Pygmy Madtom
(Noturus stanauli)

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW
Pygmy madtom/*Noturus stanauli*

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on the best available information pertaining to historic and current distribution, life history, and habitat of this species. Our sources include the final rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by Service, State and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. A *Federal Register* notice announcing the review and requesting information was published on July 29, 2008 (73 FR 43947). Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A). No part of this review was contracted to an outside party. This review was completed by the Service's lead Recovery biologist in the Cookeville Field Office, Tennessee.

Please see Appendix B (pages 16-18) for updated information on this fish that we have gained while conducting our new five-year review initiated in 2017 (82 FR 29916). Our new signature page is included on page 15.

B. Reviewers

Lead Field Office – Cookeville, Tennessee, Ecological Services: Stephanie Chance, 931-528-6481

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

C. Background

1. FR Notice citation announcing initiation of this review: July 29, 2008, 73 FR 43947.

2. Species status: Stable, 2008 Recovery Data Call. While monitoring data to detect population changes are not available, the collection of five individuals during 2007 indicates that the Clinch River population is stable. No new or increasing threats are known from the Duck River, the only other population of this species.

3. Recovery achieved: 1 (0-25%) recovery objectives achieved

4. Listing history:

Original Listing
FR notice: 58 FR 25758
Date listed: April 27, 1993
Entity listed: Species
Classification: Endangered

5. Associated rulemakings:

September 13, 2007. Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee. 72 FR 52433.

6. Review History:

Recovery Data Call: 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, and 2000
Final Recovery Plan: September 27, 1994

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

5 (degree of threat is high, potential for recovery is low, and the taxonomy is at the species level)

8. Recovery Plan

Name of plan: Recovery Plan for Pygmy Madtom (*Noturus stanauli*)
Date issued: September 27, 1994

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 consider listing this species as a DPS in accordance with the 1996 policy? No.

B. Recovery Criteria

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

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.

Reclassification to threatened:

The species will be considered for reclassification to threatened status when the likelihood of the species' becoming extinct in the foreseeable future has been eliminated by the achievement of the following criteria:

1) Through protection and enhancement of the existing population in the Duck River, Humphreys and Hickman counties, Tennessee; and in the Clinch River, Hancock County, Tennessee, two viable populations exist.

Viable Population – A reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed and the amount and quality of habitat required to meet this criterion will be determined for the species as one of the recovery tasks.

This criterion has not been met. As mentioned in the recovery plan (USFWS 1994), the pygmy madtom is only known from the Duck River, Humphreys and Hickman counties, Tennessee and the Clinch River, Hancock County, Tennessee. These rivers are separated by 600 miles and there are no other historic records for the species within the Tennessee River drainage. There have not been any new populations discovered since the recovery plan was written. The Service has designated nonessential experimental population (NEP) status for the pygmy madtom in the lower French Broad and Holston rivers, Knox, Sevier, Grainger, and Jefferson counties, Tennessee (72 FR 52433). This NEP allows for the reintroduction of the pygmy madtom into these areas of its presumed historical range. However, pygmy madtoms have not been reintroduced into the lower French Broad and Holston Rivers NEP to date.

Duck River:
Since the recovery plan was written in 1994, there have been few surveys for the pygmy madtom in the Duck River. However, in 2002, the Tennessee Valley Authority collected one individual at Duck River Mile 89, Hickman County, Tennessee, extending the known range of the madtom by 57 river miles. In 2007, TVA collected another individual at DRM 89. In 2008, CFI and persons from the

University of Alabama collected four pygmy madtoms in the Duck River in Hickman County. These specimens are currently being used in genetic studies to compare the Duck and Clinch River populations. TVA found one individual at Hite Ford on the Duck River in 2008 (Tennessee Department of Environment and Conservation, Division of Natural Areas 2009).

Clinch River:
In 2000, two pygmy madtoms were found at Frost Ford and transported to Conservation Fisheries, Inc. (CFI) for captive propagation. These madtoms spawned successfully at CFI and produced two nests with 10 and 19 eggs, respectively. Thirteen madtoms survived to adult size as a result of this propagation effort. CFI noted that the adult madtoms were only active in the early evening hours, leading CFI to believe that pygmy madtoms are crepuscular (CFI 2000). In 2002, six madtoms were released back into the Clinch River at Frost Ford. Two wild caught individuals were taken back to CFI for propagation efforts (CFI, personal communication, 2002). The 2002 captive propagation effort produced only one juvenile pygmy madtom. In 2004, no madtoms were found during surveys for propagation efforts. No madtoms were found in 2005, although CFI conducted surveys at five sites in the Clinch River (CFI 2005).

In May 2007, CFI (2007) found three female and two male pygmy madtoms in the Clinch River. CFI again brought these fish to their facility to attempt captive propagation. Another pygmy madtom was found in June by Service personnel and returned to the river. Despite problems with incubating the eggs during propagation, CFI produced seven juvenile madtoms from the 2007 propagation effort that spawned in their facility in 2008. They noted that the madtom appears to be relatively stable, albeit very rare in the Clinch River.

None of the threats (see section III.C.2.a.) affecting the pygmy madtom have been eliminated since the fish was listed; consequently, both the Duck and Clinch River populations remain vulnerable to extirpation. Existing Federal and State laws and regulations apply to actions conducted within the range of pygmy madtom to protect the fish and its habitats. However, due to difficulty in finding the fish during surveys, the extent of its habitat is unknown.

2. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies has been or is likely to be successful.

There have not been any studies on the pygmy madtom's biological and ecological requirements since the recovery plan was written. However, by attempting captive propagation, CFI has noted life history information on crepuscular activity and number of eggs produced in the laboratory (see reclassification criterion 1).

3. No foreseeable threats exist that would likely cause this species to become

endangered.

This criterion has not been met. See Section III.C.2.a. However, many organizations are working together to alleviate threats to the species, especially in the Clinch River. In response to increasing concern over impacts to freshwater mussels from coal mining in the Clinch River watershed, Regions III and IV of the USEPA, Tennessee Department of Environment and Conservation, Virginia Department of Environmental Quality, and Virginia Department of Mines, Minerals, and Energy signed an Memorandum of Understanding (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 have demonstrated an interest in working together to accomplish common goals of reducing human impacts associated with coal mining and processing, agriculture, urbanization, and the development of transportation corridors.

In 2008, a Clinch-Powell Clean Rivers Initiative (CPCRI) Group was developed to carry out the goals stated in the MOU. As part of their efforts, the CPCRI has prepared a preliminary and draft "Biodiversity Conservation Science Plan for the Clinch-Powell River System, Virginia – Tennessee, USA" for the Clinch-Powell Symposium Steering Committee and the Clinch-Powell MOU Working Group. The plan proposes to generate scientific information that can be used to aid biodiversity conservation in the Clinch-Powell system. Specifically, studies to characterize and quantify contaminant levels in the Clinch and Powell rivers will help landowners, land managers, and regulatory agencies to make decisions regarding the conservation of federally listed and other sensitive species.

Coal mining activity has increased in the Clinch River watershed in recent years, and coal fines in the upper river are moving downstream into Tennessee. Agriculture also continues to threaten the watershed. The Service along with The Nature Conservancy (TNC), local Soil Conservation Districts, the Natural Resources Conservation Service, Farm Service Agency, Clinch-Powell Resource Conservation and Development Council, and many State agencies and local partners are working together to protect aquatic biodiversity in the Clinch-Powell watershed by providing monetary assistance to facilitate the protection and recovery of riparian corridors and the reduction and prevention of non-point source pollution on private lands. In 2008, the Partners for Fish and Wildlife program began a landscape-level Strategic Habitat Conservation project in the watershed.

The Nature Conservancy established an office near the Duck River in 1999 and has been working with local communities and government agencies to ensure long-term protection of the river's water quality and ecological integrity. Through their Landowner Incentive Program, TNC has provided monetary and technical assistance to facilitate the protection of riparian corridors to prevent non-point pollution from private lands.

Removal from Endangered Species Act protection:

The recovery plan does not give delisting criteria for the pygmy madtom. The plan states that removal of the madtom from the Act's protection is not likely because the species exists at only two areas in the Tennessee River system and the river reach between these populations is significantly impacted by impoundments and is not suitable for reintroductions (USFWS 1994).

C. Updated Information and Current Species Status

1. Biology and Habitat –

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
No new information exists concerning this fish's abundance or population trends.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
There have been no genetic analyses conducted on the pygmy madtom. However, species such as the pygmy madtom, 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).

c. Taxonomic classification or changes in nomenclature:
There are no changes in the taxonomy of the pygmy madtom since the Recovery Plan was written in 1994.

d. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):
There are no changes in the spatial distribution or historic range of the pygmy madtom since the Recovery Plan was written in 1994.

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):
No new information exists concerning this fish's habitat.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms) -

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

As indicated in the Recovery Plan (USFWS 1994), increased urbanization, coal mining, toxic chemical spills, siltation, improper pesticide use, and streambank erosion remain threats to the pygmy madtom. Additional, ongoing threats to the madtom include gravel dredging, water withdrawals, and agricultural practices.

Physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian corridors, and changes in channel morphology continues to plague the Clinch and Duck river watersheds. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). 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 increased water turbidity and temperatures.

Sediment has been shown to abrade and or suffocate 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 (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. In addition, Etnier and Jenkins (1980) suggested that madtoms, which are heavily dependent on chemoreception (detection of chemicals) for survival, might be susceptible to human-induced disturbances, such as chemical and sediment inputs, because the olfactory (sense of smell) “noise” they produce could interfere with a madtom’s ability to obtain food and otherwise monitor its environment. The effects of these types of threats will likely increase as human populations grow in the Clinch and Duck river watersheds in response to human demands for water, housing, transportation, and places of employment.

Non-point 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 impervious surfaces and storm water runoff from urban areas. Pollutants entering the Clinch and Duck rivers may include sediments, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, septic tank and gray water

leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the pygmy madtom are negatively impacted.

Common land uses within the Clinch River watershed include 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 federal law that were not reclaimed properly); road and railroad networks; and forests (US EPA 2002). These land use activities act as sources of stress to the pygmy madtom by contributing sediment and contaminants into the watershed.

Coal mining activity has increased in the Clinch River watershed in recent years, and coal fines in the upper river, 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, run-off 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 pygmy madtom populations in Tennessee.

b. Overutilization for commercial, recreational, scientific, or educational purposes:
Overutilization is not known to be a factor in the decline of this species.

c. Disease or predation:
Disease and predation are not known to be factors in the decline of this species.

d. Inadequacy of existing regulatory mechanisms:
The pygmy madtom 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. 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 pygmy madtom.

In addition, the pygmy madtom 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.

Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect the species. However, the lack of Federal authority over the many actions likely impacting pygmy madtom 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 development, water withdrawals, 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 pygmy madtom, enforcement of the section 9 prohibitions is difficult. 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.

e. Other natural or manmade factors affecting its continued existence: The pygmy madtom's limited geographic range and apparent small population size leaves the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity. Potential sources of such spills include potential accidents involving vehicles transporting chemicals over road crossings of streams inhabited by the madtom and accidental or intentional release into streams of chemicals used in agricultural or residential applications.

The pygmy madtom's small population size naturally makes it vulnerable to losses in genetic diversity and 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, pp. 117-146).

In 2007-2008, middle Tennessee experienced an exceptional drought. This recent drought served as a reminder to the Duck River Utility Commission and member municipalities and utility districts who withdraw water from Normandy Reservoir on the Duck River that water quantity is an important issue for the residents of middle Tennessee. The Tennessee Duck River Development Agency is working

with local partners to develop a water supply plan for the region.

D. Synthesis –

The pygmy madtom is known from only two disjunct populations in the Tennessee River system. Since the species was listed as endangered in 1993, very few specimens have been found from both the Duck and Clinch River populations. Habitat and water quality degradation remain the greatest threats to the madtom. Captive propagation for the pygmy madtom has shown limited success due to difficulty in finding individuals for broodstock. Therefore, the species remains highly vulnerable to extinction from stochastic events.

Due to the limited distribution, small population size, and continued threats to the pygmy madtom, it continues to be in danger of extinction throughout its range. Therefore, the status of the pygmy madtom listed as endangered remains appropriate. The pygmy madtom has been successfully propagated, however, clutch sizes in the laboratory have been small and it remains very difficult to find wild adults to use in captive propagation efforts. The recovery priority number for the madtom should remain 5, as the degree of threat remains high and potential for recovery remains low.

III. RESULTS

A. Recommended Classification:

__X_ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS –

Continue efforts aimed at obtaining individuals and improving techniques necessary for captive propagation of the species.

Pursue captive propagation efforts when individuals of this species are found.

Continue to monitor population levels and habitat conditions of existing populations.

Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat.

Continue efforts to reduce non-point pollution from agricultural activities by working through the Partners for Fish and Wildlife, Farm Bill, and other landowner incentive programs to implement best management practices.

V. REFERENCES –

Allendorf, F.W. and G. Luikart. 2007. Conservation and the genetics of populations. Malden, Massachusetts, Blackwell Publishing. 642 pp.

Conservation Fisheries, Inc. 2000. Spawning the rare pygmy madtom, *Noturus stanauli*. Newsletter #2, 1 December 2000. Knoxville, Tennessee.

Conservation Fisheries, Inc. 2002. Personal Communication. Pygmy madtom release information. Knoxville, Tennessee.

Conservation Fisheries, Inc. 2005. U.S. Fish and Wildlife Service Region 4 Field Activities Report. Knoxville, Tennessee.

Conservation Fisheries, Inc. 2007. Annual report. Knoxville, Tennessee.

Conservation Fisheries, Inc. 2008. U.S. Fish and Wildlife Service Region 4 Field Activities Report. Knoxville, Tennessee.

Tennessee Department of Environment and Conservation, Division of Natural Areas. 2009. Tennessee Natural Heritage Inventory Database. Nashville, Tennessee. U.S.A.

U.S. Environmental Protection Agency. 2002. Clinch and Powell Valley watershed ecological risk assessment. National Center for Environmental Assessment, Washington, D.C., EPA/600/R-01/050.

U.S. Fish and Wildlife Service. 1994. Pygmy madtom recovery plan. Atlanta, Georgia. 20 pp.

Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Soc. Monograph 7, Bethesda, Maryland. 251 pp.

Wood, P. J., and P. D. Armitage. 1997. Biological effects of fine sediment in the lotic environment. Environmental Management. 21:203-217.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Pygmy madtom (*Noturus stanauli*)

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 Stephanie Chance

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Lee A Barclay Date 4/10/09

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Acting
Lead Regional Director, Fish and Wildlife Service

Approve Amon L Valente Date 10-5-09

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

APPENDIX A: Summary of peer review for the 5-year review of Pygmy madtom (*Noturus stanauli*)

A. Peer Review Method: On February 11, 2009, an email was sent to Conservation Fisheries, Inc. (CFI) and biologists from the Tennessee Valley Authority (TVA) Natural Heritage Program asking for peer review of the draft pygmy madtom 5 year review. These individuals are considered to be species experts.

B. Peer Review Charge: Peer reviewers were asked for scientific peer review of presented data. We did not ask for their review of the legal status recommendation.

C. Summary of Peer Review Comments/Report –TVA did not respond back with comments on the pygmy madtom review. Conservation Fisheries, Inc. responded that the total numbers collected since 1993 was incorrect. They stated that TVA had collected a number from the Duck River, as did Bernie Kuhajda last year, and that those finds extended the known range of that population. They also thought that Mr. Kuhajda might have had more records from the Clinch River.

D. Response to Peer Review – Based on the comments received from CFI, the total number collected since 1993 was corrected. The Service agreed with that concern. The Service also agreed that the TVA collections had extended the known range of the species in the Duck River, and this was also corrected in the document. Mr. Kuhjada's Duck River records were also added to the document.

FY 2018 APPROVAL*

Current Classification: Endangered

Review conducted by: Warren Stiles, Tennessee ES FO

Acting Lead Field Supervisor, Fish and Wildlife Service

Approve  Date July 3, 2018

*In 2014, Southeast Region Field Supervisors were delegated authority to approve 5-year reviews that do not recommend a status change.

Field Supervisor signature on this document reflects:

1. _____ We have no new information, received no new public comments, and the original five factor analysis remains an accurate reflection of the species' current status.
2. __X__ We have obtained a small amount of new information that we have summarized in Appendix B, received no new public comments, and the original five factor analysis remains an accurate reflection of the species' current status.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF Pygmy Madtom (*Noturus stanauli*)

Appendix B. Summary of new information obtained since the 2009 5-Year Review

We initiated a new five-year review for the pygmy madtom on June 30, 2017 (82 FR 29916). We received no public comments during the comment period. The new information we have gathered in the time since our last five-year review is outlined below along with our current recommendation of status. This completes our review initiated in 2017.

Distribution/ Status

Clinch River
Limited collections have been made at Frost Ford on the Clinch River in Tennessee since the last five-year review. Over the course of the ongoing habitat and distribution survey being carried out by researchers at Tennessee Tech University (TTU), pygmy madtoms have been consistently found at Frost Ford, including evidence of reproduction in the form of a gravid female found in early July 2017. Surveys at nearby locations and historic collections sites have not turned up any individuals (Mattingly et al. 2017, Grady Wells, pers. comm.). Within the Clinch River, pygmy madtoms are known from only a 2.5 mile (4 km) stretch around Frost Ford.

Duck River
Regular index of biological integrity samples (IBI) conducted every two years by the Tennessee Valley Authority's (TVA) have only collected a single individual in the Duck River since the last five year review of the pygmy madtom (Dave Matthews, pers. comm.). There have been fewer surveys conducted in the Duck River by the TTU group than in the Clinch, and they have only resulted in the collection of one individual near Centerville, TN (Mattingly et al. 2017, Grady Wells, pers. comm.). Pygmy madtoms are known from about 72 miles (116 km) of the Duck River, though due to limited survey results, it is unclear how much of that stretch of river is occupied.

Biology and Habitat

Genetics and taxonomy
In an investigation of the mitochondrial genome of the pygmy madtom, Bennet et al. (2009, p. 2367) found little divergence between the Clinch River and Duck River populations compared to other species found in both systems. A morphological and molecular study of madtoms found that the pygmy madtom were in a clade (an evolutionarily related group of organisms) with the elegant madtom (*Noturus elegans*) and saddled madtom (*N. fasciatus*) (Egge and Simons, 2009).

In coordination with the surveys mentioned above, TTU researchers are developing an environmental DNA (eDNA) survey protocol to detect pygmy madtoms (Carla Hurt, pers. comm.). At this point, primers have been developed to amplify pygmy madtom DNA, which is needed to detect the DNA in the water, but no positive detections have been made. Further results should be available in 2018 (Mattingly et al. 2017, Robert Paine, pers. comm.).

Habitat and life history
During the TTU surveys, microhabitat data, such as flow, depth and substrate type, have been collected to better classify the needs for the pygmy madtom (Mattingly et al. 2017, Grady Wells, pers. comm.). The full analysis of this data is ongoing. Additionally, species associations have been investigated, and it has been found that golden darter (*Etheostoma denoncourti*), mountain madtom (*Noturus eleutherus*), and gilt darter (*Percina evides*) are strong indicators of pygmy madtom habitat based on the Pflieger's Faunal Index, a method for determining associated species (Grady Wells, pers. comm.). Grady Wells also noted clumping behavior in pygmy madtoms where multiple individuals aggregate in the cooler months, a behavior seen in other madtom species, potentially allowing for improved detectability (pers. comm.).

Five Factor Analysis
Habitat degradation due to livestock access has been noted at Brooks Island on the Clinch River, a historically occupied site (Grady Wells, pers. comm.). Other than this example, no new threats are known. There are no known new conservation actions targeted to this species. Therefore, we consider the previous 5-factor analysis to be an accurate representation of the species' threats.

Synthesis
The pygmy madtom is known only from two small, highly disjunct populations in the Clinch and the Duck Rivers. Few individuals have been found since the last five-year review of this species. This species remains very vulnerable to disturbances in these two watersheds. Captive propagation efforts for this species have not advanced since the last review, because so few individuals have been found.

Due to the limited distribution, small population size, and continued threats to the pygmy madtom, it continues to be in danger of extinction throughout its range. Therefore, the status of the pygmy madtom listed as endangered remains appropriate similar to our 2009 5-year review. The pygmy madtom has been successfully propagated, however, clutch sizes in the laboratory have been small and it remains very difficult to find wild adults to use in captive propagation efforts. The recovery priority number for the madtom should remain 5, as the degree of threat remains high and potential for recovery remains low.

Additional Recommended Actions
- Continue monitoring of the species and surveying for additional locations where the species may be found.
- Investigate the possibility for introductions of the pygmy madtom into the Non-essential, Experimental Population area in the Holston and French Broad Rivers.

References

Bennett, M. G., J. H. Howell, B. R. Kuhajda, and R. M. Wood. 2009. Mitochondrial DNA divergence in the critically imperiled pygmy madtom, *Noturus stanauli* (Siluriformes: Ictaluridae). Journal of Fish Biology. 75: 2363-2372.

Egge, J. J. D, and A. M. Simons. 2009. Molecules, morphology, missing data and the phylogenetic position of a recently extinct madtom catfish (Actinopterygii: Ictaluridae). Zoological Journal of the Linnean Society. 155: 60-75.

Matthews, D. 2017. Personal communication on TVA's collection of pygmy madtoms during IBI samples. Tennessee Valley Authority River and Reservoir Compliance Monitoring

Mattingly, H., C. Hurt, W. G. Wells, and R. T. Paine. 2017. Environmental DNA Detection, Population Status, and Habitat Use of the Pygmy Madtom, *Noturus stanauli*. Annual Status Report.

Paine, R. T. 2018. Personal communication in regards to eDNA surveys for the pygmy madtom. Tennessee Technological University, School of Environmental Studies.

Wells, W. G. 2018. Personal communication in regards to surveys, microhabitat study, and species associations of the pygmy madtom. Tennessee Technological University, School of Environmental Studies.