Bluemask Darter
(Etheostoma akatulo)

5-Year Review:
Summary and Evaluation

(USFWS photo: R. Biggins)

U.S. Fish and Wildlife Service
South Atlantic - Gulf Region
Tennessee Ecological Services Field Office
Cookeville, Tennessee

5-YEAR REVIEW

Bluemask Darter / *Etheostoma akatulo*

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied upon 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Act (Act); the Recovery Plan (U.S. Fish and Wildlife Service [Service] 1997); peer reviewed scientific publications; unpublished field observations by Service, State, Tennessee Valley Authority (TVA) and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts.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 April 11, 2019 (84 FR 14669).

We did not seek external peer review for this 5-year review because it was not considered "influential" under the Service's policy for Information Quality Guidelines and Peer Review. Per the guidelines, the Service will seek peer review when we can reasonably determine that dissemination of influential information "…will have or does have a clear and substantial impact on important public policy or private sector decisions, and thus, a decision or action to be taken by the Director", such as a change in listing status (i.e., delisting, downlisting, or uplisting of a species). This 5-year review was reviewed internally by Todd Shaw and Santiago Martin with the Service's, Tennessee Field Office. Todd Shaw, the lead biologist for the species, then completed the review. Appendix A provides a brief summary of the peer-review approach and summary of public comments.

B. Reviewers

Lead Region –South Atlantic-Gulf: Carrie Straight, 404.679.7226

Lead Field Office – Tennessee Ecological Services Field Office, Cookeville, Tennessee: Todd Shaw, 931-525-4985

C. Background

1. **FR Notice citation announcing initiation of this review:** April 11, 2019, 84 FR 14669.

2. **Species status:** Stable. Threats identified in the previous 5-year review (2013) continue to affect all populations throughout the species' range. However, three genetically isolated, extant bluemask darter populations persist and are scattered throughout small areas of suitable habitat in the Caney Fork River drainage in central Tennessee, including the upper Caney Fork River, Cane Creek, Collins River, Rocky River, and Laurel Creek in Grundy, Warren, Van Buren, and White counties. Additionally, surveys conducted by TVA, Conservation Fisheries, Inc. (CFI), Tennessee Wildlife Resources Agency (TWRA), and the Service in 2014

further verified absence of wild bluemask darters at historical Calfkiller River localities.

While recent survey data suggests that bluemask darter numbers may be declining in some streams (e.g., the Caney Fork and Rocky rivers), their distribution has also been discovered to be greater than previously realized in other streams (e.g., Cane Creek and the Collins River). Therefore, further monitoring of each population is warranted before the overall species status could potentially be changed from "stable" to "declining".

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

4. Listing history:

Original Listing

FR notice:	58 FR 68480
Date listed:	December 27, 1993
Entity listed:	Species
Classification:	Endangered

5. Review History:

Recovery Plan: 1997

Each year, the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we performed a recovery data call that included status recommendations, such as "Stable" for this species. We continue to show this species' status recommendation in 5-year reviews. The last review for this species to inform the Recovery Report to Congress was conducted in 2019.

Five-year reviews:

December 27, 2013 (74 FR 31972)
In the 2013 5-year review, we determined that the species should remain listed as "endangered" due to its limited distribution, inability to expand its existing range, and continued threats, which could result in its extinction.

6. Species' Recovery Priority Number at start of review (48 FR 43098):
5 (indicates a high degree of threat and low recovery potential)

7. Recovery Plan
Name of Plan: Recovery Plan for the Bluemask (=Jewel) Darter (*Etheostoma* (*Doration*) *sp.*)
Date issued: July 25, 1997

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

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

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 bluemask darter will be considered for reclassification to threatened status when the likelihood of its becoming extinct in the foreseeable future has been eliminated by achieving the following criteria:

1) Through protection and enhancement of the existing populations, the species continues to exist in four rivers and viable populations[1] exist in at least three of these rivers.

At the time the recovery plan was written, the bluemask darter was known to occur in four streams, including the Caney Fork River, Cane Creek, Rocky River, and Collins River. The species is still present in these four streams. Since the recovery plan was written, a population structure and genetic diversity study has been completed (Robinson et al. 2012); the study determined that these streams, in addition to Laurel Creek (a Rocky River tributary where the species was found after the recovery plan was written) are comprised of three genetically distinct populations, including: (1) the Caney Fork River/Cane Creek, (2) Rocky River/Laurel Creek, and (3) Collins River. Based on this research, the Collins River population is

[1] 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 of quality habitat required to meet this criterion will be determined for the species as one of the recovery tasks.

considered to be the only population that is currently viable (G.R. Moyer, Service, pers. comm., May 3, 2013).

This criterion has not been met because a viable population only exists in one river at this time. Refer to section II.C.1.a. and II.C.1.d. for further discussion on population status and spatial distribution.

2) **Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been successful in substantially increasing the number and/or range of the bluemask darter in three rivers or additional collections or reintroduction efforts extend the darter's present known range to a fifth river (e.g., Barren Fork or Mountain Creek).**

The number and/or range of bluemask darters have not been substantially increased in three rivers, nor has the species' range been extended to another river drainage. This criterion has been partially met. As indicated above under 1), since the recovery plan was written, it has been determined that three genetically distinct bluemask darter populations occur in the four streams that were originally identified in the recovery plan. Several recent survey efforts by TVA have failed to find the species or suitable habitat in the Barren Fork or Mountain Creek.

Management strategies are continuing to be developed via an adaptive management process, which was established as a result of a section 7 consultation (FWS Log No. 42430-2006-F-0146) between the Service and TVA (Service 2006). This process continues to address the ecological needs of the species; specify biological goals and objectives for the species; identify metrics to monitor progress toward specified goals, the sampling designs for measuring those metrics, and the period over which monitoring will be conducted; and describe the management strategies to achieve the desired biological goals and objectives.

<u>Research studies</u>
Numerous studies have been conducted to provide information on the species and its life history (Layzer and Brady 2002; Simmons and Layzer 2004; Simmons et al. 2008; CFI 2014). These studies have improved our knowledge of the species' microhabitat usage, population age-class structure and variability, spawning behavior, and reproductive parameters, which has improved our ability to conserve and potentially recover the species. Adams (2017) completed a side-scan sonar project to record substrate types in the Calfkiller River from which digital imagery was created; this data will assist in identifying areas of suitable habitat for bluemask darter reintroductions.

TTU entered into a cooperative agreement with the Service in 2017 to quantitatively analyze the ecological requirements of two life-cycles of the bluemask darter at three spatial scales. The primary research goal was to determine habitat-based ecological requirements of the bluemask darter within an occupied stream (Collins River) to inform bluemask darter reintroductions into the non-occupied Calfkiller River (TTU 2017, 2018). This study is currently ongoing and anticipated to be completed within the next few months.

Reintroductions

Since completion of the 2013 5-year review, the Translocation, Propagation, and Reintroduction Plan for the Bluemask Darter, *Etheostoma akatulo*, in Calfkiller River, White County, Tennessee (CFI, et al. 2016) and the Calfkiller River Site Plan (CFI and TVA 2016) have been developed and finalized. The purpose of these documents is to provide guidance and protocols for brood collection, propagation, reintroduction, and monitoring of the species. These documents are considered living documents that can be updated as new information regarding reintroduction efforts becomes available to better guide future decisions. The translocation, propagation, and reintroduction plan was revised in 2019 to include TWRA as a potential propagation partner and to identify a new release site on the upper Calfkiller River in Putnam County (Service et al. 2019).

CFI initiated reintroduction of bluemask darters into the Calfkiller River on May 10, 2016. Subsequent releases occurred in 2017, 2018, and 2019. Table 1 provides summary information on all bluemask darters stocked into the Calfkiller River through 2019. The fish were released at two Calfkiller River sites: Calfkiller River mile (CKRM) 29 and 29.6 in White County (from 2016 through 2018) and CKRM 40.1 in Putnam County. The new Putnam County site was selected in January 2019 to avoid water quality issues associated with the Town of Monterey's Wastewater Treatment Plant (WWTP) discharge, which appear to be negatively affecting habitat quality in downstream portions of the Calfkiller River (Refer to section II.C.2.a. for further discussion on potential Monterey WWTP discharge impacts to the species and its habitat).

Monitoring reintroduced fish

TVA funded CFI to conduct a study to determine appropriate tags for use on bluemask darters released into the Calfkiller River (CFI 2016a). CFI used blueside darters (*Etheostoma jessiae*) as surrogates for bluemask darters to carry out tests comparing various tagging methods. Tag retention and survival of tagged fish were assessed, and CFI determined that Visible Implant Elastomer (VIE) Tags were the best choice for tagging bluemask darters. They reported that tagging darters with VIE Tags is relatively easy and less expensive than other methods, and the tags

Table 1. Bluemask Darters Stocked into the Calfkiller River 2016 – 2019 (CFI 2019).

Date	Approximate Location (Calfkiller River Mile = CKRM)	County	Number Stocked	Year Class
10-May-16	CKRM 29 (Near 2359 Mack Floyd Rd)	White	76	2014
10-May-16	CKRM 29 (Near 2359 Mack Floyd Rd)	White	39	2015
18-Aug-17	CKRM 29.6 (Mouth of Doe Creek, upstream of Mack Floyd Rd Bridge)	White	12	2014
18-Aug-17	CKRM 29.6 (Mouth of Doe Creek, upstream of Mack Floyd Rd Bridge)	White	25	2016
18-Aug-17	CKRM 29.6 (Mouth of Doe Creek, upstream of Mack Floyd Rd Bridge)	White	146	2017
16-Mar-18	CKRM 29 (Near 2359 Mack Floyd Rd)	White	31	2017
16-Jan-19	CKRM 40.1 (In the vicinity of the Mill Creek Rd/TN Hwy 84 intersection)	Putnam	298	2018
	TOTAL STOCKED		**627**	

can be easily observed on the fish while they are in a stream; the number of available colors and the options for placement of tags on individuals allow cohorts of darters (vs. individual fish) to be followed through time and location. Based on the results of this tagging study, CFI has used VIE Tags on all bluemask darters reintroduced into the Calfkiller River.

A monitoring protocol was developed to assess the success of bluemask darter reintroduction efforts. Following the initial 2016 bluemask darter reintroduction, visual (qualitative) monitoring occurred annually beginning in summer and fall 2017. Two tagged fish, which had been released on January 16, 2019, were discovered during a September 10, 2019 survey of the Calfkiller River (P. Rakes, pers. comm., September 10, 2019), at the most-recent release site downstream of the mouth of Mill Creek in Putnam County (CKRM 40.1). These are the first post-release bluemask darters to be observed, indicating that the species can survive in the Calfkiller River. This site is located upstream of where Monterey WWTP discharge is received, whereas, the other release sites are located downstream of where the discharge enters the Calfkiller River (where no post-release bluemask darters have been encountered), which may suggest that the discharge adversely affects the species. However, more time to allow reintroduced fish to disperse and become established and investigation of water quality parameters are warranted before we can validate this conclusion.

<u>Genetic concerns and considerations</u>

Concerns have been raised about continuing to use Collins River broodstock for Calfkiller River reintroduction efforts, based on recent Yale University research by Dr. Tom. Near in which he examined genetic

structure of the bluemask darter using double digest restriction-site associated DNA sequencing (ddRADseq) (J.W. Simmons, TVA, pers. comm., August 9, 2019). Dr. Near's ddRADseq results support an east/west population differentiation between the Collins River (western clade) and all other streams (Cane Creek, Caney Fork River, Rocky River). TVA staff believe that because the Calfkiller River flows into the Caney Fork River between the Rocky River and Cane Creek, it would be more appropriate to obtain broodstock from the Rocky River or Cane Creek, rather than from the Collins River, because this would more closely mimic the evolutionary history of the species and better support those processes in the future. TVA staff also believe that this would also eliminate the potential for genetic contamination of the Rocky River and the Caney Fork River/Cane Creek populations by the Collins River clade.

TVA staff have further suggested collection of age-0 individuals in the reservoir fluctuation zone of the lower Rocky River each autumn to use for broodstock that may otherwise perish. TVA staff also indicated that broodstock from the eastern clade could be more successful in establishing a population in the Calfkiller River, since they were probably most closely related to the Rocky River and Caney Fork River/Cane Creek populations.

However, the Collins River was originally selected as the broodstock source due to higher genetic diversity and larger distribution and abundance, based on research by Robinson et al. (2012), and it is considered the only population that is viable (G.R. Moyer, Service, pers. comm., May 3, 2013). Before the Service would consider obtaining bloodstock from the Rocky River population, a study would need to be completed, demonstrating that: (1) juveniles occurring in inundated habitats are not contributing to the overall Rocky River population and (2) removal of juvenile bluemask darters from the Rocky River for brood purposes would not adversely affect that population. Until such data are available, the Collins River will remain the sole broodstock source for Calfkiller River reintroductions.

The Bluemask Darter Technical Team also considered mitigating against the potential extinction of the Caney Fork/Cane Creek population via creation of an ark (housed at a culture facility) for the Caney Fork River/Cane Creek population. However, it was decided that annually collecting bluemask darter brood from the Collins River and adopting the combined approach to reintroduce the species into the Calfkiller River, mentioned above, was the preferred approach at this current time.

Refer to section II.C.1.a. and II.C.1.e. for further discussion on species biology and habitat.

3) **No foreseeable threats exist that would likely impact the survival of the species over a significant portion of its range.**

   This criterion has been partially met. Refer to section II.C.2. for further discussion on threats to the population of this species.

The bluemask darter will be considered for removal from Endangered Species Act protection when the likelihood of its becoming endangered in the foreseeable future has been eliminated by achieving the following criteria:

1) **Through the protection and enhancement of existing populations and successful establishment of reintroduced populations or discovery of additional populations, five distinct viable populations exist.**

   This criterion has not been met. Efforts are underway to reestablish a fourth bluemask darter population in the Calfkiller River, as previously discussed under Section II.B.3.2. Since the recovery plan was written, bluemask darters have been discovered in the lower reach of Laurel Creek, a Rocky River tributary. However, it may not be possible to recover the species to the point of delisting, because establishing a fifth viable population is unlikely due to a limited number of streams supporting suitable habitat within the species' range.

2) **Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been successful in substantially increasing the number and/or range of the bluemask darter in four rivers (other than the Collins River) or additional collections or reintroduction efforts extend the species' present known range to a total of at least six rivers.**

   This criterion has been partially met. See the summary above of studies and other work completed for the species under Criterion 2 for reclassification to threatened status.

3) **No foreseeable threats exist that would likely impact the survival of the species over a significant portion of its range.**

   This criterion has been partially met. Refer to section II.C.2. for further discussion on threats to the population of this species.

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:

The majority of sites that TVA has monitored for bluemask darters since 2008 are areas previously sampled by Simmons (2004). While some populations remain stable, others may be declining. Fish collected and observed since completion of the 2013 5-year review are indicated in Table 1 of Appendix B.

TVA conducted surveys in 2017 to determine: (1) length-frequency distributions in the free-flowing reach and reservoir fluctuation zone of the Rocky River and in the Caney Fork River/Cane Creek, and (2) densities and age-class structure in the Collins River. Data from these surveys were compared to data collected from these same sites during previous TVA surveys (TVA 2019). These established monitoring sites will continue to periodically be surveyed and data evaluated by TVA to determine if there are changes in population trends and total abundance. Presence of juveniles and adults in the Collins River was also documented by CFI (2015, 2018, 2019) and Mattingly et al. (2018), and personal observation of juveniles by CFI and the Service (October 18, 2019).

Calfkiller River survey

In 2014, TVA, CFI, and TWRA surveyed historical localities downstream of Sparta where the bluemask darter was last found in the Calfkiller River and lower Town Creek, a Calfkiller River tributary, in 1968. This survey was consistent with prior survey efforts of the Calfkiller River (Simmons 2004; TVA 2011) in that no bluemask darters were found, further verifying the species absence in the Calfkiller River system. The species is considered extirpated from this system.

Caney Fork River/Cane Creek population

The Caney Fork River population may be decreasing based on low numbers of individuals found during 2011, 2012, and 2017 surveys (Robinson et al. 2012; J.W. Simmons, pers. comm. 2013; TVA 2012, 2019). However, Cane Creek is part of the Caney Fork River population, where the number of bluemask darters was higher and its distribution greater in 2017 than during prior surveys (TVA 2019).

The following information is from the most recent survey report (TVA 2019) of this system, which covers 2017 and 2018 survey activities. The number of individuals collected during surveys in the Caney Fork River

remains low. Fourteen, three, and 19 individuals were collected in 2011, 2012, and 2017 surveys, respectively. All individuals collected during 2017 were age-0 (juvenile) fish. While similar numbers of bluemask darters were collected from this reach during 2011, those individuals represented multiple age classes. Subsequent surveys will assist in determining if the Caney Fork River population is in decline or if apparent reductions in the population are natural fluctuations. TVA also sampled the upper reaches of the Great Falls Reservoir fluctuation zone in the Caney Fork River during March 2018 with a Missouri trawl and did not capture any bluemask darters.

The Caney Fork River contains the least amount of habitat for bluemask darters of all of the occupied streams. During 2017, the 19 bluemask darters collected were found in the same site within the known occupied reach as during other recent surveys. Of the individuals collected, 14 were collected from one sand patch. At the site where fish were found, cool spring upwellings could be felt coming through the sand; fish were not found on sand patches without notable spring influence. This may indicate that bluemask darters prefer areas where water temperatures are regulated by subterranean flow emergence.

In August 2017, bluemask darters were found at four sites in Cane Creek. In September 2011 surveys, bluemask darters were found at these sites and at two additional locations upstream. During 2017 surveys, surveyors discovered that previously occupied bluemask darter habitat had been altered by beaver impoundments (Figure 1). These areas have become inundated, resulting in sediment accumulations on previously clean sand substrate; bluemask darters were no longer found in these areas. However, more individuals were detected at other, newly discovered sites in Cane Creek than had been observed during previous surveys of this stream, and these fish comprised three age classes (age-0, 1, and 2).

Sampling was conducted using a Missouri trawl (e.g., Herzog et al. 2005) in March 2018 to determine the distribution of bluemask darters within the reservoir fluctuation zone of Cane Creek. Seven bluemask darters were collected using this sampling technique, extending the known distribution of the species in Cane Creek by 2.2 river kilometers (km) (1.4 miles [mi]) to a total of 3.7 river km (2.3 mi). Following drawdown of Great Falls Reservoir, areas of the reservoir fluctuation zone were surveyed several times by snorkeling, but no bluemask darters were detected. Individuals collected with the trawl may represent seasonal migrants since this area is by inundation of the reservoir at summer pool elevations.

Rocky River/Laurel Creek population

During TVA surveys of the Rocky River, 167 fish were collected in 2002, 137 in 2008, and only 42 in 2017 (J.W. Simmons, pers. comm., May 23,

2018), which amounts to approximately a 75% reduction in the number of fish collected over a 15-year time period.

The following information is from the most recent survey report (TVA 2019) of this system, which covers 2017 survey activities. In August 2017, TVA conducted snorkel surveys for bluemask darters in areas of the Rocky River unaffected by the reservoir fluctuation zone, and 18 bluemask darters were observed, representing a considerable decrease from numbers collected at that site historically. Similar to previous surveys, young-of-year were absent from this free-flowing reach, and individuals were comprised entirely of adults. Lower densities during 2017 were likely related to reduced habitat availability. Habitat in areas that had supported high densities of bluemask darters in the past was no longer present. Stream channel morphology had changed and the large, sandy pools that were present historically had transitioned to cobble runs. Unfortunately, this appears to have restricted the already extremely limited

Figure 1. Example of numerous beaver dams in Cane Creek that affected the integrity of bluemask darter habitat (TVA 2019).

distribution of this species within the portion of the Rocky River that is unaffected by reservoir inundation.

Sampling was conducted in the upper end of the reservoir fluctuation zone in early November 2017. Of 42 bluemask darters collected from this area, 39 were age-0. Lack of age-0 fish within the free-flowing reach appears to indicate that the adult population may be confined to a short reach of the Rocky River and, as larvae hatch, they drift and settle in the reservoir fluctuation zone. It is assumed that these age-0 fish must move upstream into the free-flowing reach in order to contribute to the persistence of the population, but additional investigation on the movements of these fish is needed to verify this assumption.

Laurel Creek, a tributary to the Rocky River, has not been resurveyed since 2008.

Collins River population

Unless otherwise cited, the following information is from the most recent survey report (TVA 2019) of this system, which covers 2017 and 2018 survey activities. In 2017, TVA surveyed four sites in the Collins River where the majority of bluemask darters are known to occur. Bluemask darter densities were higher at the two most-upstream sites when compared to the middle and downstream sites. Sand substrate at the upstream sites was clean and silt-free, while substrate at the middle and lower sites was degraded by sediment deposition.

The most-upstream site was located in Grundy County, upstream of Tennessee Highway (TN Hwy) 56. Bluemask darters were restricted to a narrow sand patch, formed by a large woody debris jam. This area was free of sediment and had experienced very little change since initial surveys during 2001.

The next site downstream is also within the upstream portion of the bluemask darter's known distribution in the Collins River. During 2017, high densities of bluemask darters were found in numerous clean, sandy pools adjacent to the streambank. This was a new site that was selected due to easy, available access.

Low densities of bluemask darters were observed by TVA during the 2017 survey at the middle site (Turners Bend near Irving College). This site had historically supported high numbers of fish. Furthermore, no recruitment was observed within this reach during 2017. The sandy pool habitat that historically supported large numbers of bluemask darters was still present but appeared to be degraded by sediment accumulation. There were several areas where spring upwellings had cleared sediment from small sand patches. Bluemask darters were congregated over the clean

sand but were absent from areas covered by sediment. CFI seined this same site in October 2019 when attempting to collect bluemask darter brood. Juveniles were abundant, with well over 100 individuals sampled over an approximately two-hour period. However, adult bluemask darters were notably absent. The highest concentrations of these juvenile fish were found over clean sand, downstream of a shoal, with a woody debris jam situated immediately downstream (CFI and R.T. Shaw, Service, pers. obs., October 18, 2019).

Bluemask darter densities were also much lower than during the previous survey in 2017 at the most-downstream site (upstream of TN Hwy 8). During 2011, sandy pool habitats were mostly free of silt, and nutrient enrichment was not observed. During 2017, sediments covered sand patches, and algae and other aquatic vegetation were abundant within these habitats. A continuously running portable water pump was observed during the survey, withdrawing water for irrigation of adjacent nursery fields. During May 2018, high turbidity levels were observed in the Collins River downstream of TN Hwy 8. There had been no recent rain events, and the river was clear in upstream reaches during this time. Surrounding agricultural land uses are likely contributing to sediment and nutrient loads in the middle and lower reaches of the Collins River, which may, in turn, be contributing to declines in the bluemask darter population.

During the summer of 2018, Mattingly et al. (2018) sampled these same reaches of the Collins River. Table 1 in Appendix B indicates the number of juvenile and adult bluemask darters that they sampled and the sites where they collected. These collections are indicated as "TTU" under the "Surveyors" column in Table 1. They also discovered two individuals at a new location in the lower river at approximately Collins River mile (CORM) 20.2, upstream of TN Hwy 70 in Warren County, extending the known distribution of the species approximately 8.5 river km (5.3 mi) downstream.

Life history studies and findings

CFI developed captive propagation protocols for production of bluemask darter progeny before initiating reintroduction efforts into the Calfkiller River (2015). The first collection of brood stock included 30 adult fish from the Collins River in December 2013. CFI used these individuals to investigate reproductive and life history parameters of the species, which guided them in development of future production and management efforts.

Gravid females (N=20), with ovipositors protruding, were paired with robust males (N=10) having the most vivid nuptial coloration during a spawning period from March 20 to June 20, 2014 and at water temperatures ranging from 11-23°C (51.8-73.4°F) (CFI 2015). Spawning events in the Collins River had been observed from May 29 to July 1,

2002, when water temperatures ranged from 14.4°C to 23.6°C (57.9-74.5°F) (Simmons and Layzer 2004). CFI observed and filmed spawning in the Collins River on April 24, 2014 when the water temperature measured 13.3°C (55.9°F) (CFI 2015). So, bluemask darters begin spawning at slightly cooler temperatures than previously realized (low to mid 50s°F versus upper 50s°F and higher), indicating that the species may spawn longer, and its reproductive behavior may be more flexible than originally thought. However, this may depend on weather conditions and resultant water temperatures in any particular year (CFI 2015).

CFI (2015) found that bluemask darter eggs were very small (1.4-1.6 millimeter [mm]), oblong, clear and adhesive. Estimated time to hatch was approximately 11-12 days, and larvae were immediately pelagic after hatching, measuring only 5 mm total length (TL). Pelagic larval duration was an estimated 28 days at which time larvae became demersal at lengths of less than 10-12 mm TL. Similar to larvae of the speckled darter (*Etheostoma stigmaeum*) and blueside darter (Simon 1997), larval bluemask darters are pelagic immediately after hatching and become demersal at lengths greater than 9 mm TL (CFI 2015).

Initial culture efforts in 2014 resulted in approximately 700 larvae passively captured via an overflow drain out of the incubation tank, where the outflow was directed through a flexible tube to a "capture tub", and 60 eggs collected from the substrate. The overall survival rate of the collected larvae and eggs was low (12%), and only 95 juveniles were ultimately produced. Table 2 illustrates survival rates and the number of bluemask darters that have been propagated each year from 2014-2018. Based on observations of spawning activity in the wild (Simmons and Layzer 2004), CFI utilized two different breeding groups (propagated first generation fish and wild captured Collins River fish) and paired them at a male to female ratio between 1:1 and 1:2 for propagation purposes (CFI 2016b).

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

It was initially thought that impoundment of the Caney Fork River by Great Falls Dam in the early 1900s may have effectively isolated the remaining known populations of the bluemask darter. However, results from a population structure and genetic diversity study (Robinson et al. 2012) suggested that lack of diversity in this species is not because of the construction of Great Falls Dam but is, instead, most likely due to historically small effective population sizes.

Table 2. Survival and Production of Bluemask Darter Progeny Produced by CFI (CFI 2015, 2016a, 2016b, 2018, 2019).

Year	Number of Adult Brooders (male = M; female = F)	Number of Passively Captured Larvae	Number of Eggs Collected from Substrate	Overall Survival Rate (%)	Number of Juveniles Produced
2014	10 M; 20 F	700	60	13	95
*2015	10 M; 17 F	350	-	19	65
*2016	15 M; 22 F	116	95	12	26
2017	10 M: 22 F	688	40	24	177
2018	19 M; 41 F	970	90	29	306
	TOTAL PRODUCED				**669**

*Minimal production was allowed because stocking was not intended to occur until spring 2016 and delays occurred in obtaining new brood.

Smith (2005) studied population genetics of bluemask darters using microsatellites to determine the level of gene flow among the seemingly isolated populations and to determine the amount of inbreeding within populations. She found there was greater influence from inbreeding within subpopulations than due to isolation among them. Robinson et al. (2012) confirmed that Cane Creek occupants are part of the Caney Fork River population via Bayesian population assignment and pairwise population differentiation measures. They found genetic divergence among streams was substantial, but found no evidence of structure within individual streams. This assessment produced three clear groups, corresponding to the Collins River, Caney Fork River/Cane Creek, and the Rocky River. Robinson et al. (2012) also sampled several individuals from the lower Caney Fork River that showed large genetic contributions from the Rocky River and vice versa.

More recently, Tom Near has examined genetic structure of the bluemask darter using ddRADseq (J.W. Simmons, TVA, pers. comm., August 9, 2019). Approximately 40 specimens from the Collins River were genotyped, which provided approximately 6,000 loci. The ddRADseq results supported east/west population differentiation between the Collins River (western clade) and the streams that comprise the eastern clade (i.e., Cane Creek, Caney Fork River, and Rocky River). Near's results are similar to Robinson et al.'s (2012) dataset in that the Rocky River showed some signs of admixture with the Caney Fork River/Cane Creek population and vice versa.

c. Taxonomic classification or changes in nomenclature:

The species was recognized as bluemask (= jewel) darter (*Etheostoma* (*Doration*) sp.), but had not been formally described at the time of listing or at the time the Recovery Plan was written in 1997. Since then, Layman and Mayden (2009) have described the bluemask darter as a species of the darter subgenus *Doration* (Percidae: *Etheostoma*), which is endemic to the upper Caney Fork River system, and gave it the name *Etheostoma akatulo*. The Service has formally recognized the use of this name and used it in this review.

d. Spatial distribution, trends in spatial distribution, or historic range:

Since the recovery plan was written, bluemask darters have been discovered in Laurel Creek, which is considered part of the Rocky River population. Since the 2013 5-year review, the known distribution of the bluemask darter has been extended by 2.2 river km (1.4 mi) in Cane Creek (TVA 2019) and 8.5 river km (5.3 mi) in the Collins River (Mattingly et al. 2018). All other individuals have been collected within reaches previously identified in the recovery plan in the upper Caney Fork River, Collins River, Rocky River, and Cane Creek since 1990.

e. Habitat:

Bluemask darters utilize areas comprised of predominantly clean, sandy substrate for spawning and utilize clean, sandy pools during a majority of the year (Simmons 2004). In an isolated instance, TVA biologists observed bluemask darters in October 2009 using areas covered with a layer of fine silt in the upper Caney Fork River. These fish were apparently using what habitat was available at that time, rather than their preferred clean sand substrate (TVA 2010).

Layman (1991) considered the Calfkiller River as a potential site for reintroduction of bluemask darters based on good water quality. He specifically indicated the reach downstream of TN Hwy 111 in Sparta. This 6-mi reach ranges from 20-40 meters (m) (approximately 65-130 feet [ft]) in width, and potentially suitable sand and gravel substrates are common, particularly near Demps Road Bridge.

After discovering abundant suitable habitat in the Calfkiller River upstream of Sparta, Simmons (2004) recommended that reintroduction of the bluemask darter into the system should be considered as a recovery strategy; he also surveyed the lower Calfkiller River downstream of Sparta to its confluence with the Caney Fork River and found the sand substrate used by the species, but this reach was impacted by reservoir inundation (sediment deposition and increased water depths). In 2009, TVA searched

for suitable habitat to allow for potential reintroduction of bluemask darters into the Calfkiller River. TVA assessed the lower portion of the Calfkiller River (approximately 5.3 mi) from the mouth of the river upstream to the County House Road Bridge (White County Road 575) for suitable bluemask darter habitat. No suitable habitat was identified within this stream reach. TVA also evaluated potential habitat from England Cove Road (near the White/Putnam County line at approximately CKRM 34.5) downstream to the upper end of an old mill dam impoundment at approximately CKRM 21.1. They discovered suitable physical habitat in that portion of the Calfkiller River.

During the spring and summer of 2014, TVA, CFI, and TWRA conducted surveys of the Calfkiller River, further verifying bluemask darter absence at historical Calfkiller River localities. In concert with these surveys, habitat suitability was re-evaluated for potential bluemask darter reintroductions from approximately England Cove Road (CKRM 34.4) downstream to the confluence of Wildcat Creek (CKRM 18.5) (CFI 2015). Areas of suitable habitat in the upper reaches of the Calfkiller River were identified and documented.

Benthic surveys and water quality sampling in the Calfkiller River have indicated that conditions are favorable for reintroduction of the bluemask darter into the river. TVA observed diverse benthic taxa at four stations on the Calfkiller River in 2010 (TVA 2011). TVA staff said that presence of little black caddisflies (*Glossosomatidae* sp.) encountered during benthic surveys indicates high water quality conditions (at least during spring months when monitoring occurred), because this family of insects generally will not tolerate anthropogenic effects. They further stated that their presence during spring months may indicate that the unknown stressor, which resulted in extirpation of the bluemask darter from the Calfkiller system, may be temporal, rather than constant (year-round), if it is still present or occurring.

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

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

Layman et al. (1993), Simmons and Layzer (2004), and Simmons (2004) identified a number of threats to the bluemask darter and its habitat. These threats include:

- Pesticides, herbicides, and fertilizers used by the plant nursery industry can negatively affect water quality and be harmful to individual fish;

- Water withdrawals for nursery irrigation of nurseries can reduce habitat available to the species or result in water quality degradation during low flows;
- Gravel dredging can alter or destroy habitat and increase siltation and water turbidity downstream;
- Siltation and agricultural runoff in the Collins and Rocky rivers can imbed habitat and be harmful to individual fish;
- Acid drainage from historical coal mines in the Cumberland Plateau reaches can affect water quality in all stream systems occupied by the species;
- Logging of upland areas can result in decreased aquifer recharge, changes in the annual hydrograph, and overland runoff to streams;
- Livestock access, removal of riparian vegetation, and encroaching streamside development can result in water quality degradation and stream bank instability; and
- The presence and operation of Great Falls Reservoir has altered hydrology and degraded stream habitat in the lower reaches of occupied streams.

Great Falls Dam and its associated reservoir create a barrier to movement of bluemask darters in the upper Caney Fork River, Cane Creek, Rocky River, and Collins River. This barrier to movement is considered the greatest threat to the continued existence and recovery of the species, because bluemask darters cannot move freely among the existing populations or access other tributary streams, such as the Calfkiller River, in order to establish new populations. As a result, the bluemask darter may continue to survive in the three stream systems where it currently occurs, but the recovery of the species is unlikely due to the resulting effects of isolation on these populations caused by the presence of the dam and reservoir.

Sedimentation of bluemask darter habitat is likely the second most significant threat to the bluemask darter. Substrate in reaches inhabited by bluemask darters in the reservoir fluctuation zone are commonly embedded by silt deposited as the result of altered hydrology from on-going dam operations.

Bluemask darters in the Collins River may be impacted by activities associated with plant nurseries, including unregulated water withdrawals, sediment accumulation, and nutrient enrichment (TVA 2019). In August 2013, TWRA and the Service surveyed two reaches of the Collins River from Camp Woodlee (CORM 43.8) downstream to Myers Cove (CORM 32.7) (~11.1 mi), and from Myers Cove downstream to Shellsford (CORM 25.1) (~7.6 mi), to evaluate surface water withdrawal access points. All irrigation withdrawals were mapped, yielding a total of 32 water withdrawal access points (G. Call, pers. comm., November 5, 2013).

Some efforts have been undertaken for the purpose of reducing non-point sources of sediment in waters inhabited by bluemask darters. The Service's Tennessee Ecological Services Field Office has coordinated with private landowners to construct 19,500 ft of livestock exclusion fencing and four off-stream livestock water developments in the Rocky River Drainage and 2,500 ft of livestock exclusion fencing and one off-stream livestock water development on the Calfkiller River under the Service's Partners for Fish and Wildlife Program. The TWRA partnered with a private landowner on a bank stabilization project along several hundred feet of stream in the headwaters of the Collins River. These enhancements are expected to improve water quality and benefit the bluemask darter.

Overall water quality conditions in the Calfkiller River have generally been found to be good, with the exception of slightly elevated nitrate-nitrite and total phosphorous levels downstream of the City of Sparta's WWTP (B. Chance, TDEC, pers. comm., March 4, 2011). There is also some speculation that water quality impacts from the Town of Monterey's WWTP may have contributed to the eradication of the historical wild bluemask darter population from the Calfkiller River and more recently, be responsible for fish kills in the upper Calfkiller River. The Monterey WWTP facility has been found in violation for nitrogen/nitrate totals in effluent (U.S. Environmental Protection Agency 2010) and for overflow on several occasions (TDEC 2010). Between July 2003 and December 2004, this facility exceeded its Clean Water Act (CWA) permit during 12 reporting periods in its receiving water, the Falling Water River in Putnam County (Environment Colorado Research & Policy Center 2006). In 1999, researchers with TTU (Bradshaw et al. 1999) determined through dye trace studies that the town's WWTP discharge entered a reach of the Falling Water River containing significant karst features. During low flow conditions, the effluent entered these sinks, traveled south through China Cave, and emerged from Twenty Springs into the Calfkiller River.

In 2018, the Town of Monterey requested renewal of its National Pollutant Discharge Elimination System permit TN0064688. The renewal included: (1) proposed modification to effluent limits for an Aero-Mod type activated sludge treatment system after an upgrade from the existing 1 million gallon per day (MGD) WWTP to 1.5 MGD, and (2) relocation of the existing discharge site from an unnamed wet weather conveyance to the Falling Water River at river mile (FWRM) 46.1 to another unnamed conveyance at FWRM 46.9. At the existing discharge site, discharge comprised roughly 100% of the base flow in that reach of the Falling Water River during low flow conditions. The proposed upgrades have not yet been completed, and it has since been determined that the new discharge site will not be at FWRM 46.

During the summers of 2018 and 2019, various species of fish were found dead in over 1-mi of the Calfkiller River, downstream of the influx of Twenty Springs, which could have potentially been the result of the Town of Monterey's WWTP discharge (J.W. Simmons, TVA, pers. com., July 3, 2019; P.L. Rakes, CFI, pers. com., Sept. 10, 2019). While none of the previously reintroduced bluemask darters were observed among the fish mortalities, finding a dead or impaired individual would be difficult due to their small size, flows could carry a dead or injured individual downstream undetected for long distances, and fish decompose rapidly in warm weather. Because the species relies on high water quality conditions and is sensitive to pollutants, the species may also have been adversely affected. Additional investigations will be required to determine if the facility, despite its upgrades, is contributing to fish kills and absence of bluemask darters (based on CFI post-reintroduction monitoring) in the Calfkiller River downstream of Twenty Springs, or if another source or factor is responsible for these impacts.

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

Overutilization is not known to be a factor affecting the status of this species.

c. Disease or predation:

Disease and predation are not known to be factors affecting the status of this species.

d. Inadequacy of existing regulatory mechanisms:

The bluemask darter and its habitats are afforded limited protection from water quality degradation under the CWA 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 for the bluemask darter are the result of non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt or reduce population declines observed for the species and habitat degradation that continues to affect the species.

In addition to the Federal listing, the bluemask darter 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 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 are also required to have a state collection permit.

Portions of the Caney Fork, Collins, and Rocky rivers were listed as impaired by the State of Tennessee on the Final 303(d) List (TDEC 2016). Pollutants and causes identified on the list as occurring in these waterbodies include water chemistry imbalances (e.g., nitrate-nitrite, *Escherichia coli*, pH, low DO, aluminum, iron, phosphorous, manganese, and sulfates), siltation, temperature alterations, physical substrate habitat alterations, and loss of riparian habitat and littoral vegetative cover. Sources of these pollutants are varied and include abandoned mining areas, coal mining permitted discharges, stream and stream-side alterations, specialty crop production areas, silviculture activities, pasture grazing, animal feeding operations, unrestricted cattle access, collection system failures, discharges from MS4 areas (i.e., a municipal separate storm sewer system comprised of a collection of structures designed to gather stormwater and discharge it into local streams and rivers), municipal point sources, highway/road/bridge construction, and upstream impoundments. State and Federal water quality laws have not been used to their full potential in preventing pollution from these various sources. Partnerships between agencies (e.g., Service, Natural Resources Conservation Service, U.S. Geological Survey, TDEC Division of Community Assistance, TDEC Division of Water Supply, Tennessee Department of Agriculture) and landowners continue to be fostered in attempts to improve water quality conditions in these watersheds.

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

As indicated in the Recovery Plan (Service 1997), existing bluemask darter populations inhabit only short stream reaches, rendering them vulnerable to extirpation from stochastic events, such as accidental toxic chemical spills. The Collins River valley is used extensively for commercial plant nurseries, increasing the likelihood of a toxic agricultural chemical spill and contamination of stream substrate, which could impact that population of bluemask darters. Other sources of potential spills include accidents involving vehicles transporting chemicals over bridge crossings, or intentional releases of chemicals used in agricultural or residential applications into streams.

As also indicated in the Recovery Plan, all existing bluemask darter populations are isolated due to the presence of Great Falls Reservoir. While Robinson et al. (2012) indicate the low genetic diversity exhibited by the species may not have been the result of the impoundment, it is presumed that the reservoir restricts gene flow among the populations. Thus, the long-term genetic viability of bluemask darter populations is questionable. 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).

Regarding climate change in the Southeast U.S., clear trends in climate predictions are limited. However, annual temperatures are projected to increase, cold days will become less frequent, the freeze-free season will lengthen by up to a month, temperatures exceeding 95º F (35 ºC) will increase, heat waves will become longer, and the number of category 5 hurricanes will increase (Ingram et al. 2013). Variability in weather is predicted to increase, resulting in more frequent and more extreme dry years and wet years over the next century (Mulholland et al. 1997: Ingram et al. 2013).

In Tennessee, climate change will likely result in increased rainfall, leading to increased runoff, higher river levels, and longer periods of spilling from dams. During periods of spilling at dams, there is the chance for more oxygenation of tailwaters and temperature mixing. However, increased rainfall, especially extreme events, would increase runoff of sediment and pollutants into waterways. These inputs could potentially degrade spawning and foraging habitat for the bluemask darter. Increased flows during the spawning season could also increase the distance that the pelagic larvae of bluemask darters drift before becoming benthic. If the larvae find suitable habitat, increased flow could expand the range of the species and contribute to genetic mixing. Drought would most likely impact the shallower habitats inhabited by bluemask darters. The area of shoal habitat, available during periods of low flow, could be reduced during a drought. The flows could be further reduced by water extraction for irrigation. If discharge is reduced enough, the clean-swept sand habitats that the bluemask darter relies on could begin to retain silt, reducing habitat quality.

D. Synthesis

The bluemask darter was listed because of its restricted range and because a status survey conducted in 1990 and 1991 revealed that the species had been extirpated from one stream, the Calfkiller River, where it historically occurred. Municipal wastewater

effluent, construction of several small impoundments, and associated sedimentation in the Calfkiller River may have contributed to the extirpation of the bluemask darter from that system. Impoundment of the Caney Fork River by Great Falls Dam has effectively isolated the remaining populations.

The recovery plan (Service 1997) contains a statement that recovery of the bluemask darter may not be possible due to its restricted range and small amount of remaining habitat. Since the recovery plan was written, no additional populations of the bluemask darter have been discovered in adjoining drainages. All individuals collected since 1990 have been within the upper Caney Fork, Collins, and Rocky rivers, and Laurel and Cane creeks. Unless new populations are discovered or habitat quality in the Calfkiller River improves to the point at which the species can be reestablished, achieving recovery will be problematic.

Since completion of the previous 5-year review, the known distribution of the bluemask darter has been extended by 2.2 river km (1.4 mi) in Cane Creek (TVA 2019) and 8.5 river km (5.3 mi) in the Collins River (Mattingly et al. 2018). However, the bluemask darter continues to be affected by operation of Great Falls Dam and presence of the reservoir. Recovery will continue to be difficult due to recurring habitat alterations from the effects of impoundment and the presence of the reservoir. Bluemask darters are likely unable to migrate and establish additional populations in tributary streams, such as the Calfkiller River. Sedimentation, other water quality impacts, and the potential for toxic chemical spills also remain threats to the bluemask darter.

Due to its limited distribution, inability to expand its existing range, and continued threats, the bluemask darter continues to be in danger of extinction. Therefore, the status of the bluemask darter as endangered remains appropriate. The recovery priority number for the bluemask darter should remain 5, as the degree of threat remains high and the potential for recovery is low.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Continue to propagate and reintroduce bluemask darters into the Calfkiller River. To ensure that the species has the best chance of survival and reestablishment in the Calfkiller River, such reintroductions should be supported by the data generated by the TTU study that quantitatively analyzes the ecological requirements of the bluemask darter at multiple spatial scales.

- Additional efforts should be undertaken regarding removal or notching of the following passage impediments on the Calfkiller River: (1) The low-head dam

upstream of TN Hwy 70N downstream of the City of Sparta; (2) The check dam located near the City of Sparta's water intake; and (3) The mill pond dam on the upper Calfkiller River.

- Continue to review bluemask darter population genetics data to determine the most appropriate brood source for reestablishment of a Calfkiller River population. If additional genetics studies are necessary, conduct those studies as necessary.

- TVA's population and habitat monitoring should continue. The data produced by this monitoring should be evaluated in conjunction with Simmons' (2004) data from the monitoring stations to determine the level of change that can be detected by these efforts. These efforts should incorporate any newly discovered, introduced, or expanded population segments.

- Conduct a study to determine if juvenile bluemask darters found in the inundated lower reach of the Rocky River are contributing to the Rocky River population and if these individuals are surviving to breed.

- Use available resources and partnerships to address threats, protect the species, and conserve its habitat.

- Ensure that all collection data are provided to TVA's Regional Natural Heritage Project and the Tennessee Division of Natural Areas' Natural Heritage program.

- Water quality studies and additional fish IBI sampling should be conducted in the Calfkiller River to determine the sources and types of water quality impairments that may limit the species in the watershed. If it is determined that the Monterey Waste Water Treatment Plant is negatively affecting the species, focus available resources and partnerships to assist the City of Monterey with efforts to rectify the issue.

- Follow-up surveys in the two, previously-surveyed Collins River stream reaches should be conducted to verify actual water withdrawal sites.

V. REFERENCES.

Adams, D. 2017. Calfkiller River Stream Habitat Modeling. Senior Thesis, Tennessee Technological University, Cookeville, TN, in collaboration with the U.S. Fish and Wildlife Service – Tennessee Ecological Services Office, Cookeville, TN. 21pp.

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

Bradshaw, D., K. Bynum, S. Coho-Greigo, G. Dillehay. E. Hillis, K. McCarty. J. Lynn, G. Shofner. 1999. Following the Water in the Falling Water River. Tennessee Tech.

Univ. Technical assistance provided by the Tennessee Dept. of Environment and Conservation and analytical services contributed by Cambrian Groundwater. 6 pp.

Conservation Fisheries, Inc. 2015. Development of Propagation Protocols for Bluemask Darter, *Etheostoma akatulo*, from the Collins River, White County, Tennessee, Progress Report for 2014. 8 pp.

Conservation Fisheries, Inc. Development of Propagation Protocols for Bluemask Darter, *Etheostoma akatulo*, from the Collins River, White County, Tennessee, Progress Report for 2014-2015. 2016a. 9 pp.

Conservation Fisheries, Inc. Development of Propagation Protocols for Bluemask Darter, *Etheostoma akatulo*, from the Collins River, White County, Tennessee, Progress Report for 2016. 2016b. 9 pp.

Conservation Fisheries, Inc. 2018. Development of Propagation Protocols for Bluemask Darter, *Etheostoma akatulo*, from the Collins River, White County, Tennessee, Progress Report for 2017. 11 pp.

Conservation Fisheries, Inc. 2019. Development of Propagation Protocols for Bluemask Darter, *Etheostoma akatulo*, from the Collins River, White County, Tennessee, Progress Report for 2018. 11 pp.

Conservation Fisheries, Inc. and Tennessee Valley Authority. 2016. Calfkiller River Site Plan - Reintroduction Proposal for the Bluemask Darter, *Etheostoma akatulo*, in the Calfkiller River, Tennessee. 7 pp and appendices.

Conservation Fisheries, Inc., U.S. Fish and Wildlife Service, and Tennessee Valley Authority. 2016. Translocation, Propagation, and Reintroduction Plan for the Bluemask Darter, *Etheostoma akatulo*, in Calfkiller River, White County, Tennessee. 17 pp.

Environment Colorado Research & Policy Center. 2006. Troubled Waters – An analysis of Clean Water Act compliance, January 2003 – December 2004. 42 pp.

Herzog, D.P., V.A. Barko, J.S. Scheibe, R.A. Hrabik, and D.E. Ostendorf. 2005. Efficacy of a benthic trawl for sampling small-bodied fishes in large river systems. North American Journal of Fisheries Management 25:594-603.

Howell, W.M. 1968. Taxonomy and distribution of the percid fish, *Etheostoma stigmaeum* (Jordan), with the validation and redescription of *Etheostoma davisoni* Hay. Unpubl. Ph.D. dissertation, University ofAlabama, Tuscaloosa. 113 pp.

Ingram, K.T., K. Dow, L. Carter, and J. Anderson. 2013. Climate of the Southeast United States, Variability, Change, Impacts, and Vulnerability. 341 pp.

Krabbenhoft, T.J., F.C. Rohde, A.N. Leibman, and J. M. Quattro, J.M. 2008. Concordant mitochondrial and nuclear DNA partitions define evolutionarily significant units in the imperiled pinewoods darter, *Etheostoma mariae* (Pisces: Percidae). Copeia 2008:909-915.

Layman, S. R. 1991. Status survey for the dirty darter (*Etheostoma olivaceum*) and the jewel darter (*Etheostoma* (*Doration*) sp.) In the Caney Fork and Cumberland Rivers, Tennessee. Final report submitted to the U.S. Fish and Wildlife Service, Asheville, NC. 35pp.

Layman, S.R. 1994. Phylogenetic systematics and biogeography of the subgenus *Doration* (Percidae: *Etheostoma*). Unpubl. Ph.D. dissertation, University of Alabama, Tuscaloosa. 299 pp.

Layman, S.R., A.M. Simons, and R.M. Wood. 1993. Status of the dirty darter (*Etheostoma olivaceum*) and bluemask darter (*Etheostoma* (*Doration*) sp.) With notes on the fishes of the Caney Fork River system, Tennessee. J. Tenn. Acad. of Sci. 68(2):65-70.

Layman, S. R., and R. L. Mayden. 2009. A new species of the darter subgenus *Doration* (Percidae: *Etheostoma*) from the Caney Fork River System, Tennessee. Copeia No. 1:157-170.

Layzer, J.B., and T.R. Brady. 2002. Summer microhabitat of the bluemask darter *Etheostoma* (*Doration*) sp. Final report submitted to the U.S. Fish and Wildlife Service, Cookeville, Tennessee. 10pp.

Mattingly, H., S. Allen, and V. Jones. 2018. Determining Bluemask Darter Ecological Requirements at Multiple Spatial Scales to Support Reintroductions in the Calfkiller River System (Cooperative Agreement Award No. F17AC00592). Interim Performance Report: August 1, 2018. Submitted to USFWS – TN Ecological Services Office. School of Environmental Studies, TN Tech. Univ., Cookeville, TN. 10 pp.

Mulholland, P.J., G.R. Best, C.C. Coutant, G.M. Hornberger, J.L. Meyer, P.J. Robinson, J.N. Stenberg, R.E. Turner, F. Vera-Herrera, and R.G. Wetzel. 1997. Effects of Climate Change on Freshwater Ecosystems of the South-Eastern United States and the Gulf Coast of Mexico. Hydrological Processes, Vol. 11, 949±970.

Robinson, J.D., J.W. Simmons, A.S. Williams, and G.R. Moyer. 2012. Population structure and genetic diversity in the endangered bluemask darter (*Etheostoma akatulo*). Conservation Genetics, December 2012. DOI 10.1007/s10592-012-0427-x. 14pp.

Simon, T. P. 1997. Ontogeny of the Darter subgenus *Doration* with comments on intrasubgeneric relationships. Copeia 1997: 60-69.

Simmons, J.W. 2004. Selected life history aspects of the endangered bluemask darter, *Etheostoma* (*Doration*) sp. Unpublished M.S. thesis, Tennessee Technological University, Cookeville, Tennessee.

Simmons, J.W. and J.B. Layzer. 2004. Spawning behavior and habitat of the endangered bluemask darter, *Etheostoma* (*Doration*) sp. Copeia 2004: 412-417.

Simmons, J.W., J.B. Layzer, and D.D. Smith. 2008. Age-class structure and variability of two populations of the bluemask darter Etheostoma (Doration) sp. American Midland Naturalist 160:300-309.

Smith, E. K. 2005. Gene flow among seemingly isolated populations of the endangered bluemask darter, *Etheostoma* (*Doration*) sp. Unpublished M.S. thesis, Tennessee Technological University, Cookeville, Tennessee. December 2005. 61pp.

Tennessee Department of Environment and Conservation. 2017. Proposed Final Year 2016 303(d) List. Planning and Standards Unit, Division of Water Resources, Nashville, Tennessee. May 2017. 193 pp and appendices.

Tennessee Department of Environment and Conservation. 2010. Violation Report with Summary: TN0064688 MONTEREY STP. Run Date: 5/11/10 11:24 AM. 5pp.

Tennessee Technological University. 2017. Proposal: Determining Bluemask Darter Ecological Requirements at Multiple Spatial Scales to Support Reintroductions in the Calfkiller River System. Submitted to the U.S. Fish and Wildlife Service – Tennessee Ecological Services Office. 9pp.

Tennessee Technological University. 2018. Determining Bluemask Darter Ecological Requirements at Multiple Spatial Scales to Support Reintroductions in the Calfkiller River System (Cooperative Agreement Award No. F17AC00592). Interim Performance Report: August 1, 2018. Submitted to U.S. Fish and Wildlife Service – Tennessee Ecological Services Office. Prepared by: Hayden Mattingly, Samantha Allen, and Valerie Jones, School of Environmental Studies. 10 pp.

Tennessee Valley Authority. 2010. U.S. Fish & Wildlife Service Operations Consultation Compliance Fiscal Year 2009 Report. Knoxville, Tennessee. June 2010. 90pp.

Tennessee Valley Authority. 2011. U.S. Fish &Wildlife Service Operations Consultation Compliance Fiscal Year 2010 Report. Knoxville, Tennessee. November 2011. 98pp.

Tennessee Valley Authority. 2012. U.S. Fish & Wildlife Service Operations Consultation Compliance Fiscal Year 2011 Report. Knoxville, Tennessee. March 2012. 77pp.

Tennessee Valley Authority. 2019. Synopsis of the current status of the Bluemask Darter from 2017 surveys with comparisons to historical data. Prepared by J.W. Simmons. 17pp.

U.S. Environmental Protection Agency. 2010. Enforcement & Compliance History Online. Data last updated: FRS: 04/15/2010. ICIS: 04/16/2010. http://www.epa-echo.gov/cgi-bin/get1cReport.cgi?tool=echo&IDNumber=110009789586

U.S. Fish and Wildlife Service. 1997. Recovery Plan for the Bluemask (=Jewel) Darter (*Etheostoma* (*Doration*) sp.). July 25, 1997. 25pp.

U.S. Fish and Wildlife Service. 2006. Biological Opinion - Routine Operations and Maintenance of TVA's Water Control Structures in the Tennessee River Basin. FWS Log No. 42430-2006-F-0146. Tennessee Ecological Services Office, Cookeville, TN. 120 pp and appendices.

U.S. Fish and Wildlife Service, Conservation Fisheries, Inc., and Tennessee Wildlife Resource Agency. 2019. Translocation, Propagation, and Reintroduction Plan for the Bluemask Darter, *Etheostoma akatulo*, in Calfkiller River, White and Putnam Counties, Tennessee. 20 pp.

APPENDIX A:
Peer review approach and summary of public comments received for the 5-year review of the **Bluemask darter (*Etheostoma akatulo*)**

Peer Review

Pursuant to Service policy, no external peer review was conducted. This document was peer-reviewed internally by Service biologists: Todd Shaw and Santiago Martin with the Tennessee Field Office.

Since minimal new information was obtained since the last 5-year review in 2013 and since we did not recommend a change in listing status, we did not seek external independent peer review of this document. As we continue to support recovery actions for the species with partners, we look forward to having additional data for our next 5-year review and will conduct a peer review as necessary and according to established Service policy.

Public Comments

We received public comments from one entity during the open comment period in 2019. These came from the National Council for Air and Stream Improvement, Inc. (NCASI) and were dated June 10, 2019.

On behalf of NCASI, Philip Weatherford, Angela L. Larsen, Erik B. Schilling, and Darren A. Miller highlighted the following in their response: 1) forestry best management practices (BMPs) are implemented at high rates nationally and in the ranges of the bluemask darter, duskytail darter, and snail darter, 2) forestry BMPs are effective for protecting water quality and habitat for at-risk species, 3) forestry BMPs are effective for protecting aquatic biota, and 4) contributions of forestry BMPs to conservation of aquatic organisms has previously been recognized by the Service. In this 5-year review, we included logging of upland areas resulting in decreased aquifer recharge, changes in the annual hydrograph, and overland runoff to streams, as a potential and actual threat to the bluemask darter under Section II.C.2.a. We also describe the inadequacy of federal (CWA and the Act) and state regulations to conserve and recover the species (Section II.C.2.d.), and discuss development of partnerships with private landowners to address potential logging impacts and help further conservation of the species (Section II.C.2.d. and Section IV). Furthermore, information regarding habitat and water quality impacts have been incorporated into our analysis.

Appendix B. 2013-2019 Bluemask Darters Surveyed

Table 1. Bluemask Darters Surveyed in the Caney Fork River Drainage 2013 – 2019 (CFI 2014, 2016b, 2018, 2019; R.T. Shaw, pers. obs., October 18, 2019; TTU 2018; TVA 2019).

Location (Stream and river mile[2], description)	County	Date	Surveyors[3]	Number of Bluemask Darters Collected and Life Stage[4]		
				Adult[5]	Juvenile	Unknown Life Stage or Sex
CFRM 100.3 (upstream of Big Bottom Rd crossing)	White	2013	TVA	1M; 1 F		
CFRM 100.2 (upstream of Big Bottom Rd crossing)	White	8/24/2017	TVA		14	
CFRM 100.3 (upstream of Big Bottom Rd crossing)	White	8/24/2017	TVA		2	
CFRM 100.4 (upstream of Big Bottom Rd crossing)	White	8/24/2017	TVA		3	
CNRM 1.6 (downstream of County Rd 159 bridge crossing)	Van Buren	3/14/2018	TVA	1 M		
CNRM 1.7 (downstream of County Rd 159 bridge crossing)	Van Buren	3/14/2018	TVA	2 M; 3 F	1	
CNRM 3.1 (upstream of Haston Chapel)	Van Buren	8/28/2017	TVA	1 M; 3F	11	
CNRM 3.2 (upstream of Haston Chapel)	Van Buren	8/28/2017	TVA	3F	1	
CNRM 3.4 (upstream of Haston Chapel)	Van Buren	8/28/2017	TVA	2 M; 8 F		
CNRM 3.8 (downstream of Sweetgum)	Van Buren	8/28/2017	TVA	5 M; 4 F	2	

[2] Caney Fork = CF; Cane = CN; Collins = CO; Rocky River = RR; River Mile = RM
[3] Conservation Fisheries, Inc. = CFI; Tennessee Technological University = TTU; Tennessee Valley Authority = TVA
[4] * indicates fish collected for brood stock
[5] Male = M; Female = F

CORM 20.2 (upstream Hwy 70)	Warren	9/22/2018	TTU	2		
CORM 25.6 (downstream Shellsford Rd Bridge)	Warren	7/30/2018	TTU	2		
CORM 27.1 (upstream of Rams Creek)	Warren	9/7/2018	TTU	8	1	
CORM 29.5 (upstream of Harrison Ferry Rd)	Warren	8/25/2017	TVA	6 M; 11 F	9	
CORM 31.5 (south of G O'Neal Rd)	Warren	8/1/2018	TTU	3		
CORM 33.7 (downstream of Turner's Bend)	Warren	7/18/2018	TTU	1		
CORM 37.9 (upstream of Turner's Bend)	Warren	8/15/2018	TTU	9	1	
CORM 38 (upstream of Turner's Bend)	Warren	8/15/2018	TTU	1		
CORM 38.8 (confluence of a small tributary downstream of Hills Creek Rd)	Warren	12/2013	CFI	12*		
CORM 39 (Turner's Bend Road, downstream of Hill Creek Rd)	Warren	5/10/2016	CFI	8 M*; 12 F*		29
CORM 39 (Turner's Bend Road, downstream of Hill Creek Rd)	Warren	4/17/2017	CFI	8 M*; 22 F*		16
CORM 39.5 (downstream of Hills Creek Rd)	Warren	8/10/2017	TVA	5 M; 29 F	1	
CORM 39.5 (downstream of Hills Creek Rd)	Warren	10/18/2019	CFI	4M*	~/> 100	
CORM 40.5 (downstream of Slaughter Bend Rd)	Warren	7/27/2018	TTU	3		
CORM 40.6 (downstream of Slaughter Bend Rd)	Warren	7/27/2018	TTU	6	1	
CORM 40.7 (upstream of Slaughter Bend Rd)	Warren	8/6/2018	TTU	9	1	
CORM 40.9 (upstream of Slaughter Bend Rd)	Warren	8/6/2018	TTU	17	1	
CORM 44.3 (vicinity of Camp Woodlee Rd)	Warren	8/10/2018	TTU	2		
CORM 44.4 (downstream of Camp Woodlee Rd and Clendenon Ln intersection)	Warren	8/9/2018	TTU	1	3	
CORM 44.6 (upstream of Camp Woodlee Rd and Clendenon Ln)	Warren	8/9/2018	TTU	5	3	
CORM 45.7 (adjacent to Camp Woodlee Rd)	Warren	12/2013	CFI	18*		
CORM 46.7 (near Wanamaker Cove, at the TWRA boat launch)	Grundy	3/16/2018	CFI	7 M*; 22 F*		
CORM 47 (adjacent HWY 56)	Warren	8/2/2018	TTU	2		
CORM 47.2 (downstream Savage Cove Creek confluence)	Warren, Grundy	8/25/2017	TVA	12 M; 19 F	27	

CORM 47.2 (downstream Savage Cove Creek confluence)	Warren, Grundy	7/24/2018	TTU	7	2	
CORM 47.4 (downstream Savage Cove Creek confluence)	Warren, Grundy	7/24/2008	TTU	9		
CORM 47.6 (upstream Savage Cove Creek confluence)	Warren, Grundy	8/13/2018	TTU	10		
CORM 48.5 (upstream Cove Hollow Creek confluence)	Grundy	7/31/2018	TTU	1		
CORM 48.6 (upstream Cove Hollow Creek confluence; downstream Hwy 56)	Grundy	7/31/2018	TTU	2		
CORM 48.9 (upstream Hwy 56)	Grundy	7/31/2017	TVA	5 M; 21 F	2	
CORM 48.9 (upstream Hwy 56)	Grundy	7/19/2018	TTU	6	2	
CORM 49 (adjacent Gross Cove Rd; downstream Taylor Creek confluence)	Grundy	7/19/2018	TTU	6		
CORM 49.5 (upstream Taylor Creek; downstream Pepper Hollow Branch)	Grundy	7/16/2018	TTU	7		
CORM 49.7 (upstream of Taylor Creek; downstream of Pepper Hollow Branch)	Grundy	7/16/2018	TTU	3		
RRRM 8.7 (downstream of Rt 30)	Warren, Van Buren	11/1/2017	TVA	7 M; 1 F	34	
RRRM 9.7 (downstream of Laurelburg Bridge)	Van Buren	8/9/2017	TVA	2 M; 9 F		
RRRM 10 (upstream of Laurelburg Bridge)	Van Buren	8/9/2017	TVA	3 M; 4 F		

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Etheostoma akatulo*

Current Classification Endangered

Recommendation resulting from the 5-Year Review

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

Appropriate Listing/Reclassification Priority Number, if applicable _____

Review Conducted By Ross (Todd) Shaw, Tennessee Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service
Tennessee Field Office

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2020.08.05 20:13:15 -04'00' Date August 5, 2020