

Slender Chub
Erimystax (=Hybopsis) cahnii

**5-Year Review:
Summary and Evaluation**

**U.S. Fish and Wildlife Service
Southeast Region
Cookeville Ecological Services Field Office
Cookeville, Tennessee**

5-YEAR REVIEW
Slender chub, *Erimystax cahni*

I. GENERAL INFORMATION

A. Methodology used to complete the review

This five-year review was conducted by the Service's Cookeville Ecological Services Field Office. The primary source of information used in this analysis was the species' recovery plan (Service 1983), but information was also obtained from information on file, reports, and studies. We published a notice in the *Federal Register* on July 29, 2008 (73 FR 43497), announcing the initiation of this 5-year review for this species and opened a 60-day public comment period. We provided drafts of this 5-year review to individuals at several Federal and State government agencies, universities, and non-governmental conservation organizations who have experience with this fish or might have additional information about the species. Reviewers were asked to provide comments and any relevant information about the threats to this species, the current status of the species, and the likelihood that the species might be extinct (See Appendix A). Comments received were evaluated and incorporated as appropriate.

B. Reviewers

Lead Region – Southeast Region: Susan Oetker, 404-679-7050

Lead Field Office – Cookeville Ecological Services Field Office: Jim Widlak (original author); Peggy Shute (completing the final document), 931-528-6481

Cooperating Region – Northeast Region: Mary Parkin, 617-417-3331

Cooperating Field Office – Abingdon, Virginia Ecological Services Field Office: Brian Evans: 276-623-1233

C. Background

- 1. Federal Register Notice citation announcing initiation of this review:**
July 29, 2008, 73 FR 43947
- 2. Species status:** Uncertain
- 3. Recovery achieved:**
1 (1 = 0-25% species recovery objectives achieved)

4. Listing history

Original Listing

FR notice: 42 FR 45526
Date listed: September 9, 1977
Entity listed: species
Classification: threatened

5. Associated rulemakings:

On September 13, 2007, a final rule was published (72 FR 52434) that established nonessential experimental population status in the lower French Broad River and lower Holston River in Tennessee for 21 species, including the slender chub. The experimental population was established for future reintroductions of threatened and endangered species that were planned for these reaches, although slender chub has not yet been reintroduced there.

6. Review history:

Recovery Data Call: 2013 – 1994; generally indicated the species was declining up to 2007 and uncertain since then.

The 1983 Slender Chub recovery plan (U. S. Fish and Wildlife Service 1983) indicated that several populations have been extirpated and currently known populations continue to be threatened by various activities (e.g., coal mining, logging).

A slender chub 5-year status review was prepared by consultants Burkhead and Jenkins (1982). In addition, a 5-year review for this species was noticed in the Federal Register on November 6, 1991 (56 FR 56882). In this review, the status of many species were simultaneously evaluated with no in-depth assessment of threats as they pertained to the individual species. The notices summarily listed these species and stated that no changes in the designation of these species were appropriate at that time. In particular, no changes were proposed for the status of the slender chub in this review.

7. Species' recovery priority number at start of review (48 FR 43098):

The slender chub is assigned a recovery priority number of 5, which means a species with a high degree of threat and a low recovery potential.

8. Recovery plan:

Name of plan: Slender Chub Recovery Plan

Date issued: July 29, 1983

II. REVIEW ANALYSIS

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

1. Is the species under review listed as a DPS? No
2. Is there relevant new information that would lead you to reconsider the classification of this species with regard to designation of DPSs? No

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? Yes
- 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.

1. *Through protection of existing populations and/or by introductions and/or discovery of new populations, there exist viable populations in the Powell River, Clinch River, and Holston River of the following magnitude:*
 - a. *Viable populations¹ exist with a minimum of seven population centers on both the Clinch and Powell rivers. These population centers will be dispersed throughout these rivers so that it is unlikely that a single event would cause the loss of a river's entire population.*

¹ In the recovery plan, a "viable population" is defined as a population that is reproducing and either stable or expanding after ten years of population monitoring (biannual sampling).

- b. *A viable population is established in the Holston River with a minimum of one population center*².

Although slender chubs have not been collected such that captive propagation could take place to supply individuals to introduce into appropriate areas to accomplish this criterion, blotched and streamline chubs (*Erimystax insignis* and *E. dissimilis*, respectively), surrogates for slender chubs, have successfully been propagated (Shute et al. 2008a)

Historically, populations were known from the Powell River, Clinch River, and the lower Holston River. Although individuals have not been collected from any location for almost 20 years, populations may still exist in the Powell River and Clinch River. J. R. Shute (CFI, personal communication with Peggy Shute 2013) commented that during snorkel surveys conducted by Conservation Fisheries, Inc. (CFI), *Erimystax* minnows are observed, often at the edge of a snorkeler's visible range because of poor water visibility in areas where these minnows are found. Shute noted that traditional survey methods and methods employed to date specifically aimed at collecting slender chubs are likely only marginally effective in collecting swiftly moving, benthic minnows like *Erimystax*. He suggested other methods, some of which have been employed recently, and commented that CFI did not think all methods had yet been exhausted in attempts to collect this rare fish.

Shute and Rakes (2001) and Shute et al. (2008b) reported success in propagating streamline and blotched chubs, the slender chub's closest relatives. As a result, it is believed that these husbandry and rearing protocols would be appropriate and successful to aid in efforts to reestablish slender chubs in the Holston River, should any individuals be collected. To date, however, no slender chubs have been collected to serve as a captive population for producing individuals for reintroduction.

2. *Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal or other energy-related impacts exist in the Clinch River.*

Regions III and IV of the U.S. Environmental Protection Agency, the Tennessee Department of Environment and Conservation (TDEC), the Virginia Department of Environmental Quality (VDEQ), and the Virginia Department of Mines, Minerals, and Energy (VDMME) signed a Memorandum of Understanding (MOU) in December 2007 to establish a working group for improving

² In the recovery plan, a "population center" is defined as a large shoal area of at least 250 square meters composed of small to medium sized gravel inhabited by a viable population of slender chubs.

communications and coordinating efforts to protect and restore the Clinch and Powell rivers. This MOU is a coordinated response to the increasing concern over impacts to freshwater mussels and fish from coal mining in the Clinch and Powell rivers and is intended to improve water and habitat quality impacts in these watersheds. These agencies and others have demonstrated an interest in working together to accomplish the common goals of reducing human impacts associated with coal mining and processing, agriculture, urbanization, and the development of transportation corridors.

In addition, although both Clinch and Powell rivers continue to be impacted by coal mining activities, improvement in water and habitat quality in both rivers is indicated by recent, apparently successful efforts to reintroduce captive propagated mussels (S. A. Ahlstedt, consultant, personal communication with C. F. Saylor 2013; Dan et al. 2011) and the threatened yellowfin madtom (*Noturus flavipinnis*) (Rakes and Shute 2003, Rakes and Shute 2007, Petty et al. 2013).

3. *The species and its habitat in all three rivers are protected from foreseeable human related and natural threats that may adversely affect essential habitat or survival of any of the populations.*

The majority of the watersheds drained by the three rivers historically inhabited by slender chub are in private ownership. As a result, this criterion would be difficult to achieve. However, an increasing emphasis on conservation of the important biodiversity of the Clinch and Powell rivers has been a priority among conservation organizations, as is indicated by The Nature Conservancy's Clinch Valley Program, the multi-agency MOU (mentioned in response to recovery criterion 2 above) to address human impacts in the Clinch and Powell watersheds, and the educational programs established by Lincoln Memorial University and Virginia Department of Game and Inland Fisheries (described in more detail in discussion of Factor A below). In addition, the Northeast and Southeast regions of the Service have worked together on a draft strategy (U.S. Fish and Wildlife Service 2014), currently being reviewed by the states, that gives the Service a unified approach for conservation of aquatic fish and mussels in the Upper Tennessee River Basin, including the Clinch, Powell, and Holston watersheds and the slender chub. We are considering unique options to collaborate and protect habitat for many rare species in this area.

C. Updated Information and Current Species Status

1. Biology and Habitat –

- a. **Abundance, population trends, demographic features or demographic trends:**

The slender chub is restricted to the upper Tennessee River drainage in Tennessee and Virginia. About 430 slender chub specimens have been collected from all sites between 1893 and 1996, although only one individual has been collected since 1987. The largest collection was 86 individuals from the Powell River in 1976 (data summarized from Burkhead and Jenkins 1982, Shute et al. 2008c, Simons 2013). When the species was collected, the mean number of individuals per sample was 11.9 and ranged from a single individual to 57 and 86 in the Clinch and Powell rivers, respectively (data summarized from those presented by Shute et al. 2008c).

The last collection of slender chubs in the Holston River was in 1941, in surveys just prior to completion of Cherokee Dam, which inundated the collection locality. The species is presumed to be extirpated from the Holston River.

The last collections of the species from the Powell River were two specimens collected in 1986 (C. F. Saylor, TVA, personal communication with Peggy Shute 2013, TVA unpublished data). Before that, the most recent collections included a total of 18 individuals from three sites in 1980 and two individuals from a single site in 1981 (Shute et al. 2008c). A single specimen was collected from the Clinch River in 2002 and was mistakenly identified as a slender chub (Petty et al. 2013), but later identified as an aberrant (lacking lateral blotches) streamline chub (Petty et al. 2013). Simons (2013) suggested that this specimen might have been a hybrid. Conservation Fisheries, Inc. (CFI) biologists reported possible sightings of slender chubs in the Clinch River during surveys conducted in 2005, but the sightings were not confirmed and no individuals were collected. These sightings were also likely aberrant streamline chubs (J. R. Shute, CFI, personal communication with Peggy Shute 2013).

The last collections of the species from the Clinch River were in 1987, when Dr. Richard Mayden (presently at St. Louis University) collected eight specimens (three were frozen for DNA analysis) and in 1996, when Dr. David Etnier (University of Tennessee) and his ichthyology class collected and released a single individual.

Between 2000 and 2013, biologists from CFI, Missouri Department of Conservation, University of Tennessee, U. S. Fish and Wildlife Service, Tennessee Wildlife Resources Agency, Tennessee Valley Authority, Virginia Department of Game and Inland Fisheries, and others conducted extensive surveys to determine the status and range of the slender chub. These efforts included surveys of all known localities where the species was historically collected. Other areas within the species' range in the Clinch and Powell rivers were surveyed, as well. These surveys included standard seining techniques (both upstream and downstream seine runs), combination of

snorkeling to “herd” fishes into seines, snorkeling, electroshocking, and boat trawling using Missouri trawl (a double-bagged, small-mesh trawl) to survey deeper areas within the species’ range. These survey efforts included more than 1,000 person-hours of effort through 2012 (Shute et al. 2008c, Petty et al. 2013). The surveys were accomplished by large crews snorkeling and driving fishes into seines at shoal complexes where slender chubs had most recently been observed or collected, seining with multiple nets for single efforts, using a boat-deployed Missouri trawl to survey deeper areas, and snorkeling for observation (Petty et al. 2013). In spite of these extensive surveys specifically targeting slender chubs since 2000 in the Clinch and Powell rivers, no individuals have been collected since 1996. However, it is possible that the slender chub still exists at very low population levels in one or both rivers.

As Simons’ (2013) research proposal indicated, it is difficult to conclusively document whether or not a species is extinct or whether probability of detecting the species is extremely low because of low population size(s). Consequently, declaration of a species’ extinction usually results from repeated negative collections. While the last decade’s extensive survey efforts aimed at collecting slender chubs have not been successful, historical collections of the species supports extremely variable population sizes, as is indicated by the number of individuals in these collections (see Table 1, and Burkhead and Jenkins 1982). In addition, although the Clinch and Powell rivers are well surveyed by ichthyologists in state and federal agencies and universities (increasing the likelihood of documenting slender chub occurrence), Table 1 indicates many gaps between successful collections. As was discussed by Etnier (1994), historical collections may indicate that slender chub may be a species that exhibits natural population fluctuations that reduce our ability to detect the species at times of lower abundance.

The combined experiences of ichthyologists have resulted in recommendations for different combinations of gear and survey types, available new technology (eDNA), and additional survey sites that should be attempted before a determination about the possible slender chub extinction is made. This statement is based on personal communications with Peggy Shute 2013 from: Noel Burkhead (U.S. Geological Survey), J. R. Shute and Patrick Rakes (Conservation Fisheries Inc.); Charles Saylor (retired TVA); Mark Cantrell (Service).

b. Genetics, genetic variation, or trends in genetic variation:

Simons suggested that the species might be introgressively hybridizing with the closely related blotched and/or streamline chubs, and he proposed a study that would identify whether some of the species’ apparent decline might be related to introgressive hybridization (Simons 2013). This hypothesis was based on apparent low slender chub population sizes, as indicated by lack of collection or observation in the past several decades, in spite of extensive

efforts, and the relatively abundant population sizes of blotched and streamline chubs that inhabit the same areas as slender chubs. Simons theorized that when short-lived disturbances from drought, eutrophication, and pollution result in low slender chub population sizes, they may mate with the more numerous individuals of these closely related chub species rather than mates of their own species. To date, this proposed study has not been completed.

c. Taxonomic classification or changes in nomenclature:

As detailed by Burkhead and Jenkins (1982) and Jenkins and Burkhead (1994), the slender chub was originally described by Hubbs and Crowe (1956) as *Erimystax cahni*, based on specimens collected in 1893 and later classified as *Hybopsis (Erimystax) cahni* when the species was “rediscovered” in 1964 (Davis and Reno 1966). Mayden’s (1989) taxonomic revision resulted in the presently accepted elevation of the slender chub’s subgenus, *Erimystax*. While the formal listing rule and recovery plans identify the listed taxon as *Hybopsis cahni*, the listed species is presently recognized by scientists and ichthyologists by the scientific name *Erimystax cahni*.

d. Spatial distribution, trends in spatial distribution or historic range (e.g. corrections to the historical range, change in distribution of the species within its historic range, etc.):

The historical range of the slender chub included the Holston River (a single specimen) and Clinch River (15 total specimens at two localities) in areas presently inundated by Tennessee Valley Authority (TVA) Cherokee and Norris dams, respectively (Table 1). Since the 1960’s, the species has only been collected or observed at four separate localities encompassing 7.7 stream kilometers (km) in the Clinch River and six localities encompassing 84.2 km in the Powell River (Table 1). As noted by Burkhead and Jenkins (1982) the slender chub was believed extant only in the Clinch and Powell rivers at the time of listing.

Table 1. Slender Chub Collections or Observations Between 1893 and 2013 in the Clinch River and Powell River (adapted from Shute et al. 2008a and Burkhead unpublished data). Asterisks (*) indicate areas presently impounded by Norris Reservoir.

Year of Collection or Observation	Clinch River	Powell River
	Total number of individuals collected or observed (Number of individuals at river kilometer localities)	
1893	11 (202.7)*	
1936	4	

Year of Collection or Observation	Clinch River	Powell River
	Total number of individuals collected or observed (Number of individuals at river kilometer localities)	
	(127.9)*	
1939		5 (105.1)
1964		2 (105.1)
1968		1 (105.1)
1969	1 (304.7)	26 (105.1)
1970	3 (291.6)	
1971	13 (1 @ 277.0, 12 @ 291.6)	
1972	2 (295.3)	
1973	13 (291.6)	
1974	11 (291.6)	
1975	46 (45 @ 291.6 & 1 @ 295.3)	
1976	29 (2 @ 291.6, 26 @ 295.3, 1 @ 304.7)	86 (105.1)
1978	11 (291.6)	
1979	3 (1 @ 291.6, 1 @ 295.3 & 1 @ 304.7)	8 (1 @ 153.5, 1 @ 159.6, & 6 @ 189.3)
1980	66 (8 @ 291.6, 1 @ 295.3 & 57 @ 304.7)	18 (1 @ 153.5, 5 @ 159.6 & 12 @ 189.3)
1981	53 (291.6)	4 (2 @ 189.3, 2 @ 171.8)
1986		2 (105.1)
1987	8 (291.6)	
1996	1 (291.6)	
TOTALS	275	152

e. Habitat conditions:

The species was historically known to occur in the Holston River. As only a single individual was collected during pre-impoundment surveys in the Holston River at a site presently inundated by TVA's Cherokee Reservoir, the slender chub is believed to have been extirpated by Cherokee Dam closure. Suitable physical habitat may still exist downstream of Cherokee Dam, but cold water releases from the dam likely render the habitat unsuitable for the species. However, habitat and biological communities in the Holston River upstream of Cherokee Reservoir appear to have recovered from historical water quality and habitat impacts, and habitat there may be suitable for slender chub reintroductions (C. F. Saylor, TVA, personal communication with Peggy Shute 2013). Saylor also indicated that, although slender chub has not been historically reported from the adjacent French Broad River, habitat conditions there are similar to reaches within the slender chub's known historic range.

While coal mining and related activities in the Clinch and Powell drainages continue to impact the riverine habitat of slender chub and other aquatic animals in these rivers, a multi-agency coordinated response to these concerns has been initiated that is intended to improve water and habitat quality impacts from coal mining in these watersheds. Possibly as a result of these efforts, although both Clinch and Powell rivers continue to be impacted by coal mining activities, water and habitat quality in both rivers are improving. This is indicated by recent, apparently successful efforts to reintroduce captively propagated mussels (S. A. Ahlstedt, consultant, personal communication with C. F. Saylor 2013, Dan et al. 2011). In addition, this apparent improvement is supported by the recent dramatic geographic distribution expansion of the threatened yellowfin madtom in both rivers (Rakes and Shute 2003, Rakes and Shute 2007, Petty et al. 2013).

Rakes (CFI, personal communication with Peggy Shute 2013) commented that unlike many minnows, larval and juvenile streamline and blotched chubs were strongly benthic, and he further suggested that this life history characteristic would make these chubs (and presumably slender chub as well) vulnerable to benthic habitat degradation. Therefore, historic degradation of benthic habitat could explain apparent declines or extirpations, and recent improvement may bode well for successful reintroduction, if broodstock become available.

2. Five Factor Analysis

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

Jenkins and Burkhead (1994) described the slender chub's specialized habitat association as clean swept, relatively loose, pea-sized gravel in moderate runs where water depth is 0.2 to 0.4 meters. C. F. Saylor (TVA, personal communication with Peggy Shute 2013) reported collecting gravid female slender chubs in association with receding flood waters in May. He reported collecting gravid stargazing minnows, *Phenacobius uranops*, with these slender chubs. These fishes were found over sand and gravel where stream velocity was 2-3 feet per second.

Noel Burkhead (U. S. Geological Survey, personal communication with Jim Widlak 2008) commented that the species' benthic feeding and spawning orientation, in addition to life history attributes (lower fecundity relative to many other fishes, short lifespan, and low dispersal ability) increased the species' vulnerability. Patrick Rakes (CFI, personal communication with Peggy Shute 2013) supported this by noting slender chub larvae and juveniles were presumably strongly benthic, based on observation of streamline and blotched chub larvae and juvenile captively produced by CFI. Rakes commented that this strong benthic association is unlike that of many minnows, and he suggested that this life history characteristic could render *Erimystax* more vulnerable to benthic habitat degradation than other minnows. Fishes requiring the clean-swept gravel areas described above for feeding and breeding would be affected by sedimentation of fines (silts, clays, and coal washings), especially during low water from episodic droughts, when sediment might concentrate in these areas or not be flushed out, or when these areas could become eutrophic (Burkhead, USGS personal communication with Jim Widlak 2008).

While coal mining and related activities in the Clinch River and Powell River drainages continue to impact slender chub's riverine habitat, a multi-agency coordination in the Clinch and Powell rivers is intended to improve water and habitat quality impacts from coal mining in these watersheds. Regions III and IV of U.S. Environmental Protection Agency, TDEC, VDEQ, and VDMME signed an MOU to establish a working group for improving communications and coordinating efforts to protect and restore the Clinch and Powell rivers. These agencies and others are working together to reduce human impacts associated with coal mining and processing, agriculture, urbanization, and the development of transportation corridors. Possibly as a result of these efforts, although both Clinch and Powell rivers continue to be impacted by coal mining activities, water and habitat quality in both rivers are improving. This is indicated by recent, apparently successful efforts to reintroduce captively propagated mussels (S. A. Ahlstedt, consultant, personal communication with C. F. Saylor 2013, Dan et al. 2011). In addition, this apparent improvement is supported by the recent dramatic geographic distribution

expansion of the threatened yellowfin madtom in both rivers (Rakes and Shute 2003, Rakes and Shute 2007, Petty et al. 2013).

However, physical habitat destruction resulting from a variety of other human-induced impacts such as nonpoint source runoff and resultant sediment deposition, disturbance of riparian corridors, and changes in channel morphology continues to plague the Clinch and Powell watersheds. In addition to coal mining, the most significant sources of sediment are from activities such as agriculture, silviculture, road construction, and urban development. Activities that contribute sediment discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, excessive instream sediment deposition, and increases in both water turbidity and temperatures.

Sediment abrades and/or suffocates bottom-dwelling organisms by clogging gills; reducing aquatic insect diversity and abundance; impairing fish feeding behavior by altering prey base and reducing visibility of prey; impairing reproduction due to burial of nests; and, ultimately, negatively impacting fish growth, survival, and reproduction (Wood and Armitage 1997). At least five impacts of sedimentation on fish were identified, including (1) reductions in growth rate, disease tolerance, and gill function; (2) reductions in spawning habitat and reduced egg, larval, and juvenile survival; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency (Wood and Armitage 1997). The effects of these types of threats will likely increase as human populations grow in the Clinch and Powell watersheds in response to human demands for water, housing, transportation, and places of employment.

Nonpoint source pollution from land surface runoff can originate from virtually any land use activity (such as coal mining and agricultural activities) and may be correlated with amount or relative proportions of impervious surface and storm water runoff from urban areas. Pollutants likely to affect water quality in the Clinch and Powell rivers from land uses in these rural watersheds include sediments, fertilizers, herbicides, pesticides, and animal wastes from row crop and livestock farming, pharmaceuticals from municipalities, septic tank and gray water leakage from rural communities in the watersheds, and petroleum products from highways that cross or run parallel to streams. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the habitat and food sources for species like the slender chub.

The following are common land uses in the Clinch and Powell watersheds identified by the U. S. Environmental Protection Agency (2002) as sources of stress to the slender chub by contributing sediment and contaminants:

- Urban, industrial, commercial, and residential development
- Livestock production
- Agricultural cropping including tobacco and corn
- Coal mining, reclaimed coal mined lands and “abandoned” coal mined lands (i.e., lands affected by mining prior to the enactment of the Surface Mining Control and Reclamation Act that were not reclaimed properly)
- Runoff from road and railroad networks
- Timber harvest

Coal mining activity has increased in the Clinch River watershed in recent years, and coal fines in the upper river in Virginia, are moving downstream into Tennessee. A 585-megawatt coal-powered electric generation facility is expected to be constructed along the Clinch River in Virginia City, Wise County, Virginia. Effluent discharge, runoff from fly ash storage, and other sources related to the operation of the facility represent new threats, and may result in further impacts to the slender chub population in Tennessee.

There are several ongoing educational programs in the Clinch and Powell watersheds that may benefit slender chub by encouraging proactive conservation of water and habitat quality. These include a “snail in the classroom” educational program using aquaria and spiny river snails (*Io fluviatilis*) initiated by the Virginia Division of Game and Inland Fish (Mike Pinder, Virginia Department of Game and Inland Fisheries, personal communication with Peggy Shute 2013) that promotes appropriate environmental stewardship by educating elementary school children about activities that harm and benefit their unique aquatic resources. Also, Lincoln Memorial University provides non-traditional conservation education summer programs for high school students. These students map aquatic habitat types in the Powell River, and learn about habitat requirements of the region’s rare or sensitive species like spiny riversnails, yellowfin madtoms, mussels being reintroduced into nearby areas in the river, and slender chubs (Dr. Aggy Vanderpool, Lincoln Memorial University, personal communication with Peggy Shute 2011).

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

At the time of listing, collection for commercial, recreational, scientific, or educational purposes was determined to not be applicable to the slender

chub. We have no new information indicating that this is a current threat to the species.

c. Disease or predation:

This factor was determined to not be applicable to the slender chub at the time of listing. We have no new information indicating that disease or predation has contributed toward the decline of the species.

d. Inadequacy of existing regulatory mechanisms:

The slender chub and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.) and the Tennessee Water Quality Control Act of 1977 (Tennessee Code Annotated §§ 69-3-101). These laws focus on point source discharges, and many water quality problems are the result of non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt population declines and degradation of habitat for the slender chub.

In addition to the Federal listing, the slender chub is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "...it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered or Threatened Species state the following: "except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna. Potential collectors of this species would be required to have a state collection permit."

Section 7 of the Act requires Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect threatened and endangered species. However, the lack of Federal authority over the many actions likely impacting slender chub

habitat has become apparent. Many of the threats (including those identified at the time of listing, during recovery planning, and since development of the Recovery Plan) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from urban or commercial development, water withdrawals for agriculture, or indiscriminate logging) and, thus, may not result in section 7 consultation. Although the take prohibitions of section 9 of the Act do apply to these types of activities and their effects on the slender chub, enforcement of the section 9 prohibitions is difficult, at best. The Service is not informed when many activities are being considered, planned, or implemented; therefore, we have no opportunity to provide input into the design of the project or to inform project proponents of the need for a section 10 permit. Unlike higher profile species, conservation of the slender chub is not valued by most of the public to the extent that citizens would report to the Service the likelihood of habitat destruction or illegal taking.

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

Because of the slender chub's limited, fragmented geographic range and apparent small population sizes, the species is extremely vulnerable to localized extirpations resulting from accidental toxic chemical spills or other stochastic disturbances. Potential sources of such spills include potential accidents involving vehicles transporting chemicals over road crossings of streams inhabited by the species and accidental or intentional release into streams of chemicals used in agricultural or residential applications.

In addition, because of the slender chub's apparent small population sizes, it is vulnerable to losses in genetic diversity and reduced fitness. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007). Also of possible concern is the possibility suggested by Simons (2013) that the species' apparent decline might result from introgressive hybridization with the closely related blotched and/or streamline chubs (*E. insignis* and *E. dissimilis*, respectively). Simons theorized that when short-lived disturbances from drought, eutrophication, and pollution result in low slender chub population sizes, they may mate with the more numerous individuals of these closely related chub species rather than mates of their own species.

Climate change could alter weather patterns such that the combination of factors that may trigger slender chub reproductive condition would not consistently be present at the appropriate time for spawning slender chubs. For example, as suggested by C. F. Saylor (Tennessee Valley Authority, personal communication with Peggy Shute 2013), if slender chub reproductive condition is triggered by receding flood waters and rising water temperatures during a relatively short time period in May, inconsistency in successful slender chub reproduction (recruitment) resulting from changing climatic conditions could result in additional extirpations or impacts to population sizes and genetic diversity (C. F. Saylor, TVA, personal communication with Peggy Shute 2013).

D. Synthesis

The final listing rule and the recovery plan for the slender chub both identify that the primary threat known to still be affecting the species is habitat alteration resulting from coal mining and related activities in the Clinch and Powell drainages. In addition, it has been theorized that low population size and potential introgressive hybridization with similar, more numerous syntopic chubs may be a threat for slender chubs.

The recovery criteria in the recovery plan have not been met. In spite of extensive annual survey efforts in the rivers known to be occupied historically by the species, it has not been collected in the Powell River since the early 1980s or from the Clinch River since the mid-1990s. Individuals originally identified as slender chubs observed by snorkelers in 2005 were not collected or confirmed. Although individuals have not been collected from any location for almost 20 years, populations may still exist in the Powell River and Clinch River (J. R. Shute, CFI, personal communication with Peggy Shute 2013; Noel Burkhead, U.S. Geological Survey, personal communication with Peggy Shute 2013; Patrick Rakes, CFI, personal communication with Peggy Shute 2013; and C. F. Saylor, retired TVA, personal communication with Peggy Shute 2013).

If, after proposed survey methods have been exhausted (see **Recommendations for Future Actions** section, below) using eDNA and targeted survey methods, the slender chub has still not been collected, we will consider delisting the slender chub due to extinction. However, that is not prudent at this time, as experts agree the species is likely to still be extant.

III. RESULTS

D. Recommended Classification:

_____ **Downlist to Threatened**
_____ **Uplist to Endangered**
_____ **Delist**
____X____ **No change is needed**

B. New Recovery Priority Number

We are not recommending a change in the recovery priority number.

C. If a reclassification is recommended, indicate the listing and reclassification priority number:

We recommend the listing priority number of 2, indicating a species with imminent threats of high magnitude.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS –

1. Continue to search for the species in the Clinch River and Powell River employing targeted collection methods, possibly using environmental DNA (eDNA) technology to refine most likely survey localities, if the methodology is feasible for this species in rivers the size of the Clinch and Powell (given the presence of closely related congeners in both systems). Several reviewers suggested that slender chubs may be especially adept at avoiding net collections. They also suggested that, in spite of the exhaustive efforts that have taken place since 2000, collection methods specifically tailored to collection of slender chubs and river reaches that may contain appropriate slender chub habitat have not yet been exhausted. Tools (eDNA) that may help target these collecting efforts would increase the likelihood of success.
2. Continue efforts to restore and protect designated critical habitat in the Clinch River and Powell River.
3. If individuals are found, implement propagation in order to augment and/or re-establish viable populations.
4. If individuals are found, investigate the possibility that introgressive hybridization is a threat to extant populations.
5. If a propagated brood stock is established in the future, initiate efforts to restore an appropriate thermal regime in the Holston River and to re-evaluate habitat conditions in the French Broad River to enable reestablishment of a population (or populations) of slender chubs.

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APPENDIX A
Summary of peer review for the five-year review of
Slender Chub (*Erimystax cahni*)

A. Peer Review Method:

A draft copy of the five-year review was emailed to biologists at Conservation Fisheries, Inc., Tennessee Aquarium Conservation Institute, Tennessee Valley Authority, U. S. Geological Survey, Tennessee Wildlife Resources Agency, University of Tennessee, and Roanoke College. Reviewers provided comments by email, by modifications to the original document, and in conversations with Peggy Shute. All of the peer reviewers know the species, and are familiar with where it occurs and the threats to its long term survival.

B. Peer Review Charge:

Peer reviewers were asked to provide written comments on the information presented in our analysis of the fish, to provide comments on the validity of the data, and to speculate on the possibility that additional surveys or survey methods might result in slender chub observations or collections. Peer reviewers were asked not to provide recommendations on the legal status of the species.

C. Summary of Peer Review Comments/Report:

In general, the peer reviewers provided positive feedback and some specific comments. One reviewer from TVA provided information about conditions he believed would likely trigger reproductive activity, and speculations on possible implications of climate change to those triggers. CFI provided comments on likely reasons for slender chub vulnerability based on benthic behavior of larval and juvenile *Erimystax* chubs they propagated in their facility as surrogates for slender chubs. CFI also commented on the difficulty in effectively collecting *Erimystax* chubs with typical (seine) collecting compared with snorkel observations of these minnows, and suggested that all resources to find slender chubs have not yet been exhausted.

D. Response to Peer Review:

The author who finalized this 5-year review was in agreement with all comments and concerns received from the peer reviewers and tried to address every comment as appropriate.

CFI: Missy Petty, Patrick Rakes, J. R. Shute

TNACI: Bernie Kuhajda

TWRA: David McKinney

TVA: John T. (Bo) Baxter, Dave Matthews, C. F. (Charlie) Saylor

USGS: Noel Burkhead

University of Tennessee: Dr. David Etnier

Roanoke College: Dr. Robert Jenkins