Clubshell
(Pleurobema clava)

5-Year Review:
Summary and Evaluation

Fall 2008

U.S. Fish and Wildlife Service
Pennsylvania Field Office
315 South Allen Street, Suite 322
State College, Pennsylvania 16801-4850

5-YEAR REVIEW

Species reviewed: Clubshell (*Pleurobema clava*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Field Office: Pennsylvania Field Office, Robert Anderson 814-234-4090, Robert_M_Anderson@fws.gov

Lead Regional Office: Region 5, Mary Parkin, 617-417-3331, Mary_Parkin@fws.gov

Cooperating Field Offices:

West Virginia Field Office, Barbara Douglas, 304-636-6586, Barbara_Douglas@fws.gov
Ohio Field Office, Angela Zimmerman, 614-469-6923, Angela_Zimmerman@fws.gov
Michigan Field Office, Barbara Hosler, 517-351-6326, Barbara_Hosler@fws.gov
Kentucky Field Office, Leroy Koch, 502-695-0468, Leroy_Koch@fws.gov

Cooperating Regional Offices:

Region 3, Carlita Payne, 612-713-5339, Carlita_Payne@fws.gov
Region 4, Kelly Bibb, 404-679-7132, Kelly_Bibb@fws.gov

1.2 Methods Used to Complete the Review

The clubshell 5-year review was conducted as an individual effort by the lead recovery biologist for this species. U.S. Fish and Wildlife Service (Service) field office and State natural resource agency personnel responsible for the recovery of the clubshell were contacted for current information on occurrences, threats, and recovery activities in Indiana, Kentucky, Michigan, Ohio, Pennsylvania, and West Virginia. U.S. Geological Survey (USGS) biologists and academicians conducting research on the clubshell were also contacted, as were Service fisheries biologists and others involved with holding captive clubshell. The current recovery plan was finalized in 1994 and is out of date; therefore, the information that was provided by the State and Service biologists, and included in the Natural Heritage Database, reports and other gray literature, forms the principal basis for this status review.

1.3 Background

1.3.1 Federal Register notice announcing initiation of this review

71 FR 20178 (April 21, 2006) – Notice of Endangered and Threatened Wildlife and Plants; Initiation of a 5-Year Review of Nine Listed Species: the Purple Bean (*Villosa perpurpurea*), Clubshell (*Pleurobema clava*), Northern Red-bellied Cooter (*Pseudemys rubriventris bangsi*), Roanoke Logperch (*Percina rex*), Swamp Pink (*Helonias bullata*), Northern Riffleshell (*Epioblasma torulosa rangiana*), Flat-spired Three-toothed Land Snail (*Triodopsis platysayoides*), Puritan Tiger Beetle (*Cicindela puritana*), and Dwarf Wedgemussel (*Alasmidonta heterodon*)

1.3.2 Listing history

Federal Register notice (FR): 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, Alabama.

1.3.4 Review history

Since the time of Federal listing of the clubshell in 1993, no status review or 5-year review has been conducted for this species.

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 policy

2.1.1 Is the species under review a vertebrate? The species is an invertebrate that is listed in its entire range; therefore, the distinct population segment 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, the following 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 drainages.

   This criterion is partially met. Apparently reproducing populations occur in 7 of the 10 listed waterways: Tippecanoe River (Indiana), East Fork West Branch St. Joseph River (Michigan/Ohio), Green River (Kentucky), Little Darby Creek (Ohio), Elk

River (West Virginia), French Creek (Pennsylvania), and the 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.

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).

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat

The clubshell has been found in a variety of stream and river conditions, but it is most often observed in clean, stable, coarse sand and gravel runs, often just downstream of riffle areas, in medium to small rivers and streams (Stansbery *et al.* 1982). It typically burrows completely beneath the substrate to a depth of 2 to 4 inches, relying on water to percolate between the sediment particles (Watters 1990). More than 70 percent of a population may be hidden below the substrate surface (Smith *et al.* 2001). As a fluvial organism, the clubshell can tolerate a range of water velocities, and although often considered to be intolerant of permanently slack water conditions (USFWS 1994), it has been found living and reproducing in Navigation Pools 7, 8, and 9 in the Allegheny River at depths of 10 to 15 feet.

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

Clubshell glochidia are obligate parasites on fish gills, a possible adaptation for upstream dispersal of a relatively immobile organism living in flowing water, and which would otherwise be flushed from the river system over time. Not all fish species are suitable hosts. The striped shiner (*Notropis chrysocephalus*), central stoneroller (*Campostoma anomalum*), blackside darter (*Percina maculata*), and logperch (*Percina caprodes*) have been capable of serving as hosts for the clubshell under laboratory conditions (Watters and O'Dee 1997, O'Dee and Watters 2000). It is likely that additional untested fish species can be used by clubshell glochidia in the wild.

The clubshell likely reaches sexual maturity between 3 and 5 years, as does the closely related Tennessee clubshell, *Pleurobema oviforme* (Weaver *et al.* 1991). Clubshells are relatively long-lived with life spans of 20 years or more. Males of the genus *Pleurobema* release sperm into the water in April, May, and June, and downstream females uptake the sperm with incoming water (Weaver *et al.* 1991). The clubshell is long-lived and has low annual juvenile survival rates.

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

Clubshells are cryptic, with perhaps 70 percent of a population occurring below the substrate surface; therefore, qualitative population estimates must take into account undetected individuals. Further, where clubshells are found at low population densities, population estimates may have large margins of error due to undetected mussels. In addition, sparsely distributed juveniles used to document successful reproduction are likely even more difficult to detect. Documenting reproductive success is further complicated because clubshells are relatively long-lived. Adults, which may be less sensitive to environmental disturbance than juveniles, could persist for decades before the population shows significant evidence of decline.

Reproducing clubshell populations are often hard to detect when densities are very low or surveys are single-day, catch-per-unit efforts. Few intensive, statistically valid surveys have been conducted on clubshell populations outside of French Creek and the Allegheny River. Populations in the southern and western portions of the species range, particularly where population densities may be near or below the detection rate, may not be practically assessed with quantitative techniques. The difficulty in detecting clubshells results in poorly defined distribution and abundance information, even within the streams where the species is known to occur.

All streams with known clubshell populations are listed below by major watershed. The underlined streams and locations are listed in the recovery plan as areas where viable populations of clubshell are necessary to achieve recovery:

Wabash River System

- Clubshells occur in several locations in the Tippecanoe River in Indiana, with larger concentrations in the headwaters below Lake Tippecanoe and in the lower reaches below Lake Shaffer and Lake Freeman. The species shows evidence of a variety of year classes, which is indicative of reproduction (B. Fisher, Indiana Department of Natural Resources, 2007 pers. comm.). Although the recovery plan identified the population in the Tippecanoe River as the largest, recent surveys indicate that the population in the Allegheny River (Pennsylvania, see below) occurs over more miles of river and is larger in size.

- In 1998, a live clubshell was collected in the Middle Branch North Fork Vermilion River in Illinois. The small size of the specimen (4.5 cm) suggests that species has successfully reproduced in the Middle Branch in the last decade (Szafoni *et al.* 2000).

Maumee River System

- In 2004 and 2005, 6 living clubshells were found in an extensive qualitative and quantitative survey of 26 miles of Fish Creek in Indiana, albeit with no evidence of recent reproduction (Brady *et al.* 2004, Brady *et al.* 2005).

- A clubshell population occurs in East Branch of the West Fork St. Joseph River in Michigan, where the species can be found with relative frequency but appears to be skewed toward larger individuals and may no longer be reproducing (Badra 2000, Badra 2004).

Green River System

- Since 2000, living clubshells have been reported from the Green River in Kentucky from about 6 to 25 miles downstream of the Green River Reservoir (J. Layzer, Tennessee Technological University, pers. comm. 2007). 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 (J. Layzer, pers. comm. 2007).

Scioto River System

- Living clubshells can be found in a 13 mile stretch of Little Darby Creek in Ohio, where the species is reproducing and appears to represent a significant population (Tetzloff 2000; G.T. Watters, The Ohio State University, pers. comm. 2007).

- In 2006, a single, 5-year-old clubshell was reported from Big Darby Creek in Ohio, which may represent a recent range extension from Little Darby Creek following the removal of a low-head dam (M. Hoggarth, Otterbein College, pers. comm. 2007).

Kanawha River System

- Clubshell still occurs in localized areas of the Elk River in 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 still appears to be successfully reproducing (B. Douglas, USFWS, pers. comm. 2007; J. Clayton, West Virginia Department of Natural Resources, pers. comm. 2007).

Allegheny River System

- In the Allegheny River in 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 condition of these populations ranges from those exhibiting successful reproduction to those with apparently depressed vigor and a predominance of older adults (USGS 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 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 3025 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 km of the Allegheny River sampled by USGS may exceed 1,100,000 individuals (Villella 2007).

- The clubshell population is discontinuously distributed in the upper approximately 15 miles of French Creek in Pennsylvania, from near the confluence with LeBoeuf Creek, downstream to the vicinity of the State Route 6 Bridge at Mill Village. Within this reach, clubshells range 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 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 riffleshell.

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 in 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).

Monongahela River System

- A small and apparently non-reproducing population of clubshell exists in Hackers Creek in West Virginia (B. Douglas, pers. comm. 2007). This population appears to be in severe decline and may soon be lost (J. Clayton, pers. comm. 2007).

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 in Mercer County, Pennsylvania (EnviroScience 2002). This study provided a population density estimate of 0.33 clubshell per square meter, 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.

- An apparently small, non-reproducing population of clubshells occurs in Pymatuning Creek, Ohio (G.T. Watters, pers. comm. 2007). In 2006, only a single, large adult clubshell was found in Pymatuning Creek, along with several deeply buried, dead shells (M. Hoggarth, Otterbein College, pers. comm. 2007).

Muskingum River System

- In 1987, a single, freshly-dead clubshell (with adductor muscle tissue still attached) was reported from the Walhonding River in Ohio (M. Hoggarth, pers. comm. 2007).

No other fresh or recently dead clubshell specimens have been reported from this stream, but no comprehensive survey has been completed.

Other Ohio River Tributaries

- 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 (B. Douglas, pers. comm. 2007).

- Clubshells have been found in the South Fork of the Hughes River, a tributary of the Little Kanawha River, in West Virginia. Mussel survey data from this river are scant, so the status and extent of any clubshell population is unknown (B. Douglas, pers. comm. 2007).

In summary, clubshells appear to be restricted to 13 populations in the Ohio River and Lake Erie Basins (Appendix 1). Portions of 21 streams support or might still support the species. Evidence of recent successful recruitment has been reported in nine streams, including 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 seven streams, clubshell populations appear to be comprised of only older adults, and the populations are in decline: East Fork of the West Branch St. Joseph River, Fish Creek, Hackers Creek, Walhonding River, Cassadaga Creek, Pymatuning Creek, Conneaut Outlet, and Conneauttee Creek. Finally, based on a single specimen, the clubshell could be exhibiting a range extension as a result of habitat management in Big Darby Creek, Ohio.

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

Tim King and Cheryl Morrison (U.S. Geological Survey, Leetown, WV) have been investigating the genetic structure of the clubshell with a focus on determining the genetic relatedness of the remaining populations. The data indicate that the 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). Individual clubshells from these streams can be identified to the source population in the majority of cases. This suggests that these populations are genetically distinct and mixing should be avoided. 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 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. The existing genetic analysis is based, however, on a small sample size, and is therefore 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 *P. clava*, the species is now limited to 13 extant populations occupying 21 streams. Seven populations show signs of successful recruitment. 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, 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. Although these lentic systems tend to remove fine silts, potentially protecting downstream clubshells from upstream erosion, 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 1994 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 on clubshell, 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 continues to threaten clubshell populations, including sand and gravel dredging, gravel bar removal, bridge construction, and pipeline construction. 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 clubshell. The indirect effects of altering the streambed configuration following in-stream 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 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 that these activities generate. The clubshell in Little Darby Creek on the western side of the City of Columbus is an example of a population threatened by development, while Hackers Creek, Pymatuning Creek, and Meathouse Fork appear to be strongly influenced by agriculture.

Development has also resulted in an increased number of sewage treatment plants in drainages that support 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 comprise 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.

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. Nonetheless, 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:

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 clubshell occur, and extraction of these resources has increased dramatically in recent years, particularly in Pennsylvania and West Virginia. 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. 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 3700 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 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 unionids. 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. In this case, clubshells were eliminated from over 1000 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 clubshell. These land use changes alter runoff patterns and flow 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:

Zebra mussels (*Dreissena polymorpha*) have 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 isolated nature of remaining clubshell populations combined with life history traits means that natural recolonization is unlikely in the event of a natural or manmade catastrophic event. Many of the remaining population appear to be limited to relatively short stream reaches or single sites. These small isolated populations are particularly

vulnerable extirpation due to losses resulting from events such as droughts, floods, toxicant spills, or other stochastic events.

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). 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. The species has been documented in over 100 streams throughout its range, although it now appears to be limited to 13 populations distributed in 21 streams.

Few extant clubshell populations occupy habitats that are protected from the threats affecting this species. 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.

Only seven clubshell populations show evidence of recent reproductive success. For unknown reasons, many of the remaining clubshell populations do not appear to be reproducing in locations were many other species of freshwater mussels show evidence of recent recruitment. Large clubshell populations persist in a few streams where the Endangered Species Act (ESA) and other regulatory mechanisms have been important to maintaining these populations. However, 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, and Conneaut Outlet, the species appears to be nearly extirpated.

In sum, 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, although the downlisting criterion of 10 viable populations may be achievable. 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 and understanding of methods to augmentation and reintroduction 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.

Our current understanding of the clubshell's status leads us to conclude this species continues to face a probability of extinction throughout all its range, thereby meeting the definition of endangered under the ESA.

3.0 RESULTS

3.1 Recommended Classification: No change is needed. Retain as endangered.

Brief Rationale: 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 appears to be 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 three of the 13 extant populations due to undefined causes. Additionally, more than half of the remaining populations that show evidence of recruitment appear to be limited to single stream reaches and likely very small populations that are highly susceptible to catastrophic events. These factors contribute to the conclusion that clubshell remains susceptible to significant, but largely undefined, continuing threats.

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 low recovery potential. Although there are reliable techniques in place for managing mussel populations, strategies and techniques for abating threats to the species are less tractable.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendation: Revise recovery plan.

The recovery plan for the clubshell is more than 10 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 recovery actions:

The following recovery actions should be made a priority:

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

2) Assess the effects of stream regulation on the existing populations, and develop recommendations for dam operators to protect and enhance downstream clubshell habitat.

3) Determine contaminant sensitivity for each life stage, particularly silt concentrations.

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

5) Continue genetic analysis to define the ranges of clubshell (*Pleurobema clava*) and Tennessee clubshell (*Pleurobema oviforme*) in the Cumberland and Tennessee Rivers.

6) Captive and *in situ* holding of clubshell may provide additional options for the species' recovery and re-establishment into historic habitat through augmentation or reintroduction of relocated animals or captive propagation. Husbandry methods should be developed, and an assessment of historic habitat completed to identify sites where clubshell augmentation and re-establishment can be achieved.

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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

Review Conducted By: Robert Anderson, Pennsylvania Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 8-15-07

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 9/11/09
Acting Regional Director

INTER-REGIONAL CONCURRENCE:

Cooperating Regional Director, Fish and Wildlife Service, Region 3

Signature See other signature page Date_____

Cooperating Regional Director, Fish and Wildlife Service, Region 4

Signature _____ Date 11/27/07
acting Assistant Regional Director
Ecological Services

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 Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Robert Anderson, Pennsylvania Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 8-15-07

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve See other signature page Date _____

Cooperating Assistant Regional Director, Ecological Services
Fish and Wildlife Service, Midwest Region

__X__ Concur ____ Do Not Concur

Signature Lynn M. Lewis Date 4/7/09

Appendix 1.

Clubshell populations are presently known to occur (or appear to be extant) in the following streams.

Basin	Population	Stream	Approximate Range	Status[1]
Lake Erie (St. Lawrence River system)	St. Joseph River	East Brnch of the West Fork St. Joseph River	scattered over ~10 mile reach	No recruitment documented; status unknown
		Fish Creek (isolated from other populations)	7-mile reach	A few scattered individuals reported; no recruitment documented;; declining
Ohio River	Wabash River	Tippecanoe River	scattered over ~ 150 miles	Recruitment documented; stable
	Green River	Middle Branch, North Fork Vermilion River	1 site	1 live young individual found in 1998
	Green River Scioto River	Green River	scattered over ~20 miles	Recruitment documented; stable
		Little Darby Creek	12-mile reach	Recruitment documented; declining
	Shenango River Shenango River	Big Darby Creek	1 site	1 live young individual found in 2006
		Shenango River	1 site	Recent recruitment; status unknown
	Muskingum River	Pymatuning Creek (isolated from the Shenango River)	4 sites	No recruitment documented; declining

Ohio River (continued)	Allegheny River	Allegheny River	scattered over 66 miles	Successful recruitment at multiple sites; stable
		Cassadaga Creek (isolated from the Allegheny River)	1 site	2 live individuals found in 2005; no recruitment documented; status unknown
	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	Successful recruitment at multiple sites; stable
	Monongahela River	Hackers Creek	100-yard reach	No recruitment documented; declining
	Little Kanawha River	South Fork Hughes River	not reported	A few scattered individuals reported; no recruitment documented; status unknown
	Middle Island Creek	Meathouse Fork of Middle Island Creek	not reported	A few scattered individuals reported; no recruitment documented; status unknown
TOTALS	13 populations	21 streams		8 populations in 9 streams recruiting