Recovery Outline

For the

Spectaclecase mussel (*Cumberlandia monodonta*)

January 2014

I. INTRODUCTION

This document outlines a preliminary course of action for the recovery of the spectaclecase mussel (*Cumberlandia monodonta*) until a comprehensive recovery plan for the species is approved. The spectaclecase is a freshwater mussel that generally inhabits large rivers, and is typically found aggregated in microhabitats sheltered from the main force of current, such as under slab boulders or bedrock shelves. It occurs in substrates from mud and sand to gravel, cobble, and boulders in relatively shallow riffles and shoals with a slow to swift current. The spectaclecase mussel is endemic to the Mississippi, Ohio and Missouri River basins. This freshwater mussel was listed as an endangered species on April 12, 2012 (77 FR 14914). Primary threats to the spectaclecase include curtailment and degradation of habitat and range, recruitment reduction or failure, exotic invasive species, small and fragmented populations and their resulting vulnerability to natural or human induced events.

<u>Listing and Contact Information:</u>

Listing Classification:	Endangered range wide
Effective Listing Date:	April 12, 2012
Lead Agency, Region:	U.S. Fish and Wildlife Service, Midwest Region
Lead Field Office:	Twin Cities Ecological Services Field Office
Contact Biologists:	Tamara Smith, 612-725-3548, tamara_smith@fws.gov Phil Delphey, 612-725-3548, phil_delphey@fws.gov
Cooperating Offices:	Not applicable

II. RECOVERY STATUS ASSESSMENT

A. Taxonomy, Life History, Habitat, Distribution, and Trends

The spectaclecase is a large mussel that reaches at least 9.25 inches (23.5 centimeters (cm)) in length (Havlik 1994, p. 19). The shape of the shell is greatly elongated, sometimes arcuate (curved), and moderately inflated, with the valves being solid and moderately thick, especially in older individuals (Parmalee and Bogan 1998, p. 49). Both anterior and posterior ends of the shell are rounded with a shallow depression near the center of shell (Parmalee and Bogan 1998, p. 49, Baird 2000, p. 6). Year-one specimens have heavy ridges running parallel with the growth arrests, which are shell lines that indicate slower periods of growth, thought to be laid down annually (Baird 2000, p. 6). The periostracum (external shell surface) is somewhat smooth, rayless, and light yellow, greenish-tan, or brown in young specimens, becoming rough and dark brown to black in old shells (Parmalee and Bogan 1998, p. 50). The shell commonly will crack posteriorly when dried (Oesch 1984, p. 31). Internally, the single pseudocardinal tooth (a triangular tooth-like structure along the hinge line of the internal portion of the shell) is simple and peg-like in the right valve, fitting into a depression in the left (Parmalee and Bogan 1998, p. 50). The lateral teeth are straight and single in the right valve, and double in the left valve, but become fused with age into an indistinct raised hinge line (Parmalee and Bogan 1998, p. 50). The color of the nacre (interior covering of the shell) is white, occasionally granular and pitted, mostly iridescent in young specimens, but becoming iridescent posteriorly in older shells (Parmalee and Bogan 1998, p. 50).

The spectaclecase is a member of the mussel family Margaritiferidae and was originally described as Unio monodonta Say, 1829. The type locality is the Falls of the Ohio (on the Ohio River in the vicinity of Louisville, Kentucky, and adjacent Indiana), and the Wabash River (probably the lower portion in Illinois and Indiana) (Parmalee and Bogan 1998, p. 49). The species has been placed in the genera Unio, Margaritana, Alasmidonta, Margarita, Margaron, and Margaritifera at various times in history (Parmalee and Bogan 1998, p. 49). Ortmann (1912, p. 13) placed it in the monotypic genus Cumberlandia in the family Margaritiferidae. Currently recognized synonymy includes Unio soleniformis (Lea). Smith (2001, p. 43) reassigned the spectaclecase to the Holarctic genus Margaritinopsis based on shell and gill characters. The Service, however, will defer to the Committee on Scientific and Vernacular Names of Mollusks of the Council of Systematic Malacologists, American Malacological Union (Turgeon et al. 1998), on whether the genus Margaritinopsis is accepted as valid for the spectaclecase. Until an official decision is made, the Service will use the commonly accepted Cumberlandia for the genus of this species. Spectaclecase is the accepted common name for *Cumberlandia monodonta* (Turgeon et al. 1998, p. 32).

The spectaclecase is endemic to the Mississippi, Ohio and Missouri River basins and generally inhabits large rivers. It occurs in substrates from mud and sand to gravel, cobble, and boulders in relatively shallow riffles and shoals with a slow to swift current (Buchanan 1980, p. 13, Parmalee and Bogan 1998, p. 50, Baird 2000, pp. 5 - 6). According to Stansbery (1967, pp. 29 - 30), this species is usually found in firm mud between large rocks in quiet water very near the interface with swift currents. Specimens have also been reported in tree stumps, in root masses, and in beds of rooted vegetation (Oesch 1984, p. 33). Similar to other margaritiferids, spectaclecase occurrences throughout much of its range tend to be aggregated (Gordon and Layzer 1989, p. 19), particularly under slab boulders or bedrock shelves (Buchanan 1980, p. 13, Parmalee and Bogan 1998, p. 50, Baird 2000, p. 6), where they are protected from the current.

The general biology of the spectaclecase is similar to other bivalve mollusks belonging to the families Margaritiferidae and Unionidae. Adult mussels suspension-feed, spending their entire lives partially or completely buried within the substrate (Murray and Leonard 1962, p. 27). Adults feed on algae, bacteria, detritus, microscopic animals, and dissolved organic material (Silverman et al. 1997, p. 1859, Nichols and Garling 2000, p. 873, Christian et al. 2004, pp. 108 - 109, Strayer et al. 2004, pp. 430-341). Recent evidence suggests that adult mussels may also deposit feed on particles in the sediment (Raikow and Hamilton 2001, p. 520). For their first several months, juvenile mussels employ foot (pedal) feeding, consuming bacteria, algae, and detritus (Yeager et al. 1994, p. 221). The maximum age of the spectaclecase in one study was 56 years (Baird 2000, pp. 54, 59, 67), however a specimen from the St. Croix River, Minnesota and Wisconsin, was estimated (based on external growth ring counts) to be approximately 70 years old (Havlik 1994, p. 19). The biggest change in growth rate of the spectaclecase appears to occur at 10 to 15 years of age, which suggests that significant reproductive investment does not occur until they reach 10 years of age (Baird 2000, pp. 66 - 67).

Mussel biologists know relatively little about the specific life-history requirements of the spectaclecase. Age at sexual maturity of the spectaclecase was estimated to be 4 to 5 years for males and 5 to 7 years for females, with sex ratios approximating 50:50 (Baird 2000, p. 24). The spectaclecase life cycle includes a brief, obligatory parasitic stage on a host organism, typically fish; however, despite extensive investigation, the host species is not yet known (Knudsen and Hove 1997, p. 2, Lee and Hove 1997, pp. 9 - 10, Hove et al. 1998, pp. 13 -14, Baird 2000, pp. 23 - 24, Henley and Neves 2006, p. 3, Hove and Berg 2008, p. 5, Hove et al. 2008, p. 4, Hove et al. 2009, p. 22 - 23). The spectaclecase is thought to release larvae (glochidia) from early April to late May in the Meramec and Gasconade Rivers, Missouri (Baird 2000, p. 26). Gordon and Smith (Gordon and Smith 1990, p. 409) reported the species as producing two broods, one in spring or early summer and the other in the fall, in the Meramec River.

The spectaclecase occurred historically in at least 44 streams in the Mississippi, Ohio, and Missouri River basins (Butler 2002, p. 6, Heath 2008, pers. comm.) and its distribution comprised portions of 14 States (Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Ohio, Tennessee, Virginia, West Virginia, and Wisconsin).

Based on historical and current data, the spectaclecase has declined significantly range wide and is now known from only 20 of 44 historical streams, representing a 55 percent decline. The species is presumed extirpated from thousands of river miles and from numerous reaches of habitat in which it occurred historically, including long reaches of the upper Mississippi, Ohio, Cumberland, and Tennessee Rivers and many other streams and stream reaches. Of the 20 extant (defined as found live or fresh dead since 1990) populations, five are represented by only one or two recent specimens each and are likely declining and some may be extirpated. Populations in the Mississippi and Clinch Rivers have recently experienced significant population declines. Most surviving populations face significant threats, and with few exceptions, are highly fragmented and restricted to short stream reaches. The spectaclecase is considered extirpated from Indiana, Kansas and Ohio. Reports of the spectaclecase from 1877 in the Blue and Elkhorn Rivers, Nebraska are not considered valid (Fritz 2010, pers. comm.). The only relatively strong populations remaining are in the Meramec and Gasconade Rivers in Missouri and in the St. Croix River in Minnesota and Wisconsin. In 2012, a relatively large spectaclecase population was discovered on the Ouachita River in Arkansas and an apparent reproducing population was found in the Green River in Kentucky.

B. THREAT ASSESSMENT

This section presents a summary of threats affecting the spectaclecase and its habitat. A detailed evaluation of factors affecting the species can be found in the listing determination (77 FR 14914; March 13, 2012). Primary concerns for the species are related to curtailment and/or degradation of habitat and range, exotic-invasive species, recruitment reduction or failure, small and fragmented populations and their resulting vulnerability to natural or human induced events.

Habitat Loss and Degradation

The decline of the spectaclecase in the eastern United States (described by Butler 2002 and final rule) is primarily the result of habitat loss and degradation (Neves 1991, p. 252). These losses have been well documented since the mid-19th century (Higgins 1858, p. 550). Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining, and sedimentation (Neves 1991, p. 252, Neves 1993, pp. 4 - 6, Williams et al. 1993, pp. 7 - 9, Neves et al. 1997, pp. 60, 63 - 75, Watters 2000, pp. 262-267). These stressors have had profound impacts on spectaclecase populations and its habitat for decades.

Dams and impoundments are considered a threat of high magnitude to the spectaclecase because they alter water quality and flow, impair habitats and increase fragmentation and isolation of mussel populations. Although most impoundment and channelization of rivers and streams occurred in the past, the ongoing effects caused by such activities pose an imminent threat of high magnitude to the spectaclecase because of altered habitats, sedimentation and the subsequent transformations in biological communities that occurred due to these changes. Likewise, continued maintenance of channelized waterways adds to these threats by further increasing sedimentation and siltation. Excess sedimentation is considered an imminent threat of high magnitude to the spectaclecase because it can reduce feeding and respiratory efficiency of these species. Furthermore, sediments can be a vector for chemical contaminants. Additionally, impoundments create slow-moving deep water habitat ideal for harboring certain exotic species (e.g., zebra mussels).

Small populations of spectaclecase are vulnerable to the threat of detrimental chemical spills. Furthermore, exposure of mussels to low but ubiquitous concentrations of contaminants may not be immediately lethal but can reduce filtration efficiency, decrease growth and reproduction and induce behavioral changes in all life stages over time.

In-stream sand and gravel mining represents an imminent threat of moderate to high magnitude to the spectaclecase due to the effects of water quality and habitat impairments. Coal, oil and gas mining are a threat because these activities can cause increase in siltation, change the hydrology and alter water quality. Similarly, heavy metal contaminated sediments associated with lead mining have negatively impacted mussel populations along several miles of the Big River, Missouri (Roberts et al. 2009, p. 20).

Inadequacy of Existing Regulatory Mechanisms

Point source discharges within the range of the spectaclecase have been reduced since the inception of the Clean Water Act (33 U.S.C. 1251 et seq.), but this may not provide adequate protection for filter feeding organisms that can be impacted by extremely low levels of contaminants. There is no specific information on the sensitivity of the spectaclecase to common industrial and municipal pollutants, and very little information on other freshwater mussels. Therefore, it appears that a lack of adequate research and data prevents existing regulations, such as the Clean Water Act (administered by the EPA and the Corps), from being fully used or effective. The U.S. Army Corps of Engineers retains oversight authority and requires a permit for gravel-mining activities that deposit fill into streams under section 404 of the Clean Water Act. Additionally, a Corps permit is required under section 10 of the Rivers and Harbors Act (33

U.S.C. 401 et seq.) for navigable waterways including the lower 50 miles (80 km) of the Meramec River. However, many gravel-mining operations do not fall under these two categories.

Small Isolated Populations

The majority of the remaining populations of the spectaclecase are generally small and geographically isolated (Butler 2002, p. 27). The patchy distributional pattern of populations in short river reaches makes them much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills (Watters and Dunn 1995, p. 257). Furthermore, this level of isolation makes natural repopulation of any extirpated population virtually impossible without human intervention. In addition, the fish host of spectaclecase is unknown; thus, propagation to reestablish the species in restored habitats and to maintain non-reproducing populations and focused conservation of its fish host are currently not possible. Although there are ongoing attempts to alleviate some of these threats at some locations, there appear to be no populations without significant threats, and many threats are without obvious or readily available solutions.

Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression (Avise and Hamrick 1996, p. 461). Despite any evolutionary adaptations for rarity, habitat loss and degradation increase a species' vulnerability to extinction (Noss and Cooperrider 1994, pp. 58 - 62). Numerous authors (e.g., Noss and Cooperrider 1994, pp. 58 - 62, Thomas 1997, p. 373) have indicated that the probability of extinction increases with decreasing habitat availability. Although changes in the environment may cause populations to fluctuate naturally, small and low-density populations are more likely to fluctuate below a minimum viable population (the minimum or threshold number of individuals needed in a population to persist in a viable state for a given interval) (Shaffer and Samson 1985, pp. 148 - 150, Gilpin and Soule 1986, p. 25 - 33).

Recruitment reduction or failure is a threat for many small spectaclecase populations range wide, a condition exacerbated by reduced range and increasingly isolated populations (Butler 2002, p. 28). If these trends continue, further significant declines in total spectaclecase population size and consequent reduction in long-term viability may soon become apparent.

Exotic Species

Various exotic species of aquatic organisms are firmly established in the range of the spectaclecase. The exotic species that poses the most significant threat to the spectaclecase is the zebra mussel. The invasion of the zebra mussel poses a serious threat to mussel faunas in many regions, and species extinctions are expected as a result of its continued spread in the eastern United States (Ricciardi et al. 1998, p. 618). Zebra mussels impact native mussels primarily through direct fouling of the shells of live native mussels. Zebra mussels attach in large numbers to the shells of live native mussels and are implicated in the loss of entire native mussel beds. Fouling impacts include impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, and locally depleting food resources and increasing waste products. Heavy infestations of zebra mussels on native mussels may overly stress the animals by reducing their energy stores. Zebra mussels may also reduce food concentrations to levels too low to support reproduction, or even survival in extreme cases.

The spectaclecase's colonial tendency could allow for very large numbers to be affected by a single favorable year for zebra mussels. Zebra mussels are established throughout the upper Mississippi, lower St. Croix, Ohio, and Tennessee Rivers, overlapping much of the current range of the spectaclecase.

A molluscivore (mollusk eater), the black carp (*Mylopharyngodon piceus*) is a potential threat to the spectaclecase (Strayer 1999, p. 89); it has been introduced into North America since the 1970s. Black carp are known to eat clams (Corbicula spp.) and unionid mussels in China, in addition to snails. Several other Asian carp species, which may disrupt aquatic food chains, are present in the some of the rivers with extant spectaclecase populations (e.g., Mississippi River, Chick and Pegg 2001, pp. 2250-2251, Amberg et al. 2013, pp. 4 - 15).

Temperature and climate change
Understanding the effects of climate change on freshwater mussels is of crucial importance, because the extreme fragmentation of freshwater drainage systems, coupled with the limited ability of mussels to migrate, will make it particularly difficult for mussels to adjust their range in response to changes in climate (Strayer 2008, p. 30). For example, changes in temperature and precipitation can increase the likelihood of flooding or increase drought duration and intensity, resulting in direct impacts to freshwater mussels (Hastie et al. 2003, pp. 40 - 43, Golladay et al. 2004, p. 503). Riverine mussel distribution appears to be highly dependent on complex hydrological characteristics (e.g., Morales et al. 2006, pp. 669 - 673, Zigler et al. 2008, p. 358). Climate change currently represents a non-imminent threat that may become a future threat of high magnitude to the spectaclecase due to the limited ability of their fragmented populations to migrate.

Threats Summary
In summary, threats to the spectaclecase include the present destruction, modification, or curtailment of its habitat, inadequacy of regulatory mechanisms, isolation of populations, exotic species and climate change. We have no information indicating that the magnitude or imminence of these threats is likely to be appreciably reduced in the foreseeable future, and in the case of adverse effects associated with exotic-invasive species like the zebra mussel, we expect this threat to become more problematic over the next several years as the distribution and abundances of those species continues to intensify and expand.

C. CONSERVATION ASSESSMENT

The following actions have been taken or are in progress to conserve the species.

Inventory and monitoring: The states of Alabama, Arkansas, Illinois, Iowa, Kentucky, Minnesota, Missouri, Tennessee, West Virginia, Wisconsin and Virginia have in the past or are continuing to inventory and monitor mussel populations, including the spectaclecase. Additional information on species occurrences arises from site-specific surveys, typically to fulfill requirements for Section 7 consultations or FERC projects.

Host research: Several researchers have anticipated the potential need for propagation, and have been attempting to determine the host(s) for the spectaclecase. The host(s) remain unknown, although over 60 species of fish, amphibians, and crayfish have been tested in the lab during host suitability studies (Knudsen and Hove 1997, p. 2, Lee and Hove 1997, pp. 9 - 10, Hove et al. 1998, pp. 13 - 14, Baird 2000, pp. 23 - 24, Henley and Neves 2006, p. 3, Hove et al. 2008, p. 4, Hove et al. 2009, pp. 22 - 23). Further research is needed to determine the host, as that knowledge is a crucial step in potential propagation efforts. Spectaclecase host identification and propagation techniques will be studied as part of a study entitled “The Return of Big River Endangered Freshwater Mussels to the Ohio River Islands NWR Cooperative Recovery Initiative Project (CRI)” which received funding in 2013.

Genetics research: Several researchers have foreseen the need to increase our understanding of spectaclecase population genetics in order to inform population augmentation and reintroduction efforts and to help determine population viability. Thus, a few studies have initiated investigations of spectaclecase genetics (i.e., Monroe et al. 2007, Elderkin 2009, Inoue et al. 2011) and at least four other studies are underway; one focused on Missouri populations, another focused on the Clinch River and the St. Croix River populations, one focused on the Ouachita River population and a fourth study focused on a Green River population as part of the CRI project discussed above (Miami University of Ohio, D. Berg, principal investigator). Inoue et al. (2011) developed and characterized at least 17 polymorphic loci which indicates that a high-level resolution of genetic structure within and among extant spectaclecase populations can be developed and that estimates of population parameters such as gene flow, effective population size, etc. are likely to be robust. Further genetics research is needed to build on these studies in order to assess the conservation and population restoration approaches to management of the spectaclecase throughout its range.

Habitat Restoration and Protection: Numerous parcels of public land (e.g., state parks, state forests, wildlife management areas) occur along historical and extant streams of occurrence for the spectaclecase or in their respective watersheds. The Nature Conservancy (TNC) has created bio-reserves along two stream systems harboring extant populations of the spectaclecase: the upper Clinch/Powell River, Tennessee and Virginia; and upper Green River, Kentucky. TNC has carried out aggressive and innovative community-based projects in both watersheds that address aquatic species and instream habitat conservation on multiple scales. A small portion of the Clinch River watershed (e.g., several small tributaries) is located in the Jefferson National Forest. Numerous public lands occur in the St. Croix watershed in Minnesota and Wisconsin, and the St. Croix River spectaclecase population receives protection by being located in the St. Croix National Scenic River (SCNSR). In addition, several State public lands (e.g., Chengwatana, Governor Knowles, St. Croix State Forests; Minnesota Interstate, St. Croix, St. Croix Wild River, William O’Brien, Wisconsin Interstate State Parks; St. Croix Islands Wildlife Area; Rock Creek Wildlife Management Area) lie adjacent to some sections of the SCNSR providing additional buffering lands along the St. Croix. The Upper Mississippi River National Wildlife and Fish Refuge manages scores of islands and shoreline acreage throughout a significant portion of the upper Mississippi. In-holdings of the refuge extend from the mouth of the Chippewa River downstream to Muscatine, Iowa. Between Muscatine and Keithsburg, Illinois, the Mark Twain National Wildlife Refuge (MTNWR), Keithsburg Division, has numerous in-holdings. A small disjunct portion of MTNWR, the Gardner Division, occurs in the Canton and La Grange, Missouri, area. Segments of the lower Big Piney River and substantial reaches of the upper Gasconade River flow adjacent or through the Mark Twain National Forest;

the lower Big Piney also flows through Ft. Leonard Wood Military Reservation. Small units of public land along the Meramec River include Meramec, Pacific Palisades, and River Round Conservation Areas; and Meramec, Onandaga Cave, and Robertsville State Parks.
Several Federal programs, such as Wildlife Habitat Incentives Program and the Environmental Quality Incentives Program, emphasize stream habitat restoration and are being implemented by agency partners (e.g., NRCS-WV). Water quality and habitat improvement projects brought to fruition through these conservation practices are important conservation tools and may aid species recovery. American Rivers has a record of advocacy and action regarding dam removal, river restoration and water quality improvement.

III. PRELIMINARY RECOVERY STRATEGY

A. RECOVERY PRIORITY NUMBER WITH RATIONALE

The spectaclecase is assigned a recovery priority of 4 on a scale of 1(C) (highest) to 18 (lowest), which indicates that this species, which is in the monotypic genus *Cumberlandia*, faces a high degree of threat, but a low recovery potential. The high degree of threat is based on the fact that threats are numerous, long-standing, and ongoing. The decline of the spectaclecase (described by Butler 2002 and final rule) is primarily the result of habitat loss and degradation (Neves 1991, p. 252) due to impoundments, channelization, chemical contaminants, mining, and sedimentation (Neves 1991, p. 252, Neves 1993, pp. 4 - 6, Williams et al. 1993, pp. 7 - 9, Neves et al. 1997, pp. 60, 63 - 75, Watters 2000, pp. 262-267). These stressors have had profound impacts on spectaclecase populations and their habitat for decades. Recovery potential is considered low because the threats will require long-term management and will be difficult to alleviate. Furthermore, captive propagation of this species depends on successful determination of the host species(s).

B. RECOVERY VISION STATEMENT/STRATEGY

The ultimate goal of the recovery effort is to ensure the long-term survival of the spectaclecase by controlling or reducing threats to the extent that populations are self-sustaining and protections afforded by the Endangered Species Act are no longer required. The interim goal is to secure these species to the point that we may consider down-listing from endangered to threatened status.

Although subject to change, full recovery of the spectaclecase includes the following objectives: (1) viable populations persist throughout the species' historical range in sufficiently managed and protected habitats and (2) threats to the species, primarily modification and destruction of river and stream habitat from localized and watershed impacts, are sufficiently abated. The strategy for achieving these objectives will include providing for sufficient representation, resiliency, and redundancy to ensure the high probability of survival for the foreseeable future.

C. STATEMENT OF RECOVERY NEEDS

The spectaclecase is threatened by human activities in all watersheds where it occurs. Because of its rarity, conservation and recovery of the spectaclecase may require human intervention for decades to come. It is known that human activities, human population numbers, and associated impacts will change within these watersheds. Therefore, it is essential to characterize and monitor aquatic habitats on a watershed scale and respond to changing conditions rapidly, whether through negotiation and partnerships to alleviate threats, or through husbandry, or both. This approach will require landowner cooperation to monitor the extant populations and to characterize the current habitat conditions.

Initial recovery efforts should focus on further investigating potential causes of decline while continuing to stabilize existing populations. A crucial first step is to develop successful captive propagation techniques including host identification or alternative approaches.

Long-term recovery efforts should focus on improving water quality, reducing sediment input, pollutants, and invasive species and addressing any other threats found to contribute to declines, including those that originate far upstream of extant populations. Especially critical is the protection of spectaclecase sites where reproduction is known to still occur or which contain larger numbers of the species – this may require recovery actions on a large scale in order to restore or protect downstream aquatic habitat.

Impacts to avoid are those that may (1) result in mortality or injury to spectaclecase; (2) reduce reproduction or recruitment of young into populations; (3) increase stress to remaining individuals in the wild; or (4) alter habitat such that survival or reproduction is reduced.

D. INITIAL ACTION PLAN

Below are the anticipated recovery actions, including ongoing conservation measures outlined under the Conservation Assessment section.

The spectaclecase would benefit from a conservation strategy consisting of nine main elements including monitoring; captive propagation and population augmentation; life history and ecological research; cooperative conservation partnership with private landowners; assessment of water quality and habitat restoration and protection; outreach, section 7 consultation, and assessment and control of exotic species. Each element is discussed below.

1. Establish long-term monitoring of spectaclecase populations with associated habitat characteristics and conditions.

A long-term monitoring program should be developed and implemented to evaluate population levels and habitat conditions and assess the long-term viability of extant, newly discovered, augmented and reintroduced spectaclecase populations. Monitoring to evaluate recovery efforts such as habitat restoration should also be established. Survey work to search for potentially new spectaclecase populations, thought to be extirpated populations, and to assess the status of populations, would be beneficial for recovery and conservation of the species. Survey designs that focus on optimal habitat (e.g., under large slab boulders, rock shelves) should be developed to adequately assess spectaclecase populations. The frequency and extent of monitoring for effectively detecting statistically and biologically meaningful trends in density and abundance within the known populations should be determined. When monitoring these populations, data concerning associated species also should be recorded in order to document freshwater mussel community associations, if any. Preferred habitat and environmental ranges should also be detailed. A comprehensive Geographic Information System database to incorporate information on the species distribution, population demographics, habitat conditions and various threats identified during monitoring activities should be established. Knowing the status of individual populations will help guide and prioritize recovery efforts.

2. Continue to develop and implement technology for maintaining and propagating the spectaclecase in captivity. Develop a reintroduction and augmentation plan for the species and assess the feasibility of augmenting existing populations and reintroducing these species into restored habitats in their historic range.

The need for captive propagation should be considered in order to augment existing populations or to establish populations throughout its historic range. One crucial step in captive propagation is determining the host(s) for the spectaclecase, which remains unknown (see Biology section above). Once the host has been determined for the spectaclecase, propagation technology should be developed. Alternative approaches (e.g., in vitro) propagations should also be explored. In addition, long term monitoring of the survival and growth of spectaclecase at augmentation and reintroduction sites should be established to measure the success of those recovery efforts. In 2013, a study was funded to research propagation techniques, host identification and, if successful with propagation, re-introduction on or near the Ohio River Islands NWR (see CRI project discussion in the Conservation Actions section of this document).

In order to effectively plan for species augmentation or reintroductions, it is important to establish benchmarks for setting restoration goals and measuring success. Criteria that determine long-term population viability are crucial if we are to understand what constitutes a healthy spectaclecase population. Detailed information is needed on the demographic structure, effective population size and other genetic attributes of extant populations. Furthermore, parameters for species augmentations and reintroductions should be developed to determine if an extant spectaclecase population will be suitable for species augmentation or if a site will be suitable for spectaclecase reintroduction. Potential augmentation sites should be selected based on present population size, population genetics, demographic composition, population trend data, potential site threats, habitat suitability and any other limiting factor that might decrease the likelihood of long-term benefits from population augmentation efforts. Biological, ecological and habitat characterization parameters to determine if a site will be suitable for spectaclecase reintroduction may include habitat suitability, substrate stability, presence of host fishes, potential site threats and any other limiting factor that might decrease the likelihood of long-term benefits from population reintroduction efforts.

A recent genetic study (Monroe et al. 2007, p. 7 - 13) indicates that much of the remaining genetic variability in the spectaclecase is represented in each of the remaining large populations, and that these populations do not appear to differ significantly from one another. A study to develop and characterize microsatellite markers (i.e., Inoue et al. 2011) provided a high-level resolution of genetic structure within and among extant spectaclecase populations. As a result, they concluded that estimates of population parameters such as gene flow, effective population size, etc. are likely to be robust. This genetics study should be followed with further genetics research before any efforts are made to propagate the species for reintroduction or augmentation purposes. A few such studies have been recently funded to examine Missouri, St. Croix and Green River populations; however, research should be expanded to its entire range.

3. Conduct research on the life history and genetics of the spectaclecase and apply the results toward management and recovery actions for the species.

Little is known about the life history of spectaclecase other than research conducted on the fecundity, age and growth and longevity of Meramec and Gasconade Rivers populations (see Baird 2000). Detailed information on the reproductive biology, fecundity, longevity, food habits, habitat preference (e.g., relevant physical, biological, chemical components for all life history stages) and sensitivity to siltation and contaminants would be necessary for identifying those life history and ecological traits that influence the vulnerability of spectaclecase to various threats throughout its range. Analyses to determine the entire suite of stressors to the spectaclecase and its habitat, to locate the sites of the various stressors and to outline management activities to eliminate or at least minimize each stressor should be considered, at a minimum, in those watersheds with significant extant spectaclecase populations. Determining the host(s) is necessary in order to initiate propagation efforts -- a study of hosts and propagation techniques has been recently funded (see discussion in the Conservation Actions section of this document). The information gained from these studies would also help inform and refine future conservation efforts for the spectaclecase.

4. Encourage and support community based watershed stewardship planning and action.

Cooperative conservation partnership with private landowners: The Service should work with state, federal and other conservation agencies to identify owners of lands within extant watersheds or areas for potential reintroductions who could benefit from assistance for resulting altered riparian vegetation and streamside management zones. The Service should also seek to proactively establish cooperative agreements with landowners who, if provided information and technical assistance, might be willing to voluntarily commit to protection measures for spectaclecase mussel and their host(s). The support of the local community, including agricultural, silvicultural, mining, construction, and other developmental interests, local individuals and landowners, will be essential in order to meet spectaclecase recovery goals. Protection and enhancement of habitat will help to stabilize existing populations of the spectaclecase to prevent extirpations. Furthermore, these efforts will help to protect and expand existing populations to minimize threats and ensure long-term persistence.

5. Develop and implement programs to educate the public and private industry on the need and benefits of ecosystem management, and involve the public in watershed stewardship and conservation efforts for the spectaclecase.

Outreach should be conducted to educate all interested parties about the presence and importance of rare species such as the spectaclecase. Outreach techniques should include the preparation and distribution of materials, such as fact sheets and brochures, and utilization of social media. Presentations should be conducted for schools, regulatory agencies, and other interested groups to inform and solicit support for spectaclecase recovery efforts.

6. Protect habitat integrity and quality of river segments that currently support or could support the species.

The Service should work with state and federal conservation agencies to identify landowners adjacent to and upstream of spectaclecase populations who could benefit from assistance for restoring altered riparian vegetation and streamside management zones. The Service should also seek to proactively establish cooperative agreements with landowners who, if provided information and technical assistance, might be willing to voluntarily commit to protective measures for spectaclecase. Protection and enhancement of habitat will help to stabilize existing populations of the spectaclecase to prevent extirpations. Furthermore, these efforts will help to protect and expand existing populations to minimize threats and ensure long-term persistence.

7. Utilize section 7(a)(1) and 7(a)(2) of the Endangered Species Act as mechanisms for conservation of the spectaclecase.

The importance of the role of section 7 of the Endangered Species Act should not be overlooked as a important tool for the conservation of the spectaclecase. Federal regulatory agencies are mandated to use their authorities in furthering the purposes of the Endangered Species Act under section 7(a)(1). Agencies that have jurisdiction over water quality standard, pollution permitting programs, as well as the wetlands permitting program under the Clean Water Act, may provide benefits for spectaclecase habitat protection and restoration through compliance and section 7(a)(2) consultation with the Service. Opportunities should be sought through section 7(a)(2) consultation with all federal agencies to protect and improve the status of the spectaclecase.

8. Investigate the extent of sedimentation, pollution, impoundments, dams and other threats to the species. Examine the sensitivity of the species to various pollutants, sedimentation and apply the results toward management and protection of the species.

The direct and indirect impacts of various pollutants on the various life history stages of the spectaclecase and its host(s) should be studied. The results of toxicology studies could inform water quality regulations and inform section 7(a)(2) consultations concerning water quality and spectaclecase. The results of these investigations can also be used to identify potential re-introduction or population augmentation sites and help prioritize potential restoration sites.

Implementation of best management practices on riparian lands to maintain vegetated riparian buffers should be considered throughout the range of the spectaclecase, to reduce stream sedimentation and chemical and nutrient runoff. Watershed level, community-based riparian habitat restoration projects should be initiated in high biodiversity streams harboring the spectaclecase, to restore and protect significant levels of habitat. Additionally, management recommendations should be developed and implemented to reduce the impacts of sand, gravel, coal, lead, oil and gas extraction wherever impacts from these activities are occurring in spectaclecase habitat.

An inventory of dams and impoundments should be used to inform agencies of the potential impact of dams and impoundments, and explore the potential for replacement of structures over time through planned maintenance schedules. Including fish passageways into lock and dam design may be considered, although the potential for invasive species movement should be carefully weighed. Water releases that mimic the natural hydrological regime or are otherwise modified to improve seasonal flow patterns and in-stream habitat may also be explored. These efforts may pay dividends in improving conditions for the spectaclecase and a host of other imperiled aquatic organisms. The Service should proactively pursue cost share programs such as the Services' Fish Passage Program to help modify these structures.

9. Monitor exotic invasive species and investigate possible control measures for exotic invasive species.

A monitoring program should be developed and implemented to track the rapid spread of exotic invasive species, like the zebra mussel. Monitoring information should become part of the comprehensive Geographic Information System database (see #1) and the Nonindigenous Aquatic Species Information System, which distributes information to government agencies, private groups, the public as well as State and Federal agencies responsible for the management of public lands. Furthermore, researchers should continue to study the possible ways to eradicate and/or control the continued spread of non-native species like the zebra mussel. Measures to reduce the spread of non-native species, such as boater education programs, should be implemented throughout the range of the spectaclecase.

IV. PREPLANNING PROCESS

A. PLANNING APPROACH

A recovery plan will be prepared for the spectaclecase. The recovery plan will include objective and measurable criteria which, when met, will ensure the conservation of the species. Recovery criteria will address all significant threats to the species, as well as estimate the time and the cost to achieve recovery. The recovery plan will be prepared by the Twin Cities Ecological Services Field Office with the assistance of species experts. A recovery team may be formed to assist with the development and/or implementation of the plan.

B. STAKEHOLDER INVOLVEMENT

During the recovery planning process, input, comments, and review will be sought from multiple stakeholders throughout its historic range. These will include State and Federal agencies, industrial and agricultural groups, research universities, and conservation organizations. Many stakeholders are currently cooperating in ongoing aquatic conservation initiatives in watersheds throughout the range of this species.

C. RECOVERY PLAN TIMEFRAME

Draft Recovery Plan anticipated: December 2015
Final Recovery Plan anticipated: December 2016

These timelines may be affected by available resources and regional priorities.

D. INFORMATION MANAGEMENT

All information relevant to the recovery of the spectaclecase will be housed in the Twin Cities Field Office's administrative files. The lead biologist will be responsible for maintaining a full administrative record for the recovery planning and implementation process for the species.

Approved:

ACTING Regional Director, Region 3
U.S. Fish and Wildlife Service

1/6/14
Date

Charles M. Wooley
Acting Regional Director

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