CANDIDATE ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Cumberlandia monodonta*

COMMON NAME: spectaclecase

LEAD REGION: 3

INFORMATION CURRENT AS OF: February 4, 2003

STATUS/ACTION (Check all that apply):
_X_ New candidate
___ Continuing candidate
    ___ Non-petitioned
    ___ Petitioned - Date petition received: _____
        __ 90-day positive - FR date: _____
        __ 12-month warranted but precluded - FR date: _____
        __ Is the petition requesting a reclassification of a listed species?
    ___ Listing priority change
        Former LP: ___
        New LP: ___
Latest Date species became a Candidate: _____
___ Candidate removal: Former LP: ___ (Check only one reason)
    ___ A - Taxon more abundant or widespread than previously believed or not subject to a degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
    ___ F - Range is no longer a U.S. territory.
    ___ I - Insufficient information on biological vulnerability and threats to support listing.
    ___ M - Taxon mistakenly included in past notice of review.
    ___ N - Taxon may not meet the Act's definition of species.
    ___ X - Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Phylum Mollusca, Class Bivalvia, Order Unionoida, Family Margaritiferidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Nebraska, Ohio, Tennessee, Virginia, West Virginia, Wisconsin

CURRENT STATES/ COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: Alabama, Arkansas, Illinois, Iowa, Kentucky, Minnesota, Missouri, Tennessee, Virginia, West Virginia, Wisconsin

LEAD REGION CONTACT (Name, phone number): Leslie Tewinkel, 612.713-5164

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BIOLOGICAL INFORMATION (Briefly describe habitat, historic vs. current range, historic vs. current population estimates (# populations, #individuals/population), etc.):

Species Description

The following description of the spectaclecase is summarized from Oesch (1984), Parmalee and Bogan (1998), and Baird (2000). The spectaclecase is a large mussel that reaches at least 9.25 inches in length (Figure 1). 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. Both anterior and posterior ends of the shell are rounded with a shallow depression near the center of the valve. The anterior end is higher than the posterior end. The posterior ridge is low and broadly rounded. Year-one specimens have heavy ridges running parallel with the growth rests. The periostracum (external shell surface) is somewhat smooth, rayless, and light yellow, greenish-tan, to brown in young specimens becoming rough and dark brown to black in old shells. The shell will commonly crack posteriorly when dried.

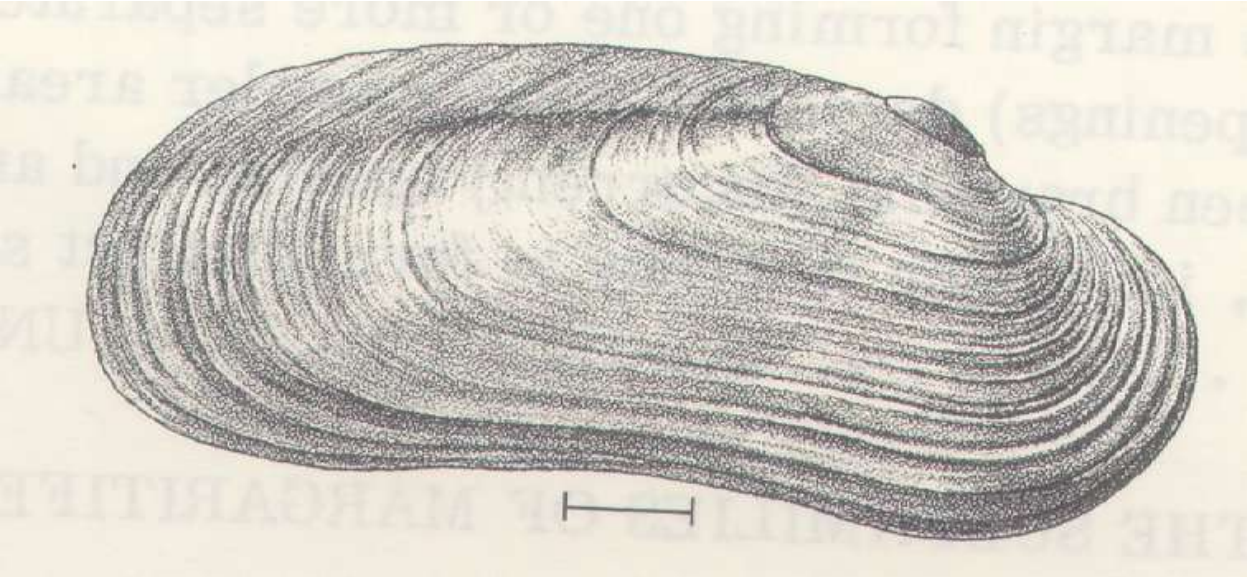

Figure 1. *Cumberlandia monodonta* (Say, 1829) -- line drawing from Burch (1975). The bar is one centimeter.

Internally, the single pseudocardinal tooth is simple and peg-like in the right valve, fitting into a depression in the left. The lateral teeth are straight and single in the right valve, double in the left valve, but with age become fused and represented by an indistinct raised hingeline. The color of the nacre (mother-of-pearl) is white, occasionally granular and pitted, mostly iridescent in young specimens, but becoming iridescent posteriorly in older shells. There is no sexual dimorphism in the shells of this species. Key characters for distinguishing the spectaclecase from other mussels are its large size, elongate shape, arcuate ventral margin, dark coloration, roughened surface, poorly developed teeth, and white nacre (Oesch 1984). No other North American mussel species has this suite of characters.

Taxonomy

Although a member of the mussel family Margaritiferidae, the spectaclecase was originally described as *Unio monodonta* Say, 1829. The type locality is the Falls of the Ohio (on the Ohio River near Louisville, Kentucky and adjacent Indiana), and the Wabash River (probably the lower portion in Illinois and Indiana) (Parmalee and Bogan 1998). Parmalee and Bogan (1998) summarized the synonomy of the spectaclecase. The spectaclecase has been placed in the genera *Margaritana*, *Alasmidonta*, *Margarita*, *Margaron*, and *Margaritifera* at various times in history. Ortmann (1912) placed it in the monotypic genus *Cumberlandia*. Smith (2001) 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 the Committee rules on this, we will use the commonly accepted *Cumberlandia* for the genus of this species. The Service recognizes *Unio soleniformis* as a synonym of *Cumberlandia monodonta*.

Habitat

The spectaclecase occurs in large rivers and is a habitat-specialist, relative to other mussel species. Baird (2000) noted its occurrence on outside river bends below bluff lines. It seems to most often inhabit riverine microhabitats that are sheltered from the main force of current. Utterback's (1915) record of this species in the Northwest Missouri Lakes is puzzling, but may refer to seasonally flooded oxbow lakes along the Missouri River. It occurs in substrates from mud and sand to gravel, cobble, and boulders in relatively shallow riffles and shoals with slow to swift current (Buchanan 1980, Parmalee and Bogan 1998, Baird 2000). According to Stansbery (1967), spectaclecase 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, root masses, and in beds of rooted vegetation (Stansbery 1967, Oesch 1984). Similar to other margaritiferids, spectaclecase tend to be aggregated (Gordon and Layzer 1989), particularly under slab boulders or bedrock shelves (Call 1900, Hinkley 1906, Buchanan 1980, Parmalee and Bogan 1998, Baird 2000), where they are protected from the current. Up to 200 specimens have been reported from under a single large slab in the Tennessee River at Muscle Shoals (Hinkley 1906). Unlike most species that move about to some degree, the spectaclecase may seldom, if ever, move except to burrow deeper; they may die from stranding during droughts (Oesch 1984).

Historical Range/Distribution

The spectaclecase occurred historically in at least 45 streams in the Mississippi, Ohio, and Missouri Rivers and in dozens of tributaries to these rivers; its distribution comprised portions of 15 states and 4 Service regions (Butler 2002). Biologists recorded spectaclecase in the following stream systems (with tributaries): Upper Mississippi River system (Mississippi River [St. Croix (Rush Creek), Chippewa, Rock, Salt, Illinois (Des Plaines, Kankakee Rivers), Meramec (Bourbeuse, Big Rivers), Kaskaskia Rivers; Joachim Creek]); lower Missouri River system (Missouri River? [Platte, River Aux Vases, Osage (Sac, Marais des Cygnes Rivers), Gasconade (Osage Fork; Big Piney River) Rivers]); Ohio River system (Ohio River [Muskingum, Kanawha, Green, Wabash Rivers]; Cumberland River system (Cumberland River [Big South, Caney Forks; Stones, Red Rivers]); Tennessee River system (Tennessee River [Holston, Nolichucky, Little, Little Tennessee, Clinch (Powell River), Sequatchie, Elk, Duck Rivers]); and lower Mississippi River system (Mulberry, Ouachita Rivers). The spectaclecase historically occurred in Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Nebraska, Ohio,

Tennessee, Virginia, West Virginia, and Wisconsin. These states comprise Service regions 3 (Midwest), 4 (Southeast), 5 (Northeast, specifically southwestern Virginia), and 6 (Great Plains).

Current Range/Distribution and Status of Populations

We considered populations of the spectaclecase as extant if live or fresh-dead specimens have been collected since the mid-1980s. Extant populations of the spectaclecase are known from 20 streams in 10 states and 3 Service regions. These include the following stream systems (with tributaries): upper Mississippi River system (Mississippi River [St. Croix, (Rush Creek), Chippewa, Meramec (Bourbeuse, Big Rivers) Rivers]; lower Missouri River system (Gasconade [Big Piney River, Osage Fork] River); lower Ohio River system (lowermost Ohio River [Kanawha, Green Rivers]); Cumberland River system (Caney Fork); Tennessee River system (Tennessee River [Clinch, Nolichucky, Duck Rivers]); and lower Mississippi River system (Mulberry, Ouachita Rivers). The 20 extant spectaclecase populations occur in the following 10 states (with streams): Alabama (Tennessee River), Arkansas (Mulberry, Ouachita Rivers), Illinois (Mississippi, Ohio Rivers), Iowa (Mississippi River), Kentucky (Ohio, Green Rivers), Minnesota (Mississippi, St. Croix Rivers; Rush Creek), Missouri (Mississippi, Meramec, Bourbeuse, Big, Gasconade, Big Piney Rivers; Osage Fork), Tennessee (Tennessee, Clinch, Nolichucky, Duck Rivers; Caney Fork), Virginia (Clinch River), West Virginia (Kanawha River), and Wisconsin (Mississippi, St. Croix, Chippewa Rivers).

The spectaclecase has declined significantly relative to its historical distribution. Known historically from at least 45 streams in 15 states in several major river systems, it is now known to occur in only 20 streams in 10 states. The species is evidently absent from hundreds of river miles and from numerous reaches of habitat in which it occurred historically. Of the 20 extant populations, seven are represented by only a single specimen each and are likely not viable. Although many populations have been extirpated for decades, most surviving populations are facing significant threats. There are relatively strong populations in the Meramec and Gasconade Rivers in Missouri, in the St. Croix River in Minnesota/Wisconsin, and perhaps also in the Upper Clinch River in Tennessee.

THREATS (Describe threats in terms of the five factors in section 4 of the ESA providing specific, substantive information. If this is a removal of a species from candidate status or a change in listing priority, explain reasons for change):

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

The decline of the spectaclecase in the Mississippi River system and other mussel species in the eastern United States is primarily the result of habitat loss and degradation (Neves 1991). These losses have been well documented since the mid-19th century (Higgins 1858). Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining, and sedimentation (Williams et al. 1993; Neves 1991, 1993; Neves et al. 1997; Watters 2000).

Impoundments

Population losses due to impoundments have probably contributed more to the decline and imperilment of the spectaclecase and other Mississippi River system mussels than any other factor. Dams impound the large river habitats throughout almost the entire range of the species. These impoundments have left short and isolated patches of remnant habitat, typically just downstream of the dams. Dams impound most of the Tennessee and Cumberland River and many of their tributaries; these systems were once strongholds for the spectaclecase (Ortmann 1924). The Tennessee Valley Authority (TVA), for example, impounded over 2,300 river miles (about 20 percent) of the Tennessee River and its tributaries with drainage areas ≥ 25 square miles by 1971 (Tennessee Valley Authority 1971). There are thirty-six major dams in the Tennessee River system.

Dams either impound or alter the temperature regimes of approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls. Other major U.S. Army Corps of Engineers (Corps) impoundments on Cumberland River tributaries (e.g., Stones River, Caney Fork) have inundated an additional 100 miles or more of riverine habitat for the spectaclecase. Coldwater releases from Wolf Creek, Dale Hollow (Obey River), and Center Hill (Caney Fork) Dams continue to adversely impact riverine habitat for the spectaclecase in the Cumberland River system. One-third of the streams that the spectaclecase historically occupied are in the Tennessee and Cumberland River systems. Watters (2000) summarized the tremendous loss of mussel species from various portions of the Tennessee and Cumberland River systems. Elsewhere, numerous navigational locks and dams (e.g., upper Mississippi, Ohio, Green, Muskingum Rivers), low-head dams (e.g., St. Croix, Chippewa Rivers), and some high-wall dams (e.g., Kaskaskia, Osage Rivers) have contributed to the loss of spectaclecase habitat. Sediment accumulations behind dams of all sizes generally preclude the occurrence of the spectaclecase.

Channelization

Channel maintenance for barge navigation has adversely affected habitat for the spectaclecase in many large rivers rangewide. Periodic maintenance may continue to adversely affect this species in the upper Mississippi River, lower Ohio River, and Tennessee River. In the Tennessee River, a plan to deepen the navigation channel has been proposed (D.W. Hubbs, TWRA, pers. comm., 2002). In addition, the Corps has proposed to enlarge locks and dams on the upper Mississippi River; this would add to the degradation of spectaclecase habitat in some reaches of the Mississippi River by making more habitats unsuitable by lengthening pools.

Chemical Contaminants

The effects of contaminants are especially profound on juvenile mussels (Robison et al. 1996),

which can readily ingest contaminants adsorbed to sediment particles while feeding and on the glochidia, which appear to be very sensitive to toxicants (Goudreau et al. 1993, Jacobson et al. 1997). Mussels are very intolerant of heavy metals (Keller and Zam 1991, Havlik and Marking 1987), and even at low levels, certain heavy metals may inhibit glochidial attachment to fish hosts (Huebner and Pynnönen 1992). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also adversely affect biological processes (Naimo 1995, Keller and Zam 1991, Jacobson et al. 1997, Keller and Lydy 1997). Bogan and Parmalee (1983) considered the spectaclecase "apparently...unable to survive even minimal amounts of organic pollution or chemical waste."

Among pollutants, ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking 1987). Ammonia is oftentimes associated with animal feedlots, nitrogenous fertilizers, and the effluents of out-dated municipal wastewater treatment plants (Goodreau et al. 1993). In streams, ammonia is most prevalent at the substrate/water interface (Frazier et al. 1996). Due to its high level of toxicity and the occurrence of the highest concentrations in the microhabitats where mussels live, ammonia may be limiting mussel populations at some locations (Augspurger et al. in prep.). Contaminants associated with households and urban areas, particularly those from industrial and municipal effluents, may include heavy metals, chlorine, phosphorus, and numerous organic compounds. Wastewater is discharged through National Pollution Discharge Elimination System (NPDES) permitted (and some non-permitted) sites throughout the country. Elimination sites are ubiquitous in watersheds with spectaclecase populations. Over 250 NPDES sites are located in the Meramec River system alone (Figure 28 in Roberts and Bruenderman 2000).

Agricultural sources of chemical contaminants are considerable, and include two broad categories: nutrient enrichment (e.g., runoff from livestock farms and feedlots, fertilizers from row crops) and pesticides (e.g., from row crops) (Frick et al. 1998). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995). Fertilizers and pesticides are also commonly used in developed areas. These contaminants have the potential to impact all extant populations of the spectaclecase.

Sediment from the upper Clinch River has been found to be toxic to juvenile mussels (Robison et al. 1996, Ahlstedt and Tuberville 1997). Toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream (S.A. Ahlstedt, USGS, pers. comm., 2002).

Toxic chemical spills have killed mussels and fish throughout the range of the spectaclecase, particularly in the upper Tennessee River system in Virginia where officials have documented several spills (Neves 1986, 1991; Jones et al. 2001). Catastrophic pollution events, coupled with pervasive and chronic contamination (e.g. municipal and industrial pollution, coal-processing wastes), have contributed to the decline of the spectaclecase in the Clinch River over the past several decades (Neves 1991). At a power plant, a spill from an alkaline fly ash pond in 1967 and a sulfuric acid spill in 1970 on the Clinch River at Carbo, Virginia, killed mussels for up to 12 miles downstream (Cairns et al. 1971). Mussels have not recolonized the affected river reach (Ahlstedt 1991a), possibly due to persistent copper contamination from the power plant at Carbo (Wilcove and Bean 1994).

One recent spill in the upper Clinch River in 1998 killed at least 7,000 mussels (Jones et al.

2001), including at least 254 specimens of three federally listed species (S.A. Ahlstedt, USGS, pers. comm., 2001). A catastrophic spill in 1999 resulted in a total loss of mussels in approximately 10 miles of the Ohio River. About one million mussels, including two federally listed species, were estimated killed (B. Tolin, U.S. Fish and Wildlife Service, pers. comm., 2002). Chemical spills will likely continue to occur and have the potential to completely eliminate spectaclecase populations from stream reaches and, possibly, entire streams.

Mining

Drainage rich in heavy metals from coal mining and associated sedimentation has adversely impacted portions of the upper Tennessee River system in Virginia. The low pH associated with mine runoff can reduce glochidial encystment rates (Huebner and Pynnönen 1992). Acid mine runoff may thus be having local impacts on recruitment of the spectaclecase. Mine discharge from the 1996 blowout of a large tailings pond on the upper Powell River resulted in a major fish kill (L.M. Koch, Service, pers. comm., 1996); it is reasonable to presume that this also detrimentally affected the mussel fauna there (S.A. Ahlstedt, pers. comm., 2002). Kitchel et al. (1981) found that Powell River mussel populations were inversely correlated with coal fines in the substrate; they found that where coal fines were present, mussels decreased filtration times and increased movements. In a quantitative study in the Powell River, a decline of federally listed mussels and a long-term decrease in overall species richness since about 1980 was attributed to general stream degradation due primarily to coal mining activities in the headwaters (Ahlstedt and Tuberville 1997).

Various mining activities that may adversely affect extant spectaclecase populations also occur outside of the Tennessee River watershed. For example, miners extract bauxite and barium sulfate in the Ouachita River system, and lead and barite mining is common in the Big River (Meramec River system), Missouri. A 1977 lead mine tailings-pond blowout discharged 81,000 cubic yards of mine tailings that affected the lower 80 miles of the Big River (Buchanan 1980, Roberts and Bruenderman 2000). High levels of zinc and lead are still found in river samples (Roberts and Bruenderman 2000) and may hinder stream recovery. Forty-five tailings ponds and numerous other waste piles remain in the watershed (Roberts and Bruenderman 2000). The spectaclecase in the Big River is now restricted to the lowermost portion of the river.

In-stream gravel mining has been implicated in the destruction of mussel populations (Hartfield 1993). Negative impacts associated with gravel mining include stream channel modifications (e.g., altered habitat, disrupted flow patterns, sediment transport), water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature), macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation), and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions) (Kanehl and Lyons 1992). Gravel mining activities may be a localized threat in some large rivers with extant spectaclecase populations. For instance, in the lower Tennessee River where a spectaclecase population survives, gravel mining is permitted at 18 reaches for a total of 47.9 river miles between the Duck River confluence and Pickwick Landing Dam, a distance of over 95 miles (D.W. Hubbs, TWRA, pers. comm., 2002) where good mussel recruitment has been noted for many species in recent years. These activities have the potential to impact the river's precarious spectaclecase population.

Sedimentation

Interstitial spaces within stream substrates provide crucial habitat for juvenile mussels. When fine sediments deposit in these spaces, interstitial flow and habitat space for juveniles is reduced or eliminated (Brim Box and Mossa 1999). Fine sediments may also act as a vector for the delivery of contaminants, such as nutrients and pesticides. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding. These may be important factors in the recruitment failures of mussel populations, including those of the spectaclecase.

Siltation has resulted in increased turbidity levels in many midwestern and southeastern streams. During reproduction, the spectaclecase produces conglutinates that contain glochidia and that appear to attract potential hosts. The success of this reproductive strategy depends on water clarity when mussels are releasing glochidia because fish hosts are likely to be visually attracted to the conglutinates (Hartfield and Hartfield 1996). Increased turbidity levels may also reduce production of food for specataclecase by reducing solar energy in the water column (Kanehl and Lyons 1992).

Dredging or other activities that destabilize instream fine sediments are likely to adversely affect spectaclecase. Dredging to maintain barge traffic on the Mississippi River below the mouth of the Chippewa River in Wisconsin, for example, has reduced mussel diversity, due to the increase in unstable sand substrates (Thiel 1981). Lake Pepin, a once natural lake formed in the upper Mississippi River upstream from the mouth of the Chippewa River, has become increasingly silted in over the past century, reducing habitat for the spectaclecase and other mussels (Thiel 1981).

Agricultural activities are responsible for most of the sediment that enters streams (Waters 1995), including both sediment and chemical run off; agriculture affects 72 percent of the impaired river miles in the country (Neves et al. (1997). Unrestricted livestock access threatens many streams and their mussel populations (Fraley and Ahlstedt 2000). Grazing may lead to a reduction in infiltration rates and an increase in run off; moreover, trampling and removal of vegetation reduces resistance of banks to erosion (Armour et al. 1991, Trimble and Mendel 1995, Brim Box and Mossa 1999). Fraley and Ahlstedt (2000) attributed the decline of the Copper Creek (an upper Clinch River tributary) mussel fauna between 1980 and 1998 to an increase in cattle grazing and loss of riparian vegetation along the stream, among other factors. These impacts may also affect the spectaclecase population in the Clinch below the confluence of Copper Creek and other populations throughout the range of the species.

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>.

The spectaclecase is not a commercially valuable species, but may be increasingly sought by collectors as it becomes more rare. Although scientific collecting is not thought to represent a significant threat, unregulated collecting could adversely affect localized populations.

C. <u>Disease or predation</u>.

Scientists know very little about the occurrence of disease in mussels, although several mussel dieoffs have been documented in the past 20 years (Neves 1986) in which disease may have played a role. Parasites on mussels include water mites, trematodes, leeches, bacteria, and some

protozoa, but biologists do not generally suspect parasites to be limiting mussel populations (Oesch 1984).

Neves and Odum (1989) concluded that muskrat predation could limit the recovery potential of endangered mussel species or contribute to local extirpations in the upper North Fork Holston River in Virginia. Böpple and Coker (1912) noted the occurrence of "large piles of shells made by the muskrats" on an island in the Clinch River, Tennessee, composed of "about one-third" spectaclecase shells. Predation by muskrats may be a seasonal and localized threat to spectaclecase populations, but is probably not a significant threat rangewide. Some species of fish feed on mussels (e.g., freshwater drum, redear sunfish), and potentially upon this species. Various invertebrates (e.g., flatworms, hydra, non-biting midge larvae, dragonfly larvae, crayfish) may feed on juvenile mussels (R.J. Neves, USGS, pers. comm. 2002). There are little or no data, however, to indicate that such predation threatens spectaclecase.

D. <u>The inadequacy of existing regulatory mechanisms</u>.

Most states with extant spectaclecase populations prohibit the taking of mussels for scientific purposes without a State collecting permit, although some states may find it difficult to enforce this requirement. Furthermore, State regulations do not generally protect mussels from other threats that may be likely to incidentally harm habitats and populations.

It is unclear whether agencies have utilized existing authorities, such as the Clean Water Act (CWA), to protect streams and rivers to the degree that is necessary to protect spectaclecase populations. This isolation may have contributed to the general habitat degradation that is evident in riverine ecosystems and the loss of populations of aquatic species in the Midwest and Southeast.

E. <u>Other natural or manmade factors affecting its continued existence</u>.

<u>Population Fragmentation and Isolation</u>

Most of the remaining spectaclecase populations are small and isolated and, therefore, susceptible to extirpation from catastrophic events, such as toxic chemical spills. Even if habitats retain or recover their ability to support spectaclecase after such events, natural recolonization of isolated habitats is unlikely. Population isolation also reduces or eliminates gene flow among local populations. This isolation in combination with small effective population size, can lead to inbreeding depression within populations (Avise and Hambrick 1996).

The likelihood that some populations of the spectaclecase are below the effective population size (Soulé 1980) necessary to adapt to environmental change and persist in the long-term seems high. Many small spectaclecase populations may be reproducing at levels too low to persist despite high adult survival. These populations may also be too isolated to be sustained by recruits from other populations. This species was widespread throughout much of the upper two-thirds of the Mississippi River system and in several tributary systems, and there were likely no or few natural barriers to prevent migration (via fish hosts) among suitable habitats. Construction of dams, primarily during the first half of the 20th century, destroyed spectaclecase populations and isolated others.

Spectaclecase are relatively long-lived (Butler 2002). Therefore, it may take decades for non-reproducing populations to become extinct following their isolation by, for example, the construction of a dam. The occasional discovery of relatively young specimens in river reaches between impoundments (e.g., lower Clinch River) indicates that some post-impoundment recruitment is occurring. The level of recruitment in these cases, however, appears to be insufficient to ensure their long-term viability. Small isolated populations that may now be comprised predominantly of adult specimens could be slowly dying out in the absence of recruitment, even without other the threats described above. In reality, however, isolated populations usually face other threats that result in continually decreasing patches of suitable habitat.

Alien Species

Various alien or nonnative species of aquatic organisms are firmly established in the range of the spectaclecase. The alien species that poses the most significant threat to the spectaclecase is the zebra mussel (*Dreissena polymorpha*). Its invasion of freshwater habitats in the United States poses a threat to mussel faunas in many regions (Ricciardi et al. 1998). Strayer (1999) reviewed in detail the mechanisms in which zebra mussels impact native mussels. The primary means of impact is direct fouling of the shells; zebra mussels attach in large numbers to the shells of live native mussels and other hard relatively stable substrates and may destroy entire mussel beds. The impacts of fouling include impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, locally depleting food resources, and increasing waste products. Heavy infestations of zebra mussels on native mussels may stress the animals by reducing their energy stores. They may also reduce food concentrations to levels too low to allow for survival and reproduction. Zebra mussels may also impede reproduction of unionids by filtering sperm and larvae from the water column. Large deposits of zebra mussel pseudofeces may also degrade habitat for native mussels by, for example, reducing dissolved oxygen concentrations (Vaughan 1997).

Overlapping much of the current range of the spectaclecase, zebra mussels are thoroughly established in the upper Mississippi, lower St. Croix, Ohio, and Tennessee Rivers. The extent to which they will affect the spectaclecase in most areas is largely unknown. The greatest potential for present zebra mussel impacts to the spectaclecase appears to be in the upper Mississippi River. Kelner and Davis (2002) stated that zebra mussels in the Mississippi River from Mississippi River Pool 4 downstream are "extremely abundant and are decimating the native mussel communities." Huge numbers of dead and live zebra mussels cover the bottom of the river in some localities up to 1-2 inches deep (Havlik 2001), where they have significantly reduced the quality of the habitat with their pseudofeces (S.J. Fraley, NCWRC, pers. comm., 2000). Zebra mussels have likely reduced spectaclecase populations in these heavily infested waters. Until 2002, zebra mussel densities in the Tennessee River remained low, but are now abundant enough below Wilson Dam to be measured (G.T. Garner, ADNR, pers. comm., 2002). Zebra mussels are most likely to adversely affect spectaclecase populations in big rivers, large tributaries, and below infested reservoirs and are likely to continue to spread to additional streams in the foreseeable future.

The Asian clam (*Corbicula fluminea*) has spread throughout the Mississippi River system since its introduction into the basin in the mid-1900s. This species has been implicated as a competitor with native mussels for resources such as food, nutrients, and space, particularly as juveniles (Neves and Widlak 1987). Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles (Strayer 1999b; Yeager et al. 2001). He also thought they actively disturb sediments, thereby reducing habitat for juvenile native mussels. Periodic dieoffs may produce enough ammonia and consume enough oxygen to kill native mussels (Strayer 1999). Specific impacts to native unionids, however, remain largely unresolved (Leff et al. 1990, Strayer 1999).

A molluscivore (mollusk eater), the black carp (*Mylopharyngodon piceus*) is a potential threat to native unionids (Strayer 1999b); it has been introduced into North America since the 1970s. The species has been proposed for widespread use by aquaculturists to control snails, the intermediate host of a trematode (flatworm) parasite that affects catfish in ponds in the Southeast and lower Midwest. Black carp are known to eat clams (*Corbicula spp*.) and unionid mussels in China, in addition to snails. They are the largest of the Asiatic carp species, reaching more than 4 feet in length and achieving a weight in excess of 150 pounds (Nico and Williams 1996). In 1994, 30 black carp escaped from an aquaculture facility in Missouri during a flood. Other escapes into the wild by non-sterile black carp are likely to occur.

BRIEF SUMMARY OF REASONS FOR ADDITION, REMOVAL OR LISTING PRIORITY CHANGE:

The spectaclecase has declined significantly relative to its historical distribution. Known historically from at least 45 streams in 15 states in several major river systems, it is now known to occur in only 20 streams in 10 states. The species is evidently absent from hundreds of river miles and from numerous reaches of habitat in which it occurred historically. Of the 20 extant populations, seven are represented by only a single specimen each and are likely not viable. Although many populations have been extirpated for decades, most surviving populations are facing significant threats. These threats include exotic species, especially zebra mussels, delivery and deposition of fine sediments, small population sizes, isolation of populations, livestock grazing, wastewater effluents, mine runoff, unstable and coldwater flows downstream

of dams, gravel mining, and channel dredging. There are relatively strong populations in the Meramec and Gasconade Rivers in Missouri, in the St. Croix River in Minnesota/Wisconsin, and perhaps also in the Upper Clinch River in Tennessee. Populations in each of these rivers, however, may be threatened by various factors; for example, workers have recently discovered zebra mussels in the lower portions of both the St. Croix and Meramec Rivers.

FOR RECYCLED PETITIONS:

a. Is listing still warranted? ___
b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? ___
c. Is a proposal to list the species as threatened or endangered in preparation? ___
d. If the answer to c. above is no, provide an explanation of why the action is still precluded.

LAND OWNERSHIP (Estimate proportion Federal/state/local government/private, identify non-private owners):

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 watersheds. Significant portions of riparian lands along streams occupied by spectaclecase are privately owned. The spectaclecase is predominantly a large-river species. The prevalence of private ownership of riparian lands along streams with extant populations would tend to diminish the importance of public lands. Riparian activities that occur outside or upstream of public lands may be pervasive and have a profound impact on their populations. Habitat protection benefits on public lands may therefore easily be negated by detrimental activities upstream in the watershed.

The St. Croix River population of the spectaclecase occurs within the St. Croix National Scenic Riverway, Minnesota and Wisconsin (SCNSR). Several state-owned properties (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. Numerous other public lands occur in the St. Croix watershed.

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 Keithsburgs, Illinois, the Mark Twain National Wildlife Refuge (MTNWR), Keithsburgs Division, has numerous in-holdings. A small disjunct portion of MTNWR, the Gardner Division, occurs in the Canton and La Grange, Missouri, area.

Parts of the lower Big Piney River and significant 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.

The Nature Conservancy (TNC) has created bioreserves along two stream systems harboring extant populations of the spectaclecase: the upper Clinch/Powell River, Tennessee and Virginia; and upper Green River, Kentucky. Although TNC has few riparian inholdings in these watersheds, they have carried out aggressive and innovative community-based projects in both watersheds that address aquatic species and instream habitat conservation on multiple scales. They have worked with scores of riparian landowners to help them restore and protect streambanks and riparian zones and partner with various other stakeholders in conserving aquatic resources. In addition to the spectaclecase, these activities aid in the recovery of 19 listed mussels and fishes in the Clinch (the largest concentration of aquatic listed species in North America) and 5 listed mussels and a cave shrimp in the Green. The location of projects in the upper Green River provides a significant level of localized watershed protection for the spectaclecase population in that system. A small portion of the Clinch River watershed (e.g., several small tributaries) is located in the Jefferson National Forest.

PRELISTING (Describe status of conservation agreements or other conservation activities):

Funding Programs

The Service=s Partners for Fish and Wildlife program has provided funding to some landowners to enhance riparian habitat in streams with spectaclecase populations. This includes work with the TNC Bioreserves in the Clinch and Green Rivers in Region 4.

Other funding sources play significant roles in the attempts to protect and improve riparian areas to conserve species in associated streams. These include CWA Section 319, Natural Resource Conservation Service programs (e.g., Environmental Quality Incentives Program, Wildlife Habitat Improvement Program, Conservation Reserve Enhancement Program [CREP]), Landowners Incentives Program, National Fish and Wildlife Foundation (NFWF) habitat programs. For instance, Kentucky secured a $110 million CREP grant to protect up to 100,000 acres of riparian lands in the upper Green River watershed, including areas that should be of direct benefit to the river=s spectaclecase population.

Several settlements from large chemical spills are currently under negotiation (J. Schmerfeld, Service, pers. comm., 2002). Money from these court cases may fund projects that would benefit a suite of imperiled species, including the spectaclecase. Similarly, money from an illegal harvest case was used to establish a Mussel Mitigation Trust Fund (MMTF). This trust is used to fund imperiled mussel recovery work.

Research and Surveys

The St. Croix River Research Rendezvous is an annual meeting of biologists and conservationists dedicated to managing the St. Croix River and its diverse mussel fauna, including the large spectaclecase population. Participants annually present their research, which are regularly abstracted in *Ellipsaria*, the newsletter of the Freshwater Mollusk Conservation Society. Recent research subjects involving mussels have included sediment contamination, juvenile toxicity, status surveys, population dynamics, and zebra mussel control. Vaughan (1997) also outlined various measures implemented for mussel conservation in the St. Croix River.

The Green River Bioreserve TNC staff has contracted with the Corps to explore ways in which flow releases from the Green River dam can be modified to improve seasonal flow patterns and in-stream habitat in the river. These efforts may improve conditions for the spectaclecase and other imperiled aquatic organisms in the upper Green River.

Survey work continues in many portions of the range of the spectaclecase. Information gathered from these surveys will help determine its population status and guide its conservation.

The Service funded a project in 2002 to study the genetics of the large extant populations of spectaclecase at Ohio State University. With funding from Service Regions 3, 4, and 5, this project represents a coordinated effort among three Service ecosystems (i.e., Lower Tennessee Cumberland, Ohio River Valley, and Southern Appalachian). Information gathered from this study is likely to aid managers in selecting source populations for reintroduction efforts and determine the genetic variability among and within populations of this species.

Outreach/Education

Most Service field offices now have public outreach/environmental education staff. These staff members are involved in various efforts to educate the general public as to the benefits of habitat preservation and water quality. For instance, in the Southern Appalachian Ecosystem, which comprises the headwaters of the Tennessee River system (among other drainages), aquatic issues form a major part of the outreach efforts in the ecosystem among Service representatives and partners. Representative projects have included posters and videos highlighting aquatic faunal groups, a riparian restoration and conservation video for streamside landowners, endangered species pamphlets, and mussel trunks (outreach/education kits) for educators.

Habitat Improvements and Conservation

The Service is planning for a new national wildlife refuge on the Clinch River. The Service would implement this non-traditional fish and wildlife refuge slowly, relative to the pace at which other refuges are established.

The TVA has modified reservoir releases from some dams in recent years to improve water quality and habitat conditions in many tailwaters. This has enabled the Service and its partners to attempt the reintroduction of some extirpated species. They are planning for the establishment of numerous experimental populations of federally listed species in the affected stream reaches.

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LISTING PRIORITY (place * after number)

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/population	3
	Non-imminent	Monotypic genus	4*
		Species	5
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

Magnitude: Most or all of the 21 known populations of spectaclecase face serious threats to their continued existence. Only three or four populations could be characterized as large and viable and, as stated above, each of these faces serious threats. Threats to the continued existence of spectaclecase include exotic species, especially zebra mussels, delivery and deposition of fine sediments, small population sizes, isolation of populations, livestock grazing, wastewater effluents, mine runoff, unstable and coldwater flows downstream of dams, gravel mining, and channel dredging. 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 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. Therefore, we consider the threats to spectaclecase to be of high magnitude.

Imminence: The immediacy of threats varies among spectaclecase populations. Threats to some populations, such as those isolated and downstream of persistent coldwater releases, clearly have placed them in jeopardy of extirpation (i.e., threats are imminent and the likelihood of survival and recovery are marginal). Seven populations seem to be clearly unviable and another four may also be unviable due to isolation and a lack of recruitment (Butler 2002). Threats and risk of extirpation are clearly imminent for these eleven populations. On the other hand, ten populations are reproducing or may be supported via immigration from large, viable populations. Three or four of these populations may be described as large and viable, although each of these also faces serious threats. For example, zebra mussels occur in the lower St. Croix River, although it is unclear whether they are likely to spread much further upstream due to the transition from lake-like conditions to almost exclusively riverine conditions above river mile 25. [The spectaclecase is currently distributed from RM 15 to 118 and appears to be recruiting over the entire reach (D.J. Heath, WDNR, pers. comm., 2002)]. Populations in the Gasconade and Meramec Rivers of

Missouri and perhaps also in the Upper Clinch River, Tennessee are also large and viable. Although these are threatened in various ways, none of these threats currently seems to place them in imminent danger of extirpation. The Service should closely monitor and work to alleviate the immediacy of threats to these important spectaclecase populations.

Taxonomy: The currently accepted taxonomy places spectaclecase in the monotypic genus, *Cumberlandia*.

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes to the candidate list, including listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all additions of species to the candidate list, removal of candidates, and listing priority changes.

Approve: Marvin Moriarty 03/13/2003
Acting Regional Director, Fish and Wildlife Service Date

Concur: Steve Williams April 5, 2004
Director, Fish and Wildlife Service Date

Do not concur:_____ _____
Director, Fish and Wildlife Service Date

Director's Remarks:

-

-

Date of annual review:_____
Conducted by:_____

Comments:

-

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(rev. 8/02)