Tar River Spinymussel
(*Elliptio steinstansana*)

5-Year Review:
Summary and Evaluation

Photo credit: C.Eads 2012

U.S. Fish and Wildlife Service
Southeast Region
Raleigh Ecological Services Field Office
Raleigh, North Carolina
2014

5-YEAR REVIEW

Tar River spinymussel/*Elliptio steinstansana*

I. GENERAL INFORMATION

A. Methodology used to complete the review

We provided public notice of this five-year review in the *Federal Register* on July 6, 2009 (74 FR 31972) and opened a 60-day public comment period. We obtained pertinent information on the status of this species from the recovery plan, peer reviewed scientific literature and published papers, unpublished reports, and also experts on this mussel species from State agencies, local universities, etc. Once all known and pertinent data were collected for this species, the status information was compiled and the review was drafted by the Asheville Ecological Services Field Office, North Carolina, with assistance from the North Carolina Wildlife Resources Commission and the North Carolina Natural Heritage Program. Final edits were compiled by the species' recovery lead biologist in the Service's Raleigh Ecological Services Field Office, North Carolina. A draft of the five year review was peer reviewed by several experts familiar with the Tar River spinymussel. Comments received were evaluated and incorporated as appropriate (see Appendix A).

B. Reviewers

Lead Region: Southeast Region: Kelly Bibb, 404/679-7132

Lead Field Office: Raleigh, North Carolina: Sarah McRae, 919-856-4520x16

Cooperating Field Office(s): Asheville, North Carolina: John Fridell, 828-258-3939x225

C. Background

1. Federal Register Notice citation announcing initiation of this review: 74 FR 31972; July 6, 2009

2. Species status: (2014) Decreasing; Monitoring and other surveys for the Tar River spinymussel have documented a continued decline in nearly all of the surviving populations of the species.

3. Recovery achieved: (2014) 1 (1=0-25% species' recovery objectives achieved)

4. Listing history

Original Listing
FR notice: 50 FR 26572
Date listed: June 27, 1985
Entity listed: species
Classification: endangered

5. Associated rulemakings: N/A

6. Review History:

Recovery Plan: May 5, 1992
Recovery Data Call: 1994 – 2014
Five Year Review: November 6, 1991. In this review (56 FR 56882), different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors as they pertained to the different species' recovery. In particular, no changes were proposed for the status of this mussel in the review.
Spotlight Species Action Plan: August 10, 2009

7. Species' Recovery Priority Number at start of review (48 FR 43098):

5C. This number indicates a high degree of threat and a low recovery potential.

8. Recovery Plan

Name of plan: (Revised) Recovery Plan for the Tar spinymussel (Elliptio (Canthyria) steinstansana) Johnson and Clarke
Date originally issued: January 16, 1987
Date of revision: May 5, 1992

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Tar River spinymussel is an invertebrate, and therefore, not covered by the DPS policy, and therefore, the policy will not be addressed further in this review.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes.

2. Adequacy of recovery criteria.

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

Although the criteria still adequately reflect the species' biology and habitat, discoveries of occurrences of the species in other watersheds subsequent to the recovery plan revisions made in 1992 may warrant revision of criteria 1 and 2 in the existing revised recovery plan.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? Yes.

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

The Service's recovery plan for the Tar River spinymussel (Service 1992) states that the species will be considered for downlisting to threatened status when the following criteria are met:

1. All three existing populations of *E. steinstansana* in both the Tar River and Swift Creek show evidence of reproduction and recruitment; i.e., gravid females and host fish must be present and populations must contain at least two year classes, including one year class at age 4 or younger.

At the time of development of the revised recovery plan for the Tar River spinymussel (Service 1992), the Tar River spinymussel was known only from the mainstem of the Tar River and from one of its tributaries, Swift Creek; and, believed to be endemic only to the Tar River system in North Carolina. However, current available information indicates the species is endemic to both the Tar River and Neuse River systems in North Carolina (North Carolina Wildlife Resources Commission's (NCWRC) 1999; NCWRC freshwater mussel survey data base (NCWRC database 2014); Sarah McRae, North Carolina Natural Heritage Program (NCNHP) personal communication, 2010). In the Tar River system, the species has been documented only from the mainstem of the Tar River and a few of its tributaries, Shocco Creek, Fishing Creek, Little Fishing Creek, Swift Creek, and Sandy Creek – Sandy Creek is a headwater stream forming Swift Creek (NCWRC data base 2014). In the Neuse River system, the species has been documented from the mainstem of the Little River (NCWRC database 2014; McRae personal communication, 2010), as well as the mainstem of the Neuse River (J Smith, NC Museum of Natural Sciences, pers. comm., 2014).

Monitoring and other surveys for the Tar River spinymussel have documented a continued decline in nearly all of the surviving populations of the species (NCWRC database 2014). Based on the most recent survey data from the NCWRC's database, the species may be extirpated from the

mainstem of the Tar River (last observation was two live individuals in 2001; no live or shells were found during surveys in 2002, 2007, or 2013) and Shocco Creek (last and only record was a shell found in 1993, many surveys since have not located the species) (NCWRC database 2014). Surveys in Swift Creek from 1987-2002 found a total of 353 spinymussels (61 live (some likely duplicative records of the same individual found on multiple surveys, as individuals were not tagged) and 292 shells), yet only one individual was found during surveys in Swift Creek in 2005 and none during surveys since (covering 2006-2014) (NCWRC database 2014; C Eads, pers. comm., 2014); in addition, none have been recorded from Sandy Creek since 1988 (NCWRC database 2014). A total of 67 individuals have been observed in Little Fishing Creek, during surveys from 1993-2014 (some potential duplicative records; NCWRC database 2014; C Eads, pers. comm., 2014); only a total of 7 individuals in Fishing Creek during surveys from 1999-2014 (NCWRC database 2014, C Eads, pers. comm., 2014). A total of only 4 individuals have ever been recorded from the Little River (Neuse River basin) – one each in 1998, 2005, 2010, and 2011; repeated surveys since have not recorded any additional specimens (NCRWC database 2014; T Savidge, pers. comm., 2010). Only two unusually large specimens have been documented from the mainstem of the Neuse River (R Nichols and J Smith, pers. comm., 2014).

Additional surveys are needed to determine the status of the Tar River spinymussel in the mainstem of the Tar River, Shocco Creek, and the mainstem of the Neuse River; however, based on all available information there is no evidence of reproduction and recruitment within these populations and all three populations may now be extirpated. More intensive survey efforts are needed in the Sandy/Swift Creek basin to determine if the species continues to persist. Although limited levels of reproduction and recruitment may be occurring within the Little Fishing Creek/Fishing Creek and the Little River populations, the amount of recruitment occurring does not appear to be at levels high enough to maintain these populations. All of these populations appear to be at extremely low levels. Because there are so few individuals, the proximity of males and females may be limiting their reproductive success.

2. <u>The reestablishment or the discovery of two additional viable populations has occurred (excluding the Tar River populations in Edgecombe and Nash Counties and the Swift Creek population). These populations should occur in two additional sections of the Tar River (or other streams if new information identifies them as historical habitat of the species), one each in Franklin and Pitt Counties, North Carolina -- areas historically supporting populations of *E. steinstansana*. A viable population is defined as a naturally reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural environmental changes. The number of individuals needed to reach a</u>

viable population will be determined as one of the recovery tasks. Each population should contain at least three subpopulation centers (a continuous river segment or a series of closely spaced river segments containing habitat and *E. steinstansana* as a breeding unit) dispersed such that a single catastrophic event would not eliminate the Tar spinymussel from newly reestablished locations. The subpopulation centers should be at least 1 river mile apart. These new subpopulations should also show evidence of reproduction and recruitment as described for criterion 1.

As indicated under the first criterion above, in addition to the mainstem Tar River and Sandy Creek/Swift Creek populations of the Tar River spinymussel, three additional populations (and one relict population) have been discovered since development of the 1992 revised recovery plan for the species – the Shocco Creek population, Little Fishing Creek/Fishing Creek population, and the Little River population, and shells from the Neuse River mainstem. However, as also stated above, the mainstem Tar River, Shocco Creek, and mainstem Neuse River populations may now be extirpated, though additional surveys are needed to determine this. Furthermore, detection of individuals in the Sandy/Swift Creek population has declined markedly over the past 15 years. In addition, of the other remaining populations, only the Little Fishing Creek/Fishing Creek population appears to meet this criterion and even its viability is questionable due to the low numbers and lack of recruitment that has been observed in recent years.

3. The population units and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence.

Although several partnerships and conservation initiatives have contributed to the protection and restoration of lands and riparian buffers at scattered sites in the upper Tar River system (through acquisition/transfer of lands from, memoranda of agreements, and conservation agreements with major timber companies and other landowners in the watershed), existing and potential future land-uses within the watersheds of streams supporting the species continue to affect and threaten the surviving populations. The surviving populations appear to be extremely small, highly fragmented, isolated from each other, and restricted to short stream reaches where they continue to be highly vulnerable to extirpation from stochastic and chronic events (e.g., drought, toxic spills, runoff, problems associated with wastewater discharges, even large trees that fall into the stream and change local hydrology and sediment transport dynamics) associated with existing and potential future land uses. In 2005-2006, the Swift Creek population was impacted by land clearing and development of a residence that resulted in large amounts of sediment runoff directly into Tar River spinymussel habitat. The primary factors affecting and endangering the species and its habitat

appear to be impacts (e.g., water pollution, sedimentation, bank instability, loss of instream habitat stability and diversity, etc.) associated with: 1) the loss of forest lands and forested riparian buffers; 2) increases in woody debris and blow-downs of large trees into the stream which change local hydrology and sediment transport dynamics; 3) poorly controlled stormwater runoff and pollutants from forestry and agricultural (livestock and crop farming) activities, residential and commercial development, and road construction, use, and maintenance; 4) municipal and industrial wastewater discharges; 5) reduced base flows due to increased runoff and reduced infiltration from cleared lands and increased imperious surfaces, water withdrawal for irrigation, and reoccurring and prolonged drought conditions; 6) reservoir/water supply construction and operation; 7) alteration of lotic habitat by beavers, and, 8) likely impacts from invasion, expansion in range, and increased densities of the Asiatic clam [*Corbicula fluminea*]) (adapted from Service et al., 2005).

Past and on-going crop and livestock farming and forestry operations threaten several of the populations with loss of hardwood and mixed forest lands and forested riparian buffers; runoff of silt and other sediments; fertilizer, insecticide, and herbicide drift, runoff, and contamination of groundwater entering the streams; and, destabilization of stream banks and substrate (from excessive stormwater runoff, loss of bank vegetation, livestock entering streams, etc.). Pesticide runoff or discharge has been implicated as the cause of a massive die-off of the Tar River spinymussel in Swift Creek in1990 (Fleming et. al. 1995). The degradation of aquatic habitat associated with forestry and timbering operations have been identified as a major cause of habitat degradation in the Swift Creek (Alderman, 2005; J Fridell, pers. obs., 2005, 2009, and 2010) and Shocco Creek watersheds (J. Fridell, pers. obs., 1993). Increased beaver activity, likely resulting from loss of large trees and an increase in a food supply of small trees and shrubs in close proximity to the streams following timbering operations (Alderman, 2005), is affecting and fragmenting habitat in Swift Creek (Alderman, 2005; S Ward, USFWS Raleigh, NC pers. comm., 2010; J Fridell, pers. obs., 2009 and 2010) and the Little River (pers. obs., 2014). The Tar River and Fishing Creek watersheds are also considered to have a high potential for, and to have suffered water and habitat quality degradation from, nonpoint source pollution, especially from croplands and animal operations (Service et. al., 2005).

Point source discharges also continue to impact/threaten habitat quality in the Tar River (Service, 1992), Swift Creek, and Fishing Creek drainages (Service et al., 2005); and in 2008 Wake County, North Carolina proposed a new wastewater discharge which threatens habitat for the Little River population of the species, although that project is not currently being pursued (T Augspurger, pers. comm., 2008, pers. obs., 2014). In 1999, the North Carolina Division of Water Quality (NCDWQ) (1999) identified

wastewater treatment plant discharges as sources limiting water quality in the Fishing Creek Basin, and two small permitted discharges in lower Swift Creek have a history of violating their permit limits (Service et al., 2005).

Prolonged and reoccurring drought conditions pose a significant threat to all of the surviving populations. Reduced water quality/bioclassification ratings in portions of the Swift Creek and Fishing Creek Watersheds in 2003 were likely attributed to basin-wide drought conditions in 2001 and 2002 (NCDWQ, 2003; Service et al., 2005). In addition, the entire range of the Tar River spinymussel was encompassed in the exceptional drought afflicting large portions of the southeast from fall 2006 through 2008 (the National Oceanic and Atmospheric Administration's worse category of drought conditions, NOAA 2008). Habitat of all of the surviving populations was severely compromised by record low flows and extensive mussel mortality was documented in several areas. In addition to stranding and desiccation, mussels were exposed to increased predation and concentrated pollutants from wastewater discharges in streams with unprecedented low stream flows and, hence, no or inadequate dilution of pollutants. Reproduction and fish host availability were also likely eliminated or significantly reduced.

Dams and impoundments on the Tar River in the vicinity of Rocky Mount, North Carolina, also continue to fragment and limit mussel habitat availability in the Tar River. In addition, in order to accommodate future increased water supply demands from existing and future residential and industrial growth in the surrounding area, the City of Raleigh in Wake County, North Carolina has proposed a new water supply reservoir on the Little River. In addition to providing for increased growth, and the effects associated with this growth, this reservoir threatens the hydrology and aquatic habitat quality of the river, and will fragment and isolate upstream and downstream habitat and populations of aquatic species. The lasting economic downturn (2008-2013) stymied the immediate need for the water supply project, although it is highly probable that the reservoir project will be resurrected when there is an uptick in growth, and concurrent increased demand for water in Wake County.

Since development of the revised recovery plan for the Tar River spinymussel (Service 1992), the Asiatic clam has invaded all of the streams supporting populations of the Tar River spinymussel and has reached high density levels in many areas within these streams, especially in areas where the substrata has become degraded by excessive siltation and fine sand (J Alderman, pers. comm., 2010; C Eads, pers. comm., 2010; pers. obs. 2014). Although the extent of threat that the Asiatic clam presents to the Tar River spinymussel is unknown and requires further study, it is probable there is competition for food, oxygen, and space

between the clam and native mussels (Alderman 2005), especially at the juvenile stage (Neves and Widlak, 1987).

4. Where habitat has been degraded, noticeable improvements in water and stratum quality have occurred.

   Since the early 1990s, habitat quality has declined significantly in the Sandy Creek/Swift Creek watershed, primarily as a result of large scale timber operations within the watersheds of these streams, but also from the effects of other land use activities within their watersheds and increased beaver activity within the streams (Alderman 2005). Beginning in the late 1980s and early 1990s, and continuing to date, extensive clear-cutting and conversion of large landscapes to pine plantations and the associated loss and of narrowing riparian buffers resulted in significant increased stormwater runoff and soil erosion and, in many areas along the creeks where only narrow buffers were left, windfall and other wind damage of remaining stream-side trees. This has lead to an excessive amount of fine sediments, woody debris, and log jams within the streams' channel, changing the stream bottom substrate in large reaches of the creek from the coarse sand and gravel substrate preferred by the Tar River spinymussel to unsuitable, unstable, silty-sand substrates (Alderman 2005; J Fridell, pers. obs., 2005; 2009; and 2010; C Eads, pers. comm., 2014).

   All of the streams supporting populations of the Tar River spinymussel were affected by severe - exceptional drought conditions which persisted from the fall of 2006 through 2008. Flow in reaches of several of the streams supporting the species was significantly reduced and in places completely dried up (R Nichols and C Wood, NCWRC, Raleigh NC, pers. comm., 2008; J Fridell, pers. obs., 2008). However, with the exception of the effects of this drought, impacts to Tar River spinymussel habitat within the other streams supporting the species have been more localized than that experienced in Swift Creek (R Nichols pers. comm., 2010; S McRae, NCNHP, pers. comm., 2010; J Fridell, pers. obs., 2008).

5. Monitoring of all population units indicates no downward trends over a period of 15 to 20 years.

   Monitoring and other surveys for the Tar River spinymussel have documented a decline in numbers and distribution throughout the species' range, including likely extirpation of populations in the mainstem of the Tar River and Shocco Creek (NCWRC database 2014) (see II.B.3.1. above).

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends:
Although there have been discoveries of additional occurrences of the Tar River spinymussel since the species was listed as endangered in 1985 (specifically, Little Fishing/Fishing Creek, Shocco Creek, Little River, and relict shells from the Neuse River), the species continues to have a very fragmented, relict distribution and available trend information (NCWRC database 2014) indicates that the species is rapidly declining throughout its range. Based on available survey data, all extant populations are extremely small in numbers and three of these populations, the Tar River, Shocco Creek, and Neuse River populations, may possibly be extirpated, though additional surveys are needed to confirm this (S McRae pers. comm., 2010). Surveys in the Sandy/Swift Creek basin have also shown dramatic declines in numbers, and intensive survey efforts are needed to determine whether the species continues to persist. Although a very low level of successful reproduction may be occurring in the Little Fishing/Fishing Creek and Little River populations, all of the surviving populations appear to be well below self-maintenance levels (see discussion of Recovery criteria #1 above).

b. Genetics, genetic variation, or trends in genetic variation:
No information is currently available concerning genetic health of the surviving populations. However, due to the extremely small size of the surviving populations (see discussion of Recovery criteria #1 above), the genetic viability of the populations is of high concern (although R Nichols (pers. comm. 2014) notes that some mussels with small populations size may not have problems with genetic variation, as doubly uniparental inheritance (as seen in several bivalve species) highly reduces the genetic problems of small populations); in fact, most, if not all, of the populations appear to be well below the numbers necessary to successfully reproduce at levels necessary to maintain themselves.

c. Taxonomic classification or changes in nomenclature:
Preliminary results from recent phylogeographic studies by Appalachian State University indicate that Tar River spinymussel is very closely related (i.e., putative sister taxa) to the James spinymussel (*Pleurobema collina*), and that both the Tar River spinymussel and James spinymussel likely belong to a genus other than *Elliptio* or *Pleurobema* (Perkins et al. 2014). This study also indicted historical gene flow between the Neuse and Tar populations of the Tar River spinymussel.

d. Spatial distribution, trends in spatial distribution, or historic range:
Current available information indicates the species is endemic to both the Tar River and Neuse River systems in North Carolina. While the species' known historic and current ranges have been expanded since development of the 1992 recovery plan, the species' distribution remains highly fragmented. All surviving populations are small to extremely small in numbers, restricted in range, and, based on the most recent survey data within each river system, each of the surviving populations appears to be isolated from the other populations in the same river system by impoundments and/or extensive unoccupied stream reaches (NCWRC database 2014).

e. Habitat:
Suitable habitat for the Tar River spinymussel appears to be extremely limited throughout the species' range, as evidenced by the low numbers of individuals within each population. Within the Tar River system, the species currently has a highly fragmented, relict distribution. Based on historic and recent records for the species (NCWRC database 2014), the surviving occurrences exist as small population fragments, restricted primarily to short reaches of tributary streams.

The species' historic distribution within the Neuse River system is less certain. Within the Neuse River system, the species has been recorded from two sites in the mainstem of the Little River and one in the Neuse River (NCWRC database 2010; J Smith, pers. comm., 2014) and Tar River spinymussel habitat within the Little River, although still present, appears to be limited and patchily distributed (T Savidge, pers. comm., 2010; S McRae pers. comm., 2010).

Suitable aquatic habitat in the streams currently supporting occurrences of the species, which appears to be already extremely limited in most of these streams, is presently either in decline or threatened with decline by existing and future changes in land use activities – agricultural and forestry activities, reservoir construction, residential and commercial development activities, point and non-point source pollutant discharges, and reoccurring drought conditions.

f. Other:
The Service has been working with the NCWRC and the NCSU to establish captive refugia populations of the Tar River spinymussel and conduct controlled propagation of the species for population augmentation and reintroduction as necessary and feasible. Through these efforts, some aspects of the species' life history have been determined, including the time of gravidity (early April thru mid-July) and likely fish host species (listed below) for Tar River spinymussel glochidia (larvae) (C Eads, pers.

comm., 2010). Also, it has been learned that females of the species release conglutinates (packets of glochidia) and release up to four or five times during their brooding season (C Eads, pers. comm., 2010).

List of fish species that successfully transformed Tar River spinymussel glochidia in the lab:
Hosts:
White shiner (*Luxilus albeolus*)
Pinewoods shiner (*Lythrurus matutinus*)
Bluehead chub (*Nocomis leptocephalus*)
Satinfin shiner (*Cyprinella analostana*)

Marginal hosts:
Creek chub (*Semotilus atromaculatus*)
Swallowtail shiner (*Notropis procne*)

2. Five-Factor Analysis

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

Based on available data, there are six known populations, and likely only three surviving populations of the Tar River spinymussel in two river basins. All surviving populations of the Tar River spinymussel are small to extremely small in size, highly fragmented and isolated from one another, and appear to be in serious decline. We have evidence that all of the surviving populations continue to be threatened by many of the same factors identified in Service's revised recovery plan for the species as leading to the loss and decline of the species throughout significant portions of its historic range and threats to surviving populations, including habitat fragmentation, loss, and alteration resulting from impoundments, wastewater discharges, loss of forested lands and riparian buffers, and the runoff of silt and other pollutants from ground disturbance activities (see section II-B-3(3) above). For example, despite repeated surveys, no live individuals of the species have been observed in the Sandy/Swift Creek watershed since 2005. This can be attributed to the cumulative effects of multiple threats - the pesticide-induced die off, drought, and large scale clearing of timber within the watershed. The Neuse River basin population(s) will likely face development-related pressures as several Wake County municipalities (e.g., Raleigh, Rolesville, Zebulon and Wendell) expand and grow. If the water supply reservoir and wastewater discharge on the Little River in Wake County are pursued, the population in the Little River will be under imminent threat from decreased flows and chemical contaminants from discharged effluent.

Water quality continues to be an issue affecting habitat quality, as freshwater mussels are some of the most sensitive forms of aquatic life to toxicity of common pollutants in surface waters, such as ammonia, chlorine, chloride, copper, nickel, lead, potassium, sulfate, and zinc (Augspurger et al. 2003; Wang et al. 2007a, 2007b, 2010). Recent studies indicate that Tar River spinymussels are sensitive to contaminants (T Augspurger, pers. comm. 2014), thus pollutants are important to consider in managing Tar River spinymussel populations.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization for commercial, recreational, scientific or educational purposes was not specifically considered to be a limiting factor in 1985 when the species was listed as endangered or in the species' 1992 revised recovery plan. We have no new information to indicate that this has changed.

c. Disease or predation:

At the time of listing, disease and predation were not considered significant threats to the Tar River spinymussel. However, based on available information, all the surviving populations are small in number; most appear to be extremely small with only a few live Tar River spinymussels documented during the most recent surveys (NCRWC database 2014). Several small mammal species are known to feed on mussels including muskrat, otter, raccoon, mink, etc. While predation is not thought to be a significant threat to a healthy mussel population, it could, as suggested by Neves and Odum (1989), limit the recovery of endangered mussel species or contribute to the local extirpation of mussel populations already depleted by other factors. Also, while we do not have any new information indicating that disease has been a contributing factor in the decline of the Tar River spinymussel, extensive mussel kills or die-offs have been reported at various times in streams throughout the United States. The cause(s) of many of these die-offs is unknown, but disease has been suggested as a possible factor.

d. Inadequacy of existing regulatory mechanisms:

The overwhelming majority of statutory or regulatory mechanisms capable of affording protection to the Tar River spinymussel derive from the species' Federal status under the Endangered Species Act (Act) of 1973, as amended. This statute provides various protections to this species that would not otherwise occur under any other Federal, state, or local statute. In particular, federally funded activities with the potential to affect this species that are authorized, funded or otherwise carried out by Federal agencies are subject to section 7 consultation with the Service to ensure that such actions do not jeopardize the continued existence of the species. Section 7(a)(1) of this statute also directs Federal agencies to utilize their

authorities to assist the Service in the recovery of species (such as Tar River spinymussel) listed under this statute.

Many of the activities that pose a significant threat to the surviving populations of the Tar River spinymussel and its habitat are not subject to the regulations of section 7 of the Act because they do not have any federal involvement – no federal permits, federal authorization, or federal funding associated with the activity – and therefore no requirement for consultation with the Service if they may adversely affect federally-listed species. Accordingly, most of these activities occur without any coordination with the Service and are reviewed and regulated, if any review/regulation takes place, only by state and local regulatory agencies/governments for compliance with any applicable state and local regulations/ordinances[1]. Neither the State of North Carolina nor the local governments with jurisdictions within the watersheds of streams supporting populations of the Tar River spinymussel, currently have regulations/ordinances that are adequate to protect the species from many of the adverse effects of agriculture, private forestry, and residential and commercial development activities (e.g., degradation or loss of riparian buffers; impacts to the streams' hydrographs; stormwater runoff of sediments and other non-point source pollutants; wastewater discharges, etc.).

The Tar River spinymussel is listed as endangered by the state of North Carolina. The NC Wildlife Resources Commission administers the NC Endangered Species Act (ESA) (General Statues 113-331 to 113-337; enacted in 1987), which protects animals, and maintains the state's list of "protected animal species." The NC ESA generally prohibits killing, harming, possessing, or trading protected species without a permit (NC NHP 2001; NC Bar Association 2013), and regulates collection and commercial trade of species listed under the statute. This law does not prohibit habitat modification (NC NHP 2001).

Since 2011, several state environmental regulations have been under intense review and scrutiny, dubbed as "regulatory reform". The NC General Assembly has considered regulatory reform legislation that repeals "unnecessary" state agency rules (NC General Assembly HB74, 2013), and those directly affecting the Tar River spinymussel include provisions that repeal stream buffer requirements in the Neuse and Tar-Pamlico River basins, as well as the elimination of a dedicated funding source for parks/conservation programs. Further, the NC General

[1] Unless it can be proven: (1) in a federal court of law that violation of section 9 of the Act, which prohibits the "take" of federally listed species, or other federal regulation, has occurred as a result of the activity; or, (2) that violation of section 9 will occur and a permit pursuant to section 10(a)(1)(B) of the Act is required. However, under the former scenario, impact(s) to the species has (have) already occurred or is(are) occurring, and the latter requires notification of the Service of the impending activity.

Assembly has decided that if a federal environmental standard exists, state and local environmental rules should not go beyond the federal requirement except in extraordinary circumstances (Smith 2013).

One area where this is a concern relates to the Clean Water Act. Recent studies indicate that current federal and state water quality standards for several pollutants commonly found in wastewater discharges and stormwater runoff are either not available (no criteria or standard derived) or likely not protective of freshwater mussels and current regulations controlling the discharge or runoff of these pollutants are not protective. For example, studies show that ammonia is extremely toxic to freshwater mussels at levels well below the current federal standard for this pollutant (Augspurger et al. 2003). Significant sources of ammonia include municipal and package wastewater treatment plants, agricultural runoff (animal wastes and chemical fertilizers), and lawn and turf runoff. In 2013, the U.S. Environmental Protection Agency (EPA) revised the water quality criteria for ammonia (EPA 2013). Acute and chronic criteria were developed to protect organisms from both immediate effects, such as mortality, and longer-term effects on reproduction, growth and survival, respectively. EPA provides several supporting documents to aid states considering adoption of the updated criteria, but North Carolina has not undertaken this effort. Also, recent studies indicate that pharmaceuticals and personal care products are commonly being discharged into surface waters and may be having acute and chronic impacts on aquatic species. For example, Fluoxetine, an often prescribed antidepressant drug, is increasingly being detected in surface waters at high enough levels that can cause female mussels to discharge/abort undeveloped glochidia and has the potential to disrupt numerous other aspects of native mussel reproduction (Bringolf et al., 2007). However, very few if any treatment plants monitor for these pollutants and there are no federal or state standards regulating the discharge of pharmaceuticals or numerous other pollutants commonly found in wastewater discharges.

e. Other natural or manmade factors affecting its continued existence:

The genetic viability of the surviving populations remains a significant concern. All of the remaining populations of the Tar River spinymussel appear to be effectively isolated from one another by impoundments and long reaches of highly degraded habitat; and, the numbers of all of the surviving populations appear to be well below the level necessary to maintain a reproductively viable population (Courchamp et al. 2008, Kramer et al. 2009).

The multitude of effects of climate change has and will likely continue to impact the Tar River spinymussel. Many species of native freshwater

mussels are especially sensitive to climate change because of their patchy distribution, limited mobility, and dependence on host fish for their larval stage, as well as fragmentation of their ranges by habitat alteration (Newton and Lubeck 2013). Thermal regime change (e.g., higher temperatures) and habitat alteration/degradation (e.g., severe storm events and droughts) are climate change threats that aquatic species will face in the future (Pandolfo 2014). These changes can alter nutrient cycling, decrease habitat availability, decrease water quality, and possibly introduce parasites and pathogens into freshwater ecosystems (Pandolfo 2014 and references therein). Furthermore, climate change can alter species interactions and cause shifts in species distributions (Pandolfo 2014 and references therein).

Streams supporting populations of the Tar River spinymussel have been affected by reoccurring drought conditions, including prolonged severe - exceptional drought conditions which persisted from the fall of 2006 through 2008 (NOAA 2008) – flow in reaches of several of the streams supporting the species was significantly reduced and in places completely dried up. In addition, from 2010-2012, Pandolfo (2014) found that temperatures in streams supporting the Tar River spinymussel reached thresholds that have been shown to cause harm to mussels in laboratory tests. These temperatures are also known to cause harm to several fish species, thus threatening the host-fish interaction with mussels. A recent study in Oklahoma found that mussel assemblages shifted from thermally sensitive to thermally tolerant species, and that these changes corresponded with a period of drought in the river (Galbraith et al. 2010). Thus, droughts and thermal stress, in conjunction with several other factors, could be shifting the mussel communities and thus threatening Tar River spinymussel persistence in the basins.

D. Synthesis

Although there have been discoveries of additional occurrences of the Tar River spinymussel since the species was listed as endangered in 1985, the species continues to have a very fragmented, relict distribution and available trend information indicates that the species is rapidly declining throughout its range. Based on available survey data, all extant populations are extremely small in numbers and three of the populations in the Tar River, Shocco Creek, and Neuse River may possibly be extirpated, though additional surveys are needed to confirm this. Surveys in the Sandy/Swift Creek basin have also shown dramatic declines in numbers, and intensive survey efforts are needed to determine whether the species continues to persist. Although a very low level of successful reproduction may be occurring in the Little Fishing/Fishing Creek and Little River populations, all of the surviving populations appear to be well below self-maintenance levels. Because of these extremely low population levels, the proximity of

males and females may be limiting their reproductive success. All surviving populations are isolated from one another and restricted to short stream reaches. Habitat in the streams were the species exists generally appears to be marginal at best, as evidenced by the extremely low numbers of individuals found, and patchily distributed. All surviving populations are under significant and increasing threat of extirpation from existing and likely future land use activities. Once extirpated, opportunities for populations to reestablish through natural recolonization do not appear to be possible.
Due to the threats from habitat destruction and modification, inadequacy of existing regulatory mechanisms, small population size, and climate change, the Tar River spinymussel continues to meet the definition of endangered under the ESA.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

1. Improve planning, coordination, and efficacy of recovery activities with key partners (e.g., NCWRC, NCDWR, NCNHP, USFWS, NRCS, local governments, local conservation NGOs, researchers, etc.) by meeting at least biennially to share information and review and recommend priority recovery actions.
2. Formalize a detailed population and habitat monitoring plan for all surviving populations.
3. Continue working with state and local governments to implement protective regulations/ordinances for addressing the impacts and threats from forestry, agriculture, development, and other land disturbance activities; wastewater discharges; and other impacts and threats to aquatic habitats within the streams supporting the Tar River spinymussel. One of the highest priorities is to continue working closely with state and local partners to develop, encourage public support for, and effectively implement protective water quality management strategies for the Tar River spinymussel such as protective stream designations and site-specific plans like the those required by *North Carolina Procedures for Assignment of Water Quality Standards* Rule 15A NCAC 02B .0110. In addition to addressing nonpoint source pollution, any strategy/plan should work to eliminate surface wastewater discharges from streams supporting the species. The strategy/plan should also result in implementation of regulations for water withdrawals that are protective of the streams' hydrology, especially during periods of low flow.
4. Continue analyzing threats to the species and measures for off-setting these threats; determine species specific vulnerability to commonly discharged wastes (e.g. ammonia, chlorine) for which present discharge limits may not be protective of mussels.

5. Continue captive propagation efforts. Several of the extant populations are likely to become extirpated in the very near future. These populations represent a significant portion of the species' historic geographic range. Without immediate efforts through captive holding and propagation to maintain the genetic material from these populations for augmentation and reintroduction efforts, we may forever lose the genetic strains necessary for reestablishing these and other already extirpated populations of the species.
6. Work in coordination with federal and state agencies, knowledgeable biologists, and land stewards, using information about current water quality, fish and mussel assemblages, current watershed conditions, and prospective protective mechanisms to identify and evaluate candidate streams for potential reintroduction efforts and reintroduce/establish new populations were feasible. Because of their small size, amount of habitat degradation that has already occurred, existing land uses and degree of future threats, conservation of some of the extant populations in the streams they currently occupy is likely untenable. Immediate efforts should be undertaken to secure individuals from these populations and move them to captivity for propagation or refugia streams and use for reintroduction to suitable habitats. This would maintain the genetic diversity represented in these populations, while allowing for development of wild, viable populations within the species' historic range.
7. Continue habitat, life history, and captive propagation studies aimed at specific conservation applications, including: water temperature tolerances and optimal range; instream flow requirements, DO requirements, and specific impacts from altered flow regimes; support continued controlled propagation experiments with congeneric surrogates and permit work directly with Tar River spinymussel.
8. Continue working with partners to acquire land and establish conservation easements and restore forested buffers and instream habitat. Initially these efforts should be focused primarily on the best of the remaining populations of the Tar River spinymussel and areas targeted for population augmentation and/or reintroduction of the species.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Tar River spinymussel (*Elliptio steinstansana*)

Current Classification: Endangered
Recommendation resulting from the 5-Year Review

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X__ No change is needed

Review Conducted By: Initially drafted by John A. Fridell, Asheville Ecological Services Field Office, Asheville, NC; finalized by Sarah McRae, Raleigh Ecological Services Field Office, Raleigh, NC

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date 8/25/14

REGIONAL OFFICE APPROVAL:

for

Lead Regional Director, U.S. Fish and Wildlife Service

Approve _____ Date 9-10-14

APPENDIX A: Summary of peer review for the 5-year review of Tar River spinymussel

Peer Reviewers:
John Alderman, Alderman Environmental Services, Pittsboro, North Carolina; Telephone: (919) 542-5331

Dr. Arthur Bogan, Curator of Aquatic Invertebrates, North Carolina Museum of Natural Sciences, Raleigh, North Carolina; Telephone: (919) 707-8863

Chris Eads, North Carolina State University College of Veterinary Medicine, Raleigh, North Carolina; Telephone: (919) 645-8657

Sarah McRae, Aquatic Ecologist, North Carolina Natural Heritage Program; currently working with the USFWS and responsible for completing this review.

Rob Nichols, Aquatic Diversity Research Coordinator, Eastern Region, North Carolina Wildlife Resources Commission; Telephone: (919) 896-6254

Tim Savidge, The Catena Group, Raleigh, North Carolina; Telephone: (919) 417-2314

A. Peer Review Method: A draft 5-year review for the Tar River spinymussel was sent to each of the reviewers requesting their review and any other comments or additions that should be included in the document. All reviewers have extensive knowledge of this species and have worked with the species in field conditions.

B. Peer Review Charge: Reviewers were charged with providing a review of the document including any other comments and/or additions appropriate to include. Reviewers were not asked to comment on the legal status of the species.

C. Summary of Peer Review Comments/Report: Reviewers responded verbally and/or by email with responses placed in the file record. All reviewers thought the information in the draft 5-year review provided to them was accurate. They did provide some additional references and recommendations that were incorporated into the 5-year review as appropriate.

D. Response to Peer Review: Recommendations from the reviewers were included in the document.