forest County, Pennsylvania	In 2017, 2 live clubshells and weathered dead shells discovered. Surveys planned for approximately 20 sites upstream of Tionesta Lake
		Oil Creek	Upstream to the ice dam in Oil Creek State Park (~5.25 river miles upstream from the creek's confluence with the Allegheny River).	An assessment of Oil Creek between the upstream-most clubshell observation and the Allegheny River has not been completed; status unknown.
		Cassadaga Creek (isolated from the Allegheny River)	1 site	2 live individuals found in 2005; no recruitment documented; status unknown.
		Allegheny River (NY)	Reintroduction of 1,017 individuals to a site in the Seneca Nation Territory, New York	Reintroduction between 2015 and 2018. Seneca Nation is currently seeking funding to do a comprehensive mussel survey.
	French Creek	French Creek	Scattered over 15 miles - Erie, Venango & Crawford Co.	Successful recruitment at multiple sites; stable.
		Conneauttee Creek	1 site	No recruitment documented; declining.
		LeBoeuf Creek	3-mile reach	Recruitment documented; stable.
		Muddy Creek	1 site	Recruitment documented; status unknown.
		Conneaut Outlet (isolated from the French Creek)	500-foot reach	No recruitment documented; declining.

	Kanawha River	Elk River	Scattered over 42 miles - Braxton and Clay Counties; 27 site records exist for the Elk River since 2008	Successful recruitment at multiple sites; stable; Upper Braxton County sites (Sutton) not showing reproduction in over 15 years; lack of recruitment evidenced in all species; studies currently underway to determine cause.
	Monongahela River	Hackers Creek	100-yard reach	No recruitment documented; declining; population salvaged in 2018 and moved to White Sulphur Springs National Fish Hatchery for captive propagation; most of the salvaged mussels have died while in captivity; poor condition and potential disease transmission have hampered propagation efforts or stocking to new location; population was not able to recover from some catastrophic event that occurred in the mid-1990s.
	Little Kanawha River	South Fork Hughes River	6 sites over a 7.5 mile reach; Ritchie County, West Virginia	1 fresh dead individual found March 27 2018; no recruitment documented; status unknown; 2 live individuals observed from two sites in 2013 and 2014; 2 fresh dead individuals from 2 sites in 1997 and 1999; other individuals were characterized as weathered dead; 1 additional weathered dead individual observed in Middle Fork of South Fork approximately 4 miles upstream of the 7.5-mile reach.

		Little Kanawha River	Currently known from three sites including restoration site; between 2013 and 2017, 2,505 individuals released near Annamoriah, Calhoun County, West Virginia	Four records prior to 1983. Augmentation appears to be successful, and mortality remains low (only 5 dead individuals reported).
	Middle Island Creek	Meathouse Fork of Middle Island Creek	Found within 8 sites (13 records) since 1995	A few scattered individuals reported; no recruitment documented; status unknown; watershed is being significantly impacted by gas exploration and associated infrastructure.
		Middle Island Creek	Reintroduction to Middle Island Creek near Falls Mills, Tyler County, West Virginia	Reintroduction of 6,571 clubshells between 2014 and 2016. Only 22 individuals reported dead since 2017.
	Ohio River	Ohio River	Reintroduction at Muskingum Island, Belleville Pool, Wood County, West Virginia	Reintroduction of 4,619 individuals between 2013 and 2016. Mortality has been low with only 7 individuals recovered dead.
			Reintroduction at Buckley Island, Belleville Pool, Wood County, West Virginia	Reintroduction of 4,917 individuals between 2013 and 2016. Mortality has been low with only 1 dead individual recovered.
			Reintroduction at Ohio River Mile 284, Greenup Pool, Mason County, West Virginia	Reintroduction of 5,660 individuals between 2013 and 2016. Only 5 dead individuals recovered; indications are that the mussels are doing well.

TOTALS	**11 populations**	**19 streams**		**8 populations in 11 streams recruiting** **3 populatiaons declining or unknown**

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

Tim King and Cheryl Morrison (USGS, Leetown, West Virginia) have been investigating the genetic structure of the clubshell with a focus on determining the genetic relatedness of the remaining populations. Their data indicate that clubshell populations in the Allegheny River, French Creek, and the St. Joseph River system are genetically diverse and have not undergone a bottleneck event (sometimes evident after population recovery from a highly reduced abundance). In the majority of cases, individual clubshells from these streams can be traced back to the source population, suggesting that mixing should be avoided. Translocations of clubshells from the Allegheny River have mostly involved placement in streams that have little or no documented natural clubshell reproduction.

Few genetic samples have been included from populations in the southern portion of the range of the clubshell, including the Tennessee and Cumberland River systems. Some populations of the Tennessee clubshell (*Pleurobema oviforme*), identified based on shell morphology, may actually be *Pleurobema clava*.

2.3.1.4 Taxonomic classification or changes in nomenclature:

The genetic relationship between *Pleurobema oviforme* and *Pleurobema clava* in the Tennessee and Cumberland Rivers is unclear, and some populations may not be correctly identified as Tennessee clubshell based on shell morphology and geography; however, the existing genetic analysis is based on a small sample size, and is therefore considered to be incomplete and inconclusive.

2.3.1.5 Spatial distribution, trends in spatial distribution, and/or changes from historical range:

Although population numbers are relatively high in a few localized areas, the remaining clubshell populations are now sparsely distributed across the range of the species. Of 100 streams once known to be occupied by *Pleurobema clava*, the species is now limited to 11 extant populations occupying 19 streams including those where the species has been reintroduced or augmented between 2014 and 2018. Eight populations show signs of successful recruitment. Augmentation and reintroduction sites have not shown evidence of successful reproduction as of 2018; however, clubshells take a number of years to reach a size likely to be detected. Impoundments and degraded habitat separate most populations from each other, eliminating the potential for natural recolonization if a catastrophic event temporarily degrades habitat (*e.g.,* toxic spill event, flood).

2.3.1.6 Habitat or ecosystem conditions:

The extant clubshell populations occur in relatively small streams to medium-sized rivers. Many of the clubshell populations in smaller streams appear to be limited in extent (*e.g.,* a single stream reach, a small number of individuals) and show no evidence

of recent recruitment (including Fish Creek, Pymatuning Creek, Conneaut Outlet, Hackers Creek, and Cassadaga Creek). Because up to 70 percent of a clubshell population can be distributed below the substrate surface (Smith *et al*. 2001), this species is presumed to be highly dependent on interstitial flow through the substrate for oxygen and food and therefore is highly susceptible to siltation that fills interstitial voids. The reduced hydraulic energy typical of smaller streams may make this habitat type more susceptible to siltation. Smaller streams are also less likely to be able to ameliorate localized disturbance that increases silt or contaminant loads.

All clubshell populations in medium-sized rivers (*i.e*., Allegheny River, French Creek, Green River, Tippecanoe River, and Elk River) occur downstream of reservoirs or natural lakes. These lentic systems tend to remove fine silts, potentially protecting downstream clubshells from upstream erosion; however, they also limit the range of the species, which is not tolerant of predominantly lentic conditions. Regulated river flows can also limit the range of the clubshell; for example, in the Allegheny River clubshells become more abundant several kilometers downstream of Kinzua Dam.

2.3.2 Five-Factor Analysis

The purpose of a 5-year review is to recommend whether a listed taxon continues to warrant protection under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq), as amended (ESA) and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA protections may shed light on some future activities that constitute threats to the species. However, the analysis under Factor D (Inadequacy of Existing Regulatory Mechanisms) focuses on the availability of alternative (i.e., non-ESA) mechanisms to address the continuing and foreseeable threats.

The Recovery Plan identified four primary factors responsible for the decline of clubshell populations: siltation, impoundments, in-stream sand and gravel mining, and pollutants (USFWS 1994). These threats have been organized to align with the five listing factors, as follows.

2.3.2.1 Present or threatened destruction, modification, or curtailment of its habitat or range:

Ongoing threats to the clubshell include water quality degradation from point and non-point sources, particularly in small tributaries that have limited capability to dilute and assimilate sewage, agricultural runoff, and other pollutants. In addition, the species is affected by hydrologic and water quality alterations resulting from the operation of impoundments such as Union City Reservoir on French Creek, Green River Reservoir on the Green River, Pymatuning Reservoir on the Shenango River, Kinzua Dam on the

Allegheny River, and Sutton Dam on the Elk River. The presence of impoundments may have ameliorated the effects of downstream siltation, but these structures also control river discharges (and the many environmental parameters influenced by discharge), which may profoundly affect the ability of these populations to occupy or successfully reproduce in downstream habitats.

A variety of instream activities continue to threaten clubshell populations, including sand and gravel dredging, gravel bar removal, bridge construction, and pipeline construction. For example, in West Virginia, major projects included commercial sand and gravel dredging in the New Cumberland Pool of the Ohio River, capping of nearly 11 acres of stream bottom on the Kanawha River, and numerous stream crossings for gas pipelines. Protecting clubshell populations from the direct physical disturbance of these activities depends on accurately identifying the location of the populations, which is difficult with a cryptic species such as the clubshell. The indirect effects of altering the streambed configuration following instream disturbance can result in long-lasting alteration of streamflow patterns that may result in head-cutting and channel reconfiguration, thereby eliminating previously suitable habitat some distance from the disturbance.

Coal, oil, and natural gas resources are present in a number of the watersheds that are known to support clubshell, including the Allegheny River, Hackers Creek, Meathouse Fork, and the Elk River. Exploration and extraction of these energy resources can result in increased siltation, a changed hydrograph, and altered water quality even at a distance from the mine or well field. Clubshell populations in smaller streams are more vulnerable to the effects of these resource extraction activities, which can account for a much larger percentage of a small watershed. However, clubshell habitat in larger streams can also be threatened by the cumulative effects of a large number of mines and well fields.

Land-based development near streams of occurrence, including residential development and agriculture, often results in loss of riparian habitat, increased storm water runoff due to increased impervious surfaces, increased sedimentation due to loss of streamside vegetation, and subsequent degradation of streambanks. Because clubshells often live below the gravel surface, this species may be exceptionally sensitive to the increased siltation generated by these activities. The Little Darby Creek population on the western side of the City of Columbus (Ohio) is an example of a population threatened by development, while Hackers Creek, Pymatuning Creek, and Meathouse Fork appear to be strongly influenced by agriculture and Marcellus gas exploration and associated infrastructure (Janet Clayton, personal communication 2019)

Development has also resulted in an increased number of sewage treatment plants in drainages that support the clubshell as well as an increase in the amount of sewage discharged from existing plants. Mounting evidence indicates that freshwater mussels are more sensitive to several components of treated sewage effluent (*e.g.*, ammonia, chlorine, and copper) than are the typical organisms used to establish criteria protective

of aquatic life. Small streams, such as Conneaut Outlet, are particularly vulnerable to sewage effluent, which can constitute a significant portion of the total stream flow.

This species, like many mussels, is susceptible to permanent, temporary, and intermittent forms of environmental degradation. Reduced populations may take several decades to recover, even if no further degradation occurs.

In summary, the species continues to be affected by habitat loss and degradation throughout its range.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Collection is not known to present a significant threat at this time. The clubshell is not a commercially valuable species; however, the small number of remaining populations increases its vulnerability to over-zealous scientific collecting or educational programs that sample mussels and may increase the value for illegal trade by shell collectors.

2.3.2.3 Disease or predation:

At the time of listing, disease and predation were not considered to be significant threats to the species. Little is known about diseases in freshwater mussels (Grizzle and Brunner 2007). However, mussel die-offs have been documented in clubshell streams, and some researchers believe that disease may be a factor contributing to the die-offs (Haag 2012). Since listing, mussel die-offs have occurred in two clubshell streams (Elk River (WV) and Big Darby Creek (OH)). The causes of these recent die-offs are not known. It is also not known if any clubshells were affected during these events.

Mussel parasites include water mites, trematodes, oligochaetes, leeches, copepods, bacteria, and protozoa (Grizzle and Brunner 2007). Generally, parasites are not suspected of being a major limiting factor (Oesch 1984), but Butler (2007) found that reproductive output and physiological condition were negatively correlated with mite and trematode abundance, respectively. Stressors that reduce fitness (e.g., poor water quality) may make mussels more susceptible to parasites (Butler 2007). Furthermore, nonnative mussels may carry diseases and parasites that are potentially devastating to native mussel fauna, including the clubshell (Strayer 1999).

Several animals prey on this species, including muskrats, raccoons, otters, molluscivous fish, and some invertebrates. This effect may be negligible in larger populations such as the Allegheny River but could represent a significant threat to the small isolated clubshell populations.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Coal, oil, and gas resources are present in a number of the basins where the clubshell occurs, and extraction of these resources has increased dramatically since 2000. Extraction in the Utica and Marcellus shale formations, particularly in Pennsylvania and West Virginia, is expected to expand further (Marcellus Shale Coalition 2019).

Although oil and gas extraction generally occurs away from the river, extensive road networks are required to construct and maintain wells. These road networks frequently cross or occur near tributaries, contributing sediment to the receiving waterway. In addition, the construction and operation of wells may result in the discharge of brine into local waterways, and withdrawal of water for use in well development and pipline hydro-tests could exacerbate water quality and water quantity stresses during low flow events. Point source discharges are typically regulated; however, nonpoint inputs such as silt and other contaminants may not be sufficiently regulated, particularly those originating some distance from a waterway. In 2006, more than 3,700 permits were issued for oil and gas wells by the Pennsylvania Department of Environmental Protection, which also issued 98 citations for permit violations at 54 wells (Hopey 2007).

Even regulated point sources may adversely affect clubshells. Freshwater mussels appear to be more sensitive to some pollutants than are the organisms typically used in toxicity testing. As a result, some of the water quality criteria established by the U.S. Environmental Protection Agency (EPA) to protect aquatic life may not be protective of mussels. For example, Augspurger *et al*. (2003) found that the current EPA numeric criteria for ammonia may not protect mussels. Consequently, even those sewage treatment plants that comply with their ammonia effluent limits at all times may still be discharging water that is toxic to freshwater mussels. Few substances have been tested for their toxicity to mussels, let alone the endangered clubshell, so “safe” concentrations for this species are not yet known. In addition, some states allow mixing zones, or zones in which numeric water quality criteria can be exceeded. Conneaut Outlet in Crawford County, Pennsylvania, is an example of a clubshell population that has been adversely affected by a regulated discharge. Clubshells were eliminated from over 1,000 feet of suitable habitat immediately downstream of a municipal sewage treatment plant, probably due to lethal levels of chlorine and ammonia.

Agriculture, suburban, and urban land uses continue to expand in many watersheds in the existing range of the clubshell. These land use changes alter runoff patterns and flows in clubshell habitat, with unknown consequences to these remaining populations. Few regulatory mechanisms exist to address land use changes that may indirectly affect stream habitat that is remote from the disturbance.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Invasive species:

The zebra mussel (*Dreissena polymorpha*) has been documented in headwater lakes and reservoirs of a number of streams supporting clubshell populations. These lakes and reservoirs supply a source for zebra mussel veligers (larvae) to colonize downstream reaches. The presence of zebra mussel populations may also cause increased use of molluscides to treat zebra mussel infestations in the watershed. Nearly all remaining reproducing clubshell populations are downstream of lakes or reservoirs that support, or could support, zebra mussels.

The round goby (*Neogobius melanostomus*) first invaded North America in 1990 in the Great Lakes basin (Phillips *et al*. 2003), and it has recently been found in the French Creek tributary of LeBoeuf Creek in the Allegheny River basin. Round gobies prey on mollusks and small fish that may serve as clubshell host fish. The gobies have achieved high population densities that may also compete with host fish thereby limiting clubshell reproduction (Fuller *et al.* 2019).

The black carp (*Mylopharyngodon piceus*), a molluscivore, has been reported in Arkansas, Illinois, Mississippi, and Missouri (Nico and Nelson 2019). It is established in Louisiana (since the early 1990s), and was observed most recently in 2018 in Tennessee and Kentucky (Nico and Nelson 2019). The black carp is also listed as Injurious Wildlife under the Lacey Act. The species is present in the lower Ohio, Cumberland, and Tennessee River systems. There is high potential that the black carp will negatively impact native aquatic communities by direct predation, thus reducing populations of native mussels and snails, many of which are considered endangered or threatened (Nico and Nelson 2019).

Shifting precipitation and temperature:

The ultimate results of climate change remain unknown, but increased periods of drought are a possibility in some areas, as are changes in precipitation and water temperature cycles (Strayer and Dudgeon 2010). Physiological tolerances (e.g., temperature, dissolved oxygen) of most mussel species are largely unknown, but changes that cross critical thresholds could disrupt life stages or host availability. The isolated nature of remaining clubshell populations combined with life history traits (e.g., slow growth, low dispersal potential) means that natural recolonization is unlikely in the event of a natural or manmade catastrophic event. Many of the remaining populations appear to be limited to relatively short stream reaches or single sites. These small isolated populations are particularly vulnerable to extirpation due to losses resulting from stochastic events such as droughts, floods, and toxicant spills.

2.4 Synthesis

The clubshell was listed as endangered, without critical habitat, in 1993. Historically, the clubshell was once abundant and appears to have been a highly successful species occupying a range of riverine habitats throughout the Ohio River basin and tributaries of western Lake Erie (Stansbery *et al.* 1982). It has been documented in over 100 streams throughout its range, although it now appears to be limited to 11 populations distributed in 30 streams. Only eight clubshell populations show evidence of recent reproductive success.

Few extant clubshell populations occupy habitats that are protected from the threats affecting this species. The clubshell often shares habitat with the northern riffleshell in Pennsylvania but is extant in more streams, particularly those of smaller drainages, than typically used by northern riffleshell.

For unknown reasons, many of the remaining clubshell populations do not appear to be reproducing in locations where many other species of freshwater mussels show evidence of recent recruitment.

Riverine habitat adjacent to extant populations is not easily protected, other than by state shoreline protection regulations or local land use regulations. Development of adjacent uplands continues to be a significant and pervasive threat to remaining populations because of the resulting sedimentation and contaminant releases.

Large clubshell populations persist in a few streams where the ESA and other regulatory mechanisms have been important to maintaining these populations. However, despite these protections, the species continues to decline in half of the streams where it was present when listed as endangered in 1993. In some of these streams, such as Fish Creek, Hackers Creek, Pymatuning Creek (however, 1050 individuals have been translocated into this stream), and Conneaut Outlet, the species appears to be nearly extirpated. In the absence of protections provided by the ESA to the clubshell specifically, risks to the species would be considerably greater.

In summary, the more extensive but geographically limited populations found in the Allegheny River do not compensate for the declining populations and lost habitat elsewhere in the clubshell's range. These concerns are paired with the fact that the recovery criteria for downlisting have not been met. Without significant recovery activities targeted at understanding those life history traits of the clubshell that make it susceptible to land use changes, as well as a concerted effort to address ongoing threats, it is unlikely the species can be downlisted in the near future, since there is a real possibility of further range contraction. There is increased interest in and understanding of methods to augment and reintroduce clubshell populations. However, while promising, these efforts maybe limited by an incomplete understanding of the factors that appear to be limiting natural population recovery in most of the extant populations.

3.0 RESULTS

3.1 Recommended Classification

No change is needed. Retain as endangered.

3.2 New Recovery Priority Number

No change recommended. Retain as 5.

Brief Rationale:

Recovery Priority Number of 5 indicates that the clubshell is taxonomically categorized as a species, has a high degree of threat, and has low recovery potential. Despite an apparently healthy population in the Allegheny River system (including its tributary, French Creek), and evidence of reproduction in six other rivers, the listing as endangered is appropriate because the criteria to downlist the species have not been achieved. An endangered classification is also appropriate because of the species' continued decline and apparent lack of reproduction in at least 3 of the 13 extant populations due to undefined causes. Additionally, more than half of the remaining populations that show evidence of recruitment appear limited to single stream reaches and likely very small populations that are highly susceptible to catastrophic events. These factors contribute to the conclusion that the clubshell remains susceptible to significant, but largely undefined, continued threats.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendation: Revise recovery plan.

The clubshell Recovery Plan is more than 20 years old. A significant amount of information is available regarding threats to the essential recovery streams identified in the plan. A revised plan will assist local and state entities in planning watershed and ecosystem actions to recover habitat for eventual relocation. The recovery criteria also need to be updated to specifically address each of the relevant listing factors.

Recommendations for specific priority recovery actions:

The following recovery actions should be made a priority:

Priority 1 Recovery Actions:

1) Continue to survey for clubshell to determine abundance, distribution, and recruitment.

2) Identify and map both actual and potential threats at existing sites, and identify activities or practices that may affect the clubshell.

3) Continue to monitor reintroduction and augmentation sites to determine if natural reproduction is occurring.

4) Determine contaminant sensitivity for each life stage, particularly chloride, nutrients, and trace metal concentrations and develop recommendations for EPA and state water quality criteria to protect and enhance clubshell habitat.

Priority 2 Recovery Actions:

1) Assess the effects of streamflow manipulation on the existing populations, and develop recommendations for dam operators, water withdrawal, and state water quality criteria to protect and enhance clubshell habitat.

2) Implement a quantitative monitoring program at sites within the reproducing populations to assess the reproductive success of these populations.

3) Continue captive and *in situ* holding programs of the clubshell, which have provided additional options for the species' recovery and re-establishment into historical habitat through augmentation or reintroduction of relocated animals or captive propagation.

4) Publish a FWS clubshell propagation plan with feeding regime and captive care protocols.

Priority 3 Recovery Actions:

1) Continue genetic analysis to define the ranges of the clubshell (*Pleurobema clava*) and the Tennessee clubshell (*Pleurobema oviforme*) in the Cumberland and Tennessee Rivers .
2) Conduct genetic analyses of mussels used for relocation/augmentation, and compare to original population at augmentation sites.

3) 3) Develop database of stocking programs, and broodstock source; include genetic information on broodstock and progeny.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Clubshell (*Pleurobema clava*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_✓_ No change needed

Appropriate Delisting Priority Number: N/A

Review Conducted By: Robert Anderson and Melinda Turner, Pennsylvania Field Office

REGIONAL OFFICE APPROVAL:

Approve Paul R. Phy Date 8/28/19

Assistant Regional Director - Ecological Services, DOI Unified Region 1 – North Atlantic–Appalachian, U.S. Fish and Wildlife Service