Species Biological Report for

Chucky Madtom (*Noturus crypticus*)

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This Species Biological Report informs the Draft Recovery Plan for the Chucky Madtom (*Noturus crypticus*) (U.S. Fish and Wildlife Service (Service) 2016). The Species Biological Report is a comprehensive biological status review by the Service for the Chucky madtom (*Noturus crypticus*) and provides an account of the species' overall viability. A Recovery Implementation Strategy, which provides the expanded narrative for the Chucky madtom recovery activities and the implementation schedule, is available at http://www.fws.gov/cookeville. The Recovery Implementation Strategy and Species Biological Report will be updated on a routine basis.

EXECUTIVE SUMMARY

Chucky madtoms, a small catfish, are known from a single population in Little Chucky Creek, a tributary to the Nolichucky River in Tennessee. To evaluate the biological status of the Chucky madtom both currently and into the future, we consider the species' viability as characterized by resiliency, redundancy, and representation (i.e., 3Rs). The Chucky madtom needs multiple resilient populations across its range to maintain its persistence into the future and to avoid extinction. Given the reduction of the range to only one stream and the small population size, Chucky madtom has low resilience and redundancy, making it more difficult for the species to withstand and recovery from stochastic or catastrophic events. Further, the species is likely suffering genetic isolation and reduced adaptive capabilities, resulting in low representation. These conditions combined, give the species a high likelihood of extinction.

They are threatened by habitat degradation, extreme curtailment of habitat and range, small population size and low numbers, inability to offset mortality with natural reproduction and recruitment, and their resulting vulnerability to natural or human induced catastrophic events (e.g., droughts, pollution spills, etc.). The species has not been detected since 2004, and was comprised of only a few individuals and is apparently unable to offset mortality with its current recruitment rate. It is threatened by inadequate water quality, habitat deterioration, and introduced species. Virilis crayfish (*Orconectes virilis*) and Kentucky River crayfish (*Orconectes juvenilis*), both introduced species, are abundant in Little Chucky Creek and compete with Chucky madtoms for access to the little habitat that is available for cover and spawning, as well as likely predating on madtom embryos.

INTRODUCTION

The Species Biological Report is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The biological report is intended to be an interim approach as we transition to using a species status assessment (SSA) as the standard format that the Service utilizes to analyze species as we make decisions under the Endangered Species Act. The intent is for the species biological report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery. Many species will have a Species Biological Report or SSA developed during the listing process. However, for species that are currently listed, such as the Chucky madtom, a Species Biological Report or an SSA may be first developed during the recovery process. As such, the Species Biological Report or SSA will be a living document. In this document, we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf et al. 2015).

- **Resiliency** is having sufficiently large populations for the species to withstand stochastic events (arising from random factors).

- **Redundancy** is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations).

- **Representation** is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity of populations across the species' range.

Status of the Species

The Chucky madtom (*Noturus crypticus*) was federally listed as endangered on August 9, 2011 (76 FR 48722). The Tennessee Wildlife Resources Agency (TWRA) lists the Chucky madtom as endangered, under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112). The Chucky madtom grows to 2.9 inches (in) (7.4 centimeters (cm)) total length and is endemic to the upper Tennessee River system in Tennessee. This fish is historically known from two creek systems, but currently persists only in Little Chucky Creek, where a total of 14 individuals have been collected. All 14 have been collected in Little Chucky Creek since 1991; however, none have been captured since 2004 despite considerable survey effort. Extensive efforts have been conducted to survey for and locate Chucky madtoms; however, despite numerous surveys, the last individuals found and sampled in the wild were discovered in 2004.

These small catfish, when compared to other *Noturus* species, require clear flowing water habitats to complete their life cycle, healthy riparian buffers, and appropriate clean spawning habitat. The lack of collection records since 2004 along with habitat changes and modification to existing habitat are cause for concern and suggest that the Chucky madtom may be close to extinction. Approximately 20 river miles (rmi) (32 river kilometers (rkm)) in Little Chucky Creek have been designated as critical habitat for the Chucky madtom (77 FR 63604). The critical habitat is located in Greene County, Tennessee. This fish has a recovery priority number of 5 which indicates the species faces a high degree of threat, but has a low recovery potential.

Taxonomy and Species Description

The Chucky madtom is in the genus *Noturus* in the family Ictaluridae. All species in this genus, referred to as madtoms, are diminutive and possess long and low adipose fins (Burr and Stoeckel 1999, Page and Burr 2011). The Chucky madtom is a member of the *Rabida* subgenus (i.e., the "mottled" or "saddled" madtoms) and was first mentioned as a potential distinct species when its close relative, the elegant madtom (*N. elegans*), was described by Taylor (1969), who included the elegant madtom, the Scioto madtom (*N. trautmani*), and specimens referred to as "*N. elegans*?" in the "*elegans* species group." The questionable *N. elegans* museum specimens included Tennessee River collections from Dunn Creek (TN) and Big Piney Creek (AL) and a Cumberland River collection from the Roaring River (TN). They differed from the elegant madtom on several morphological characters, including body and fin-spine shape, pigment, and number of fin rays. Taylor also recognized color differences between elegant madtoms in the Green and Duck river systems (Taylor 1969). Phylogenetic studies that included the *N. elegans* species group based on combined allozyme, chromosome, and morphology characters (Grady and LeGrande 1992) or mitochondrial and nuclear DNA (Hardman 2004) only included elegant madtom specimens from the Green River (*N. elegans*) and an additional undescribed taxon (*N.* sp. cf. *elegans*) from the Duck River; Scioto madtoms have not been collected since 1957 and are presumed extinct (USFWS 2009), and no Chucky madtom tissues were available for these studies.

The Chucky madtom was first discovered in Little Chucky Creek in 1991 by Charles Saylor, a Tennessee Valley Authority (TVA) biologist. Based on 12 specimens collected in this creek over the next 10 years and the one historical specimen from Dunn Creek collected in 1940, the Chucky madtom was described as *N. crypticus* in 2005 (Burr *et al.* 2005). The Duck River form of the elegant madtom was also described in the same publication as the saddled madtom, *N. fasciatus*. Morphology, allozyme, and mitochondrial sequence data were used to diagnose these new species from the elegant madtom, and phylogentic analysis of the mitochondrial DNA showed that the Chucky and saddled madtom were sister species closely related to the elegant, smoky (*N. baileyi*), and least (*N. hildebrandi*) madtoms. Burr *et al.* (2005) examined the morphology of the other "*N. elegans*?" museum specimens collected from the Roaring River and Piney Creek, along with more recent specimens from other Tennessee River systems in Alabama (West Fork Flint and Paint Rock rivers). They consider these specimens to be members of the *N. elegans* species complex, but were not able to assign them to a species due to the shape of the museum specimens, fading of pigment, and possession of some intermediate characters (Burr *et al.* 2005). Thus, the Little Chucky and Dunn Creek specimens are the only ones recognized as Chucky madtoms. More recent molecular research included another Tennessee River madtom that was missing from all previous genetic studies, the pygmy madtom (*N. stanauli*). Results show that the Chucky and pygmy madtom are closely related and are nested within a *N. hildebrandi* clade (least, elegant, saddled, and smoky madtoms) (Near and Hardman 2006, Bennett *et al.* 2009). A clade is a taxonomic group of organisms classified together on the basis of shared features traced to a common ancestor.

The Chucky madtom is small, even for madtoms, with the largest specimen measuring 2.9 in (7.4 cm) total length (Burr *et al.* 2005). Its robust body is very wide at the pectoral fin origins, greater than 23 percent of the standard length. The back contains three dark, nearly black blotches ending abruptly above the lateral midline of the body, with a moderately contrasting, oval, pale saddle in front of each blotch. The head is pale on the underside and sides except for medium-size melanophores (dark spots) on the cheek below and behind the eyes. The upper half of the opercle (gill cover) has dark pigment continuous with the dark pigment on the top of the head. Sides are moderately pigmented. The belly anterior to pelvic fins has no pigment. The caudal (tail) fin typically has three evenly spaced pale and dark bands and a narrow pale marginal band.

The adipose fin in Chucky madtoms is very low, well connected to the caudal fin, and has a band restricted to the base or half-way up the fin (Burr *et al.* 2005).

Life History

No studies to determine the life history and behavior of this rare species have been conducted.

While nothing is known specifically about the Chucky madtom's reproductive biology, recruitment, growth and longevity, food habits, or mobility, this information is available for madtoms in general (Lang *et al.* 2005) and for some closely-related species in the *Noturus hildebrandi* clade. The least *(N. hildebrandi)* and smoky madtom (*N. baileyi*) reach sexual maturity at 1 year of age (i.e., during their second summer) (Mayden and Walsh 1984, Baker and Heins 1994, Dinkins and Shute 1996). Elegant madtoms are sexually mature as small as 1.7 in (44 millimeters (mm)) standard length (Burr and Dimmick 1981), suggesting they mature at age 1 year. Similarly, only two size groups are apparent in collections of the pygmy madtom (*N. stanauli*) (Etnier and Jenkins 1980). These observations from closely related species indicate that the Chucky madtom also likely matures at age 1 year. A male and female Chucky madtom collected in May 1991 appeared to be in prespawning condition, indicating an early summer spawn (Burr *et al.* 2005). Other closely related madtom species show similar timing for spawning. The breeding season of the least madtom is primarily from mid-April to July, but southern populations (Homochitto River, MS) may spawn from February to September. Larger females spawn earlier in the breeding season (Mayden and Walsh 1984, Baker and Heins 1994). Smoky madtoms spawn primarily during June through July, though development of breeding condition is initiated as early as May (Dinkins and Shute 1996). Elegant madtom nests have been found in June (Burr and Dimmick 1981).

Fecundity in madtoms is among the lowest for North American freshwater fishes due to their small size, relatively large egg size, and high level of parental care given to the fertilized eggs (embryos) and larvae (Dinkins and Shute 1996, Burr and Stoeckel 1999). Least madtom clutch size based on mature oocytes (immature female reproductive cells prior to fertilization) range from 16 to 68, with southern populations having larger clutches (average 35 vs. 25 for northern populations), and only one clutch may be produced in a lifetime (Mayden and Walsh 1984, Baker and Heins 1994). The number of mature oocytes in elegant madtoms range from 19 to 42 and average 31 (Burr and Dimmick 1981). Two smoky madtoms had the largest oocyte size classes, numbering 55 and 87 oocytes (Dinkins and Shute 1996). Number of eggs or larvae in a nest can serve as a proxy for clutch size of females. Twenty five eggs were found in an elegant madtom nest and egg counts during captive breeding of smoky madtoms range from 20 to 65 with an average of 30 (Burr and Dimmick 1981, Dinkins and Shute 1996).

All nesting sites for madtoms are generally cavities under natural material (rocks, logs, empty mussel shells) or human litter (inside cans or bottles, under boards). Cavities are produced on the stream bottom by madtoms moving substrate, including using their heads to push gravel or their mouths to carry gravel and pebble to clear out a cavity. Both sexes may construct nesting cavities (Burr and Stoeckel 1999). Nesting sites for least, elegant, and smoky madtoms are cavities under flat rocks at or near the head of or along the edge of riffles (Burr and Dimmick 1981, Mayden and Walsh 1984, Dinkins and Shute 1996). Shallow pools are also used by the elegant and smoky madtoms, with smoky madtoms observed to select rocks of larger dimension for nesting than were used for shelter during other times of year (Mayden and Walsh 1984, Dinkins and Shute 1996). A single male guards nests in least, elegant, smoky, and presumably all madtoms (Mayden and Walsh 1984, Dinkins and Shute 1996). Guardian males have empty stomachs, suggesting that they do not feed during nest guarding, which can last as long as 3 weeks (Burr and Dimmick 1981, Dinkins and Shute 1996).

Conservation Fisheries, Inc. (CFI) had one male Chucky madtom in captivity from 2004 through 2008. However, based on information from closely related least and smoky madtoms, it is unlikely that Chucky madtoms can survive this long in the wild. Least madtoms reach a maximum age of 18 months, though most individuals live little more than 12 months, dying soon after reproducing (Mayden and Walsh 1984). Based on length-frequency distributions, smoky madtoms exhibit a lifespan of 2 years, with two cohorts present in a given year (Dinkins and Shute 1996). Collection of two age classes together provides evidence that life expectancy does not extend into a third year in the pygmy madtom *(N. stanauli)* (Etnier and Jenkins 1980).

Chucky madtom prey items are unknown; however, least madtom consume midge larvae, caddisfly larvae, stonefly larvae, and mayfly nymphs (Mayden and Walsh 1984). In smoky madtoms, mayfly nymphs comprised 70.7% of stomach contents; fly, mosquito, midge, and gnat larvae 2.4%; caddisfly larvae 4.4%; and stonefly larvae 1.0%; with significant daytime feeding (Dinkins and Shute 1996). Pygmy madtoms may be active during the daytime, with night sampling for specimens less productive (Etnier and Jenkins 1980).

Distribution and abundance

The Chucky madtom is a rare catfish known from only 15 specimens collected from two Tennessee streams. A lone individual was collected in 1940 from Dunn Creek (a Little Pigeon River tributary) in Sevier County, and 14 specimens have been encountered since 1991 in a 1.8 mi (3 km) reach of Little Chucky Creek (a NoliChucky River tributary) in Greene County, Tennessee. Because these creeks are in different watersheds and physiographic provinces, it is likely that the historical range of the Chucky madtom encompassed a wider area in the upper Tennessee River drainage in the Blue Ridge and the Ridge and Valley physiographic provinces in Tennessee than is demonstrated by its current distribution (Figure 2).

Four surveys for Chucky madtoms were completed during 1993-2003 (Burr and Eisenhour 1994, Shute *et al.* 1997, Rakes and Shute 2004, Lang *et al*. 2005). The Tennessee Wildlife Resources Agency (TWRA) funded the initial survey for Chucky madtoms, following collection of two specimens in Little Chucky Creek by Charles Saylor, a Tennessee Valley Authority (TVA) biologist, in 1991. Burr and Eisenhour (1994) sampled 14 sites in addition to five Little Chucky Creek sites during this survey, including streams in the Ridge and Valley and Blue Ridge physiographic provinces in Cocke, Greene, Hamblen, Unicoi, and Washington counties. Sampled streams were tributaries to either the Nolichucky (13 sites and Little Chucky Creek) or the French Broad (one site) rivers. This survey produced nine specimens of Chucky madtom, four of which were taken from the exact same Little Chucky Creek riffle where they were found by TVA in 1991. An additional five specimens were taken from a new location at the mouth of

Jackson Branch, a tributary to Little Chucky Creek, approximately 1.9 mi (3 km) upstream from the locality where the four specimens were collected and in similar habitat.

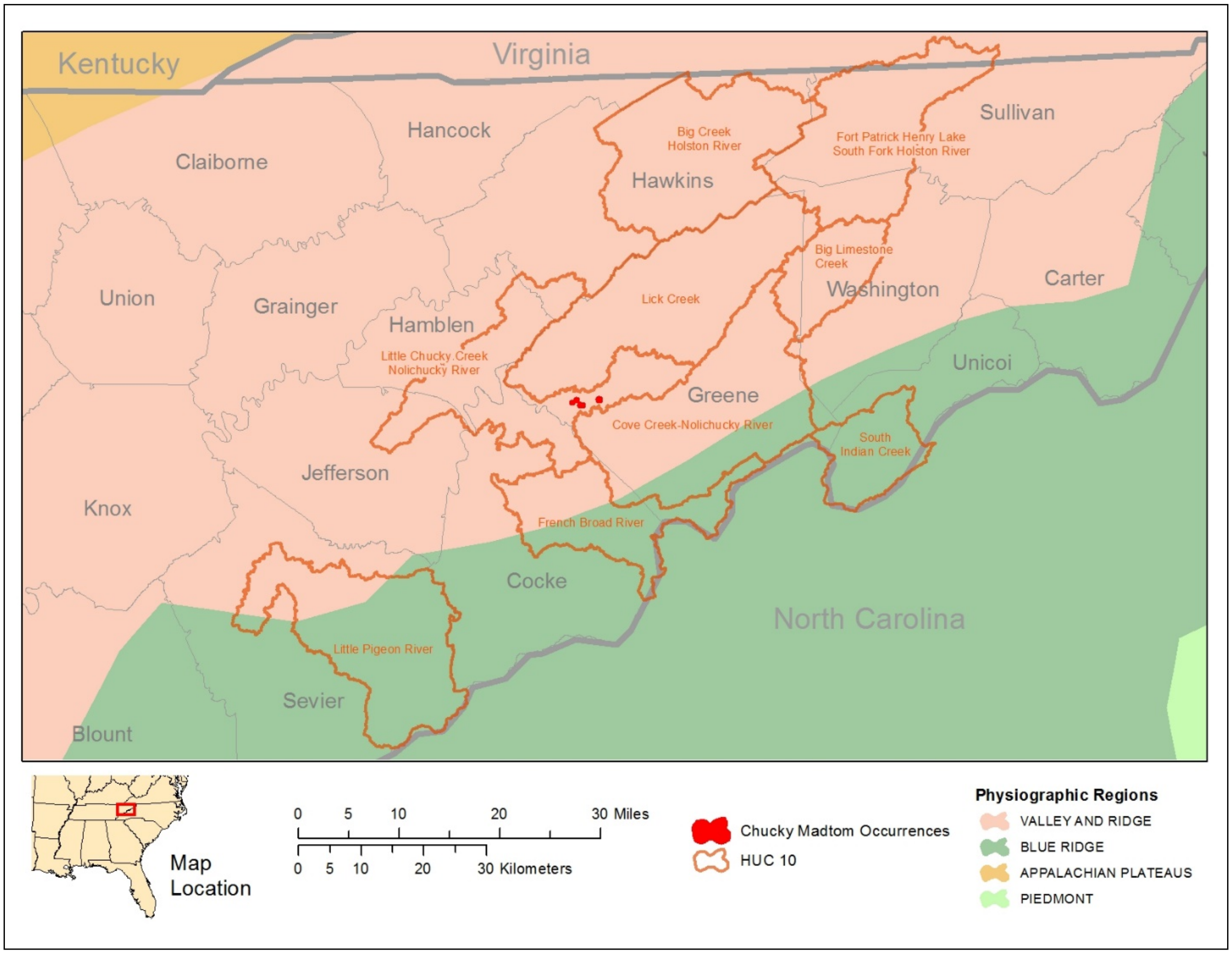

Figure 2. Chucky madtom distribution in the upper Tennessee River drainage (HUC 10 refers to Hydrologic Unit Code 10).

The TWRA funded a second survey (Shute *et al.* 1997) that included the 19 sites surveyed by Burr and Eisenhour (1994) and an additional 35 sites that were reconnoitered and surveyed if suitable habitat was observed. This survey was completed during 1995-1996 and added streams in the Holston River system which were chosen for their apparent similarity to Little Chucky Creek with respect to stream size and physiography. This survey employed both seining and snorkeling, but did not produce any Chucky madtom specimens. In response to the collection of a single specimen in March 2000 at the locality where TVA first collected Chucky madtoms in Little Chucky Creek, the Service funded a third survey, completed between February and September 2001, that encompassed 36 sites in the middle and upper Tennessee River drainage but failed to produce Chucky madtom specimens (Lang *et al.* 2005).

The Service provided funding for a fourth survey for Chucky madtoms in Little Chucky Creek and to collect individuals to initiate a captive propagation program. Fifteen surveys conducted by CFI, between June 13, 2002 and December 5, 2003, totaling 134 person-hours of instream effort, were unsuccessful at relocating any specimens of the Chucky madtom (Rakes and Shute 2004). Two additional collection efforts in Little Chucky Creek were conducted by personnel from the Service, TVA, TWRA, CFI, the Izaak Walton League, and the University of Tennessee on two separate days during the spring of 2004. Two individuals were collected during the first of these two efforts and transported to CFI's facility in Knoxville, Tennessee, for the purpose of initiating a captive propagation program. The collections were taken from a riffle habitat where specimens had not previously been collected. One of these specimens died during 2004, leaving a single live specimen in captivity at CFI, which died in 2008.

The Service and U.S. Geological Survey secured funds for a fifth survey, which was conducted during 2005 and 2006 and focused on tributaries and headwater reaches of Little Chucky Creek – areas not investigated during previous surveys. The focus on tributaries and headwaters was selected due to unconfirmed reports of two madtoms collected during a TWRA spill investigation in 1973 in a tributary to Little Chucky Creek near the town of Rader. No Chucky madtoms were encountered during this survey.

In March 2007, CFI, with assistance from Service biologists, installed a series of artificial nesting structures in one of the two sites in Little Chucky Creek from which Chucky madtoms have been collected. These structures consisted of PVC tubes capped on one end and tied in series. Each string contained approximately 6 to 12 artificial nests. These artificial nests were monitored for presence of nesting Chucky madtoms periodically during spring and summer of 2007-2010, but none were found. Almost all were inhabited by crayfish.

In April 2009, the Service installed 70 artificial nesting structures in Little Chucky Creek. These structures were made from the bottoms of terra cotta pots, with a small hole as both an entrance and an exit to the structure. These artificial nests were monitored for presence of nesting Chucky madtoms during spring and summer 2009-2010, but none were found. Similar to the PVC structures, almost all of the terra cotta pots were inhabited by crayfish.

Because of the extreme rarity or low collection rate for this species, monitoring has been limited to the surveys and collection efforts described. Such monitoring involves conducting surveys to identify stream runs with slow to moderate current over pea gravel, cobble, or slab-rock substrates (Burr and Eisenhour 1994, Burr *et al.* 2005) in Little Chucky Creek. Collections have been attempted in these habitats by kick-seining or snorkeling. This level of monitoring is appropriate for this species due to its apparent rarity or low detection rate, which prevents utilization of a sampling design that would allow for detection of population trends.

A survey for the Chucky madtom in Dunn Creek in 1996 was not successful at locating the species (Shute *et al.* 1997). The Dunn Creek population may be extirpated (Shute *et al.* 1997, Burr *et al.* 2005) because adequate habitat and a diverse fish community were present at the time of the surveys, but no Chucky madtoms were found. Only three Chucky madtom individuals have been encountered since 2000; one in 2000 (Lang *et al.* 2005) and two in 2004 (CFI 2008, unpublished data), despite surveys conducted between 2000 and 2010 in historical localities

(Rakes and Shute 2004, Weber and Layzer 2007, CFI 2008, unpublished data). In addition, several streams in the Nolichucky, Holston, and French Broad River watersheds of the upper Tennessee River drainage, which are similar in size and character to Little Chucky Creek, have been surveyed with no success (Burr and Eisenhour 1994, Shute *et al.* 1997, Rakes and Shute 2004, Lang *et al.* 2005). CFI and the Service did not find Chucky madtoms in Little Chucky Creek from 2007 to 2010 after attempting new sampling techniques (e.g., PVC "jug" traps, terra cotta pots) (CFI 2008, unpublished data; Service 2009-2010, unpubl. data).

There are no population size estimates or status trends for the Chucky madtom in Little Chucky Creek due to low numbers and only sporadic collections of specimens. The Chucky madtom is likely extirpated from Dunn Creek (Shute *et al.* 1997, Burr *et al.* 2005). Given the reduction of the range to only one stream and the small population size, Chucky madtom has low resilience; populations are not sufficiently large for the species to withstand stochastic events (arising from random factors). Additionally, the restricted range results in low redundancy; there are not a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations).

Genetics

Genetic analyses have been used to assess relationships (see Taxonomy), but no population-level studies have been done. Currently, there are only 15 Chucky madtom specimens preserved or frozen, one from Dunn Creek and 14 from Little Chucky Creek (Burr *et al.* 2005, Lang *et al.* 2005). Only six of these specimens potentially have tissue or DNA available for further genetic studies (Burr *et al.* 2005, Near and Hardman 2006), but this number is far below what is necessary for statistical rigor in any population-level study. Sample size is an issue even if researchers are able to extract usable DNA from formalin-fixed museum specimens. Given the reduced range and small population size, the species is likely suffering genetic isolation and reduced adaptive capabilities, resulting in low representation.

Habitat

All Chucky madtom specimens collected in Little Chucky Creek have been found in reaches 16 to 23 feet (ft) (5 to 7 meters (m)) wide in stream runs boarded by water willow (*Justicia* spp.) beds with slow to moderate current over pea-sized gravel, cobble, or slab-rock substrates (Burr and Eisenhour 1994, Burr *et al.* 2005). Habitat of these types is sparse in Little Chucky Creek, and the stream affords little loose, rocky cover suitable for madtoms (Shute *et al.* 1997). It is notable that intact riparian buffers are present in the locations where Chucky madtoms have been found (Shute *et al.* 1997).

Chucky madtoms have not been reported to use other habitats in Little Chucky Creek, but shifts to different habitats have been recorded for closely related species. Smoky madtoms are found underneath slab rocks in swift to moderate current during May to early November. Habitat use shifts to shallow pools over the course of a 1-week period, coinciding with a drop in water temperature to 7 or 8°C (45 to 46°F), and persisted from early November to May (Dinkins and Shute 1996). Saddled madtoms are found in gravel, cobble, and slab-rock substrates in riffle and run habitats with depths ranging from 0.3 to 1.0 ft (0.1 to 0.3 m) from May to November. Based on a limited number of observations, it is hypothesized that saddled madtoms occupy this habitat in the daylight hours and then move to pools at night and during crepuscular hours (dawn and dusk) to feed. All Chucky madtoms have been collected in Little Chucky Creek in late March (1 specimen), May (4), or September (9) (Burr *et al.* 2005, Lang *et al.* 2005, CFI 2008, unpublished data). During non-spawning months (potentially October through February), Chucky madtoms may utilize other habitat either within or outside of Little Chucky Creek. Although surveys have been conducted from October through February, no individuals have been observed in these months.

No Chucky madtoms have ever been collected in the Nolichucky River, even though it is only 6.5 to 9.5 km (4.0 to 5.9 miles) downstream of all Little Chucky Creek sites where Chucky madtoms have been collected. The closely related pygmy and saddled madtoms use mainstem habitat; all collections of pygmy madtoms are from the mainstem of the Duck and Clinch rivers and saddled madtoms are occasionally collected in the Duck and Buffalo river mainstems (Etnier and Jenkins 1980, Eisenhour *et al.* 1996, Burr *et al.* 2005). Given that Chucky madtoms are known from two creeks in different watersheds (Little Pigeon and Nolichucky rivers), they must have historically used mainstem habitat, at least for movement between smaller creeks in the upper Tennessee River drainage. But given that detection of such a small, secretive, and rare fish in larger habitats is difficult, the lack of mainstem collections is not unexpected. Few surveys have focused on these large river habitats and additional surveys in these habitats are warranted.

Critical Habitat

Approximately 20 rmi (32 rkm) of stream channel in Little Chucky Creek have been designated as critical habitat for the Chucky madtom (77 FR 63604) (Figure 3). The critical habitat is located in Greene County, Tennessee. Critical habitat includes one unit:

- Little Chucky Creek Unit, Greene County, TN: Little Chucky Creek Unit includes 19.8 rmi (31.9 rkm) of Little Chucky Creek from its confluence with an unnamed tributary, downstream to its confluence with the Nolichucky River, at the Greene and Cocke County line, TN.

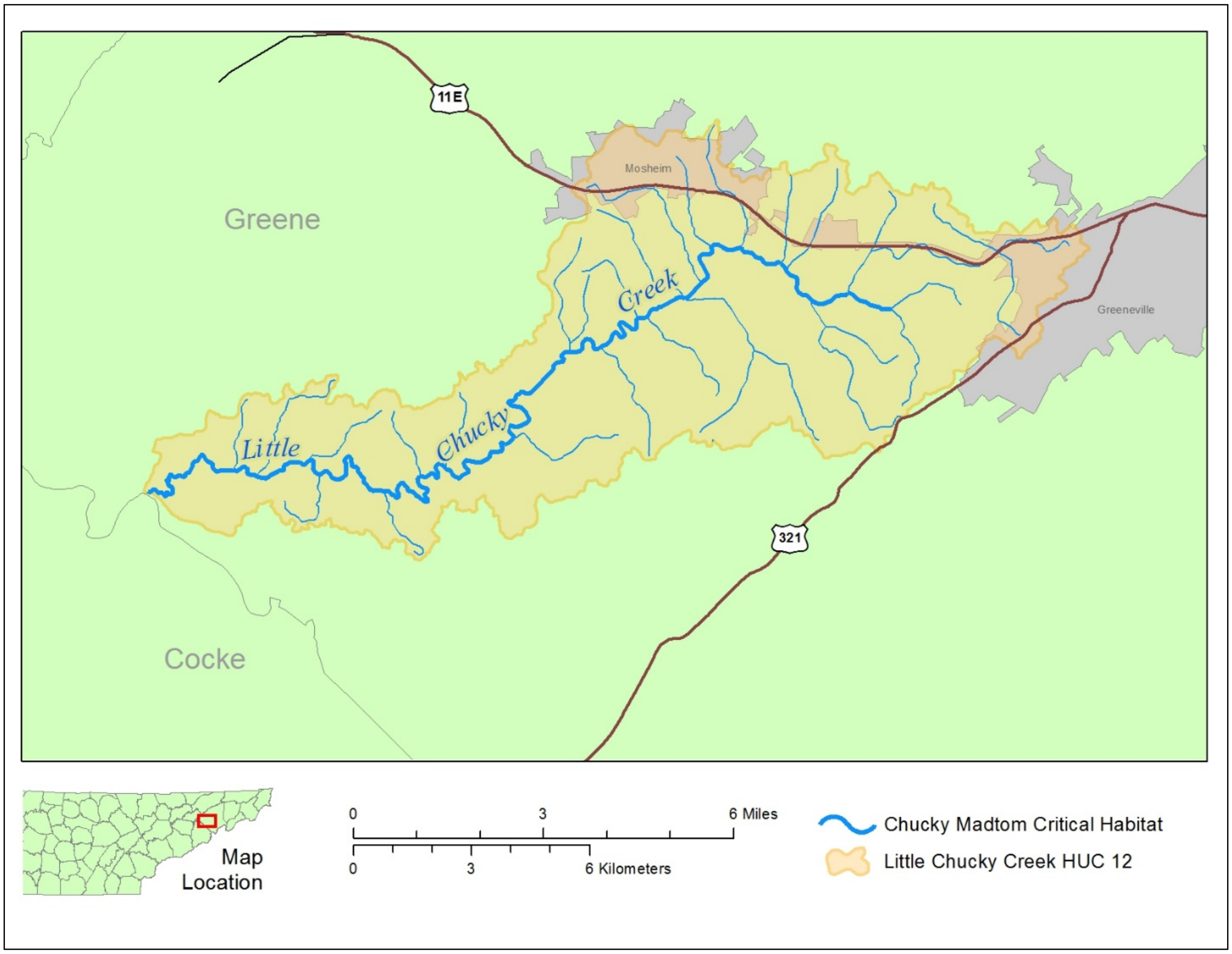

Figure 3. Designated critical habitat for the Chucky madtom.

The primary constituent elements of critical habitat for this fish are:

- Gently flowing run and pool reaches of geomorphically stable streams with cool, clean, flowing water, shallow depths, and connectivity between spawning, foraging, and resting sites to promote gene flow throughout the species' range.

- Stable bottom substrates composed of relatively silt-free, flat gravel, cobble, and slab-rock boulders.

- An instream flow regime (magnitude, frequency, duration, and seasonality of discharge overtime) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species.

- Adequate water quality characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants. Adequate water quality is defined for the purpose of this rule as the quality necessary for normal behavior, growth, and viability of all life stages of the Chucky madtom.

- Prey base of aquatic macroinvertebrates, including midge larvae, mayfly nymphs, caddisfly larvae, and stonefly larvae.

Summary of current resiliency, redundancy, and representation

In summary, resiliency, redundancy, and representation are all low for Chucky madtom. Although this fish is historically known from two creek systems, it currently persists only in Little Chucky Creek, where a total of 14 individuals has been collected from 1991-2004. It has not been detected in historical collections sites since 2004. It is likely that an individual Chucky madtom will only have a single clutch in its lifetime and a mutli-year disturbance could completely prevent the individual from ever reproducing. Therefore, captive propagation will be needed to achieve resiliency. Chucky madtoms are known from only two watersheds and no individuals have been collected since 2004. The species would need to be reintroduced to multiple sites within these watersheds to achieve redundancy. Representation can be measured through the genetic diversity within and among populations and the ecological diversity of populations across the species' range. No populations have been detected since 2004. No population level genetic work is available for this species. Only taxonomic level work has been done and it provides the species relationship within the clade. More individuals are needed to develop an understanding of the potential species representation. However, due to the restricted range and small population size, the species is likely suffering genetic isolation and reduced adaptive capabilities, resulting in low representation

REASONS FOR LISTING/THREATS ASSESSMENT

The Chucky madtom (*Noturus crypticus*) is federally listed as endangered, is listed as endangered by TWRA, under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), and is considered one of the 12 most imperiled freshwater fishes in the southeastern United States (Kuhajda *et al.* 2009).

Below, we present a summary of threats affecting the Chucky madtom and its habitats. A detailed evaluation of factors affecting the species can be found in the listing determination (76 FR 48722) and the designation of critical habitat (77 FR 63604). Primary threats to the species include habitat degradation due to factors like sedimentation, extreme range curtailment, small population size and naturally low fecundity, drought, contaminants associated with land use (primarily agriculture), and resource competition and predation by native and invasive species.

Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range

Water and Habitat Quality: The TVA Index of Biological Integrity results indicate that Little Chucky Creek is biologically impaired (Middle Nolichucky Watershed Alliance 2006). Land use data from the Southeast GAP Analysis Program (SEGAP) show that land use within the Little Chucky Creek watershed is predominantly agricultural, with the vast majority of agricultural land being devoted to production of livestock and their forage base (Jones *et al.* 2000). Traditional farming practices, feedlot operations, and associated land use practices contribute many pollutants to rivers. These practices degrade habitat by eroding stream banks which results in alterations to stream hydrology and geomorphology. Nutrients, bacteria, pesticides, and other organic compounds generally are found in higher concentrations in agricultural areas than forested areas. Nutrient concentrations in streams may result in increased algal growth and a related alteration in fish community composition (Petersen *et al.* 1999). Given the predominantly agricultural land use within the Little Chucky Creek watershed, nonpoint source sediment and agrochemical discharges may pose a threat to the Chucky madtom by altering the physical characteristics of its habitat, thus potentially impeding its ability to feed, seek shelter from predators, and successfully reproduce. The Chucky madtom is a bottom-dwelling (benthic) species; all benthic fishes are especially susceptible to sedimentation and other pollutants that degrade or eliminate habitat and food sources (Berkman and Rabeni 1987, Waters 1995, Richter *et al.* 1997). Etnier and Jenkins (1980) suggested that madtoms, which are heavily dependent on chemoreception (detection of chemicals) for survival, are susceptible to human-induced disturbances, such as organic chemical and sediment inputs, because the olfactory (sense of smell) "noise" these pollutants produce could interfere with a madtom's ability to obtain food, coordinate behavioral patterns, and otherwise monitor its environment.

Degradation from sedimentation, physical habitat disturbance, and contaminants threaten the habitat and water quality on which the Chucky madtom depends. Sedimentation from agricultural lands could negatively affect the Chucky madtom by reducing growth rates, disease tolerance, and gill function; reducing spawning habitat, reproductive success, and egg (embryo), larva, and juvenile development; reducing food availability through reductions in prey; reducing foraging efficiency; and reducing shelter. Sediment is the most visible pollutant in the Little Chucky Creek watershed and one of the greatest threats to the Chucky madtom. Chucky madtoms are restricted to habitat with pea-sized gravel, cobble, or slab-rocks substrates not embedded by large amounts of silt (Burr and Eisenhour 1994, Burr *et al.* 2005); this habitat is sparse in Little Chucky Creek (Shute *et al.* 1997). Contaminants associated with agriculture (e.g., fertilizers, pesticides, herbicides, and animal waste) can cause degradation of water quality and habitats through instream oxygen deficiencies, excess nutrification, and excessive algal growths.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Chucky madtoms are not commercially utilized. Individuals have been taken for scientific studies and potential propagation from 1991-2004. Since listing of the species under the ESA in 2011, take for scientific purposes is strictly regulated by both TWRA and the Service, and is not expected to be a threat to the species. There is low risk of take by anglers for bait; other madtom species are considered highly prized bait for black bass and walleye (Chan and Parsons 2000, Emmett and Cochran 2010), but not all anglers commonly use madtoms as bait (Robison and Harris 1978).

Factor C: Disease or Predation

Disease is not considered to be a factor in the decline of Chucky madtoms. Predation may be occurring from piscivorous fishes native to Little Chucky Creek, other madtom species are preyed upon by black basses (Emmett and Cochran 2010). Recently, a yellowfin madtom (*Noturus flavipinnis*) was observed in the stomach of a Smallmouth bass (*Micropterus dolomieu*) in Abrams Creek (Dinkins 2014, pers. comm.). Non-native or introduced species are a potential threat to Chucky madtom. Virilis crayfish (*Orconectes virilis*) and Kentucky River crayfish (*Orconectes juvenilis*), both introduced species, are abundant in Little Chucky Creek and compete with Chucky madtoms for access to the little habitat that is available. Artificial nesting sites installed in Little Chucky Creek were almost all inhabited by crayfishes (CFI 2008, unpubl. data; Service 2009-2010, unpubl. Data). Crayfishes may also pose a threat of predation to Chucky madtoms, especially early life stages. Madtom embryos have been preyed on by crayfish (Mayden and Burr 1981) and analyses of the diet of stream-dwelling crayfishes show that 12% of the diet is fish (Taylor and Soucek 2010). Given the limited habitat available to Chucky madtoms in Little Chucky Creek, crayfish predation or competition for spawning habitat could have a major impact on Chucky madtom persistence and recovery.

Factor D: Inadequacy of Existing Regulatory Mechanisms

The Chucky madtom and its habitats are afforded some protection from water quality and habitat degradation under the Clean Water Act (CWA) and by TDEC's Division of Water Pollution Control under the Tennessee Water Quality Control Act of 1977 (TWQCA, T.C.A. 69-3-101). Portions of the Nolichucky River in Greene County, Tennessee, are listed as impaired (303d) by the TDEC due to pasture grazing, irrigated crop production, unrestricted cattle access, land development, municipal point source discharges, septic tank failures, gravel mining, agriculture, and channelization (TDEC 2012). However, Little Chucky Creek is not listed as "an impaired water" by the State of Tennessee (TDEC 2012). For water bodies on the 303(d) (impaired) list, States are required under the Clean Water Act to establish a Total Maximum Daily Load (TMDL) for the pollutants of concern that will bring water quality into the applicable standard. The TDEC has developed TMDLs for the Nolichucky River watershed to address the problems of fecal coliform loads, siltation, and habitat alteration by agriculture. However, population declines and degradation of habitat for this species are ongoing. Federal and state regulations alone have not been adequate to fully protect this species; sedimentation and nonpoint source pollutants continue to be a significant problem. Sediment is the most visible pollutant in the watershed and one of the greatest threats to the Chucky madtoms. Adequate regulatory mechanisms to protect water quality for the Chucky madtom are currently not in place.

In addition to the federal listing, the Chucky 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 or nexus over the many actions likely impacting Chucky madtom habitat has become apparent. Many of the threats (including those identified at the time of listing) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from agriculture, water withdrawals, or logging on private lands) 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 Chucky madtom, enforcement of the section 9 prohibitions is difficult since these violations may occur on private land, remote locations, or go unreported. 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.

Factor E: Other Natural or Manmade Factors Affecting its Continued Existence
Restricted Range and Population Size: The current range of the Chucky madtom is believed to be restricted to approximately a 1.8-mi (3-km) reach of Little Chucky Creek in Greene County, Tennessee. The range of the Chucky madtom has been reduced to only one stream due to fragmentation and destruction of habitat. Habitat fragmentation has subjected the small population to genetic isolation, reduced space for rearing and reproduction, reduced adaptive capabilities, and increased the likelihood of extinction (Burkhead *et al.* 1997, Hallerman 2003). 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, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Soule 1980, Hunter 2002, Allendorf and Luikart 2007). It is likely that the only known Chucky madtom population is below the effective population size required to maintain long-term genetic and population viability (Soule 1980, Hunter 2002). Only 14 specimens of Chucky madtom have been collected in Little Chucky Creek since its discovery in 1991, and none have been collected since 2004 despite several targeted surveys. It has been estimated that effective population sizes may range from 500 individuals (Franklin and Frankham 1998) to avoid deleterious effects of genetic drift over several generations, up to 5,000 individuals (Lande 1995) for long-term survival. The long-term viability of a species is founded on the conservation of numerous local populations throughout its geographic range (Harris 1984). These separate populations are essential for the species to recover and adapt to environmental change (Harris 1984, Noss and Cooperrider 1994). The Chucky madtom is restricted to a single small population, and this level of isolation would make natural repopulation of Dunn Creek and any other areas of suitable habitat within its historical range virtually impossible without human intervention.

Low Fecundity: Fecundity in madtoms is among the lowest for North American freshwater fishes (Burr and Stoeckel 1999) which could limit the potential for populations to rebound from disturbance events. As described above, members of the *N. hildebrandi* clade of madtoms exhibit relatively short life spans of 2 years or less and only one clutch of eggs may be produced in a lifetime (Mayden and Walsh 1984, Baker and Heins 1994). This is likely the case for the Chucky madtom; therefore, the species' viability is vulnerable to severe demographic shifts from disturbances that prevent reproduction in even a single year. If the disturbance persists for successive years, this could be devastating to the species.

Competition for Resources from Invasive Species: Appropriate nesting sites and shelter for Chucky madtoms are rare in Little Chucky Creek due to sedimentation issues. Installation of artificial nesting sites (PVC tubes capped on one end and bottoms of terra cotta pots) have been unsuccessful in attracting any Chucky madtoms; these structures were almost all inhabited by crayfishes (Chance 2008, pers. obs.). Crayfish compete with Chucky madtoms for nesting sites and shelter. Invasive crayfish are an even greater threat, as they rapidly expand their distribution and abundance, competing with native crayfishes and benthic fishes (Taylor *et al.* 2007). One widespread invasive crayfish in the Tennessee River drainage is the virilis crayfish (*Orconectes virilis*) (Smith *et al.* 2011). This species has preyed upon slender madtom (*N. exilis*) embryos (Mayden and Burr 1981). Both the virilis crayfish and the Kentucky river crayfish are present within Little Chucky Creek. When habitat for the federally listed, endangered watercress darter (*Etheostoma nuchale*) was reduced due to a dewatering event, the invasive virilis crayfish competed for shelter with and preyed upon watercresss darters (Fluker *et al.* 2009). Given the limited habitat available to Chucky madtoms in Little Chucky Creek, crayfishes could have a major impact on Chucky madtom persistence and recovery.

Climate Change: Climate change has the potential to increase the vulnerability of rare species to random catastrophic events (e.g., McLaughlin *et al.* 2002; Thomas *et al.* 2004). Climate change is expected to result in increased frequency and duration of droughts and the strength of storms (e.g., Cook *et al.* 2004). Climate change could intensify or increase the frequency of drought events, such as the one that occurred in the southeastern U.S. in 2007. Thomas *et al.* (2004) report that the frequency, duration, and intensity of droughts are likely to increase in the southeastern U.S. as a result of global climate change. Stream flow is strongly correlated with important physical and chemical parameters that limit the distribution and abundance of riverine species (Power *et al.* 1995, Resh *et al.* 1988) and it regulates the ecological integrity of flowing water systems (Poff *et al.* 1997).

ONGOING CONSERVATION EFFORTS

The Chucky madtom was first identified as a federal candidate species in 1994 based on existing threats to the species, followed by federally listing as endangered on August 9, 2011 (76 FR 48722). In 1994, with help from our many partners, we started implementing habitat conservation actions to help conserve the species. The Service has participated in efforts to survey for and locate Chucky madtoms; however, despite numerous surveys, the last individuals found and sampled in the wild were discovered in 2004.

The Middle Nolichucky Watershed Alliance (MNWA) coordinates conservation and outreach efforts throughout the Middle Nolichucky watershed, of which Little Chucky Creek is a part. In 2005, the MNWA established a Technical Advisory Committee comprised of federal, state, and local governmental agency and nongovernmental organization representatives. The Technical Advisory Committee selected the Little Chucky Creek watershed as the focal region for its initial efforts in the watershed. This committee plans to build on the conservation efforts described below and assume a leadership role in establishing conservation priorities, seeking funding for conservation measures, and implementing and monitoring the effectiveness of those measures. The Service serves as a partner in the alliance. Conservation efforts in the Little Chucky Creek watershed to date are described below in two broad categories: 1) general habitat conservation to protect water quality by encouraging sound land use practices, and 2) specific measures to determine the distribution and status of Chucky madtoms, generate knowledge regarding the species' biology, or propagate Chucky madtoms for population augmentation.

Habitat Conservation

Numerous partners are cooperating in efforts to implement agricultural best management practices in Little Chucky Creek watershed by delivering various incentive programs to private landowners. These partners include the Greene County Soil Conservation District (GCSCD), Natural Resources Conservation Service (NRCS), TVA, TWRA, and the Service. The Service has completed Partners for Fish and Wildlife projects with local landowners along Little Chucky Creek, which have involved matching funds from TVA and technical assistance from GCSCD and NRCS. These projects involve installation of riparian fencing, creation of alternate water sources and development of hardened stream access points for cattle, and bank stabilization. Partners for Fish and Wildlife funds are sought annually for new habitat restoration projects in the watershed.

The GCSCD and NRCS staff have been instrumental not only in helping the Service to deliver Partners for Fish and Wildlife programs (types of projects mentioned above) in the Little Chucky Creek watershed, but also in delivering other conservation programs, including: Environmental Quality Incentives Program (EQIP), Tennessee Department of Agriculture's Agriculture Resource Conservation Fund (ARCF), and the Tennessee Landowner Incentive Program (LIP).

In addition, the Land Trust for Tennessee and the Appalachian Resource Conservation and Development Council have purchased permanent conservation easements along Little Chucky Creek. These actions ensure that development will not occur along the creek.

Chucky Madtom Conservation Measures

The Service is continuing to work with partners to develop new techniques for surveying the Chucky madtom (environmental DNA). (See Distribution and Abundance section for a detailed survey history.)

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