Cape Fear Shiner
(Notropis mekistocholas)

5-Year Review:
Summary and Evaluation

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

5-Year Review:
Cape Fear Shiner (*Notropis mekistocholas*)

I. GENERAL INFORMATION

A. Methodology used to complete the review:

This review was completed by the U.S. Fish and Wildlife Service's (hereafter the Service) Raleigh Ecological Services Field Office. All literature and documents used for this review are cited in the References section and are on file at the Raleigh Field Office. We used published literature; technical reports; data and information on the Internet; unpublished data; and personal communications with land managers, biologists, and researchers. Public notice of this review was given in the *Federal Register* (FR) on July 6, 2009, with a 60-day public comment period (74 FR 31972). After requesting new information concerning the biology and status of the species, the Service received only one public comment for this review.

On September 4, 2009, the North Carolina Natural Heritage Program (NCNHP) submitted to the Service element occurrence data for the Cape Fear Shiner within the Deep, Rocky, Haw and Cape Fear rivers in North Carolina. For each element occurrence of the shiner, the NCNHP also assigned a viability ranking. This information was incorporated into this review. The Service also sent a draft of this 5-year review document to five experts for peer review (See Appendix A). The Service addressed all comments received from the peer reviewers. A summary of the original peer review process is included in Appendix A. It should be noted that in the process of drafting this 5-year review in 2009, we made an error in the original document we sent out for peer review. The error included suggested changes to the content of the recovery plan; we now recognize these changes cannot be made through the 5-year review process and we must do a separate draft and final recovery plan and offer public comment. Therefore, we document in this revised 5-year review the original recovery plan criteria and our progress towards them, with qualifiers that we are in the process of reevaluating our original recovery plan. We will maintain the original (2009) peer review comments to consider as we reevaluate the recovery plan, however we have added new peer review for this revised 5-year review document after fixing the error. We requested formal peer review from three experts in May 2017 and received comments back from one peer reviewer (see Appendix A); those comments have been incorporated into this 5-year review.

B. Reviewers

Lead Region: Kelly Bibb, Southeast Region, Atlanta, GA, (404) 679-7132.

Lead Field Office: Sarah McRae, Raleigh Ecological Services Field Office, Raleigh, NC, (919) 856-4520x16.

C. Background

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

2. **Species Status:** 2016, stable; consistent observations of Cape Fear Shiners and expansion of range post dam removal in Deep River.
3. **Recovery Achieved: 2** (2 = 26-50%) of species' recovery objectives have been partially achieved.
4. **Listing History**

Original Listing
FR notice: 52 FR 36034
Date listed: September 25, 1987
Entity listed: species
Classification: endangered

5. **Associated rulemakings**: None

6. **Review History:**

Each year the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we did a recovery data call that included showing status recommendations like "Stable" for this fish each year. We continue to show that species status recommendation in 5-year reviews. The most recent evaluation for this fish was completed in 2016.

The Service conducted a 5-year review for the Cape Fear Shiner in 1991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No new information or additional data was received. Therefore, no change in the fish's listing classification was found to be appropriate.

1988 – Recovery Plan

7. **Species' Recovery Priority Number at start of review (48 FR 43098): 5.** At the time of listing, the Cape Fear Shiner was determined to be a species with a high degree of threat and a low recovery potential.

8. **Recovery Plan:**

Name of plan: Cape Fear Shiner Recovery Plan
Date issued: October 7, 1988

II. REVIEW ANALYSIS

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

1. Is the species under review listed as a DPS? No

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No

B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes. The measurable criteria included in the plan to downlist and delist the species included the number of distinct viable populations needed.

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. The Cape Fear Shiner has a final approved recovery plan (USFWS 1988), but it is outdated. We have learned more information about the species' biology, genetics, distribution, and habitat. Several genetic studies (Burridge and Gold 2003; Gold et al. 2004; Saillant et al. 2004) have documented information that we will consider upon possibly revising the recovery plan in the near future. This may lead to different criteria to be evaluated in the next 5-year review and may lead us to identify populations differently in the future.

   b. **Are all of the five listing factors that are relevant to the species addressed in the recovery criteria?** Yes. When the recovery plan was approved, the Cape Fear Shiner was largely threatened by Factors A and E. These factors are addressed in these criteria.

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 recovery plan states that the Cape Fear Shiner will be considered for reclassification to threatened status when the following criteria have been achieved:

1. *Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, <u>a total of four distinct viable populations</u> exist in the Cape Fear River basin.*
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 or are likely to be successful.*

In 2010, the Service developed a Strategic Habitat Conservation Framework for the Cape Fear Shiner. We may use information from this document in a separate process to revise the recovery plan and to determine high priority recovery activities for the Cape Fear Shiner, as well as conduct a population viability assessment. For now, we assess where we are at based on the existing criteria in the current recovery plan.

Criterion #1 has been partially met. The Lower Rocky River-Deep River population has been expanded through the removal of Carbonton Dam. Extensive habitat protection efforts are underway along both the Rocky River and Deep River corridors. We will reevaluate this criterion more fully when we propose to revise the recovery plan.

In relation to criterion #2, the Service has helped fund 15 Cape Fear Shiner research studies. These include the following topics:

- Habitat requirements (2 studies)
- Reproductive behavior (1 study)
- Sensitivity to water-borne contaminants (4 studies)
- Genetic diversity (4 studies)
- Mortality risk due to electroshocking (1 study)
- Suitable surrogate species for future water quality studies (1 study)
- Population status across the shiner's historic range (4 studies)

See Appendix B for a summary of all studies completed to date.

While we have made great progress towards completion of studies on the fish's biological and ecological requirements, we believe this criterion is only partially met because the implementation of management strategies developed from these studies has not been successful range-wide. For example, management strategies for the Haw River and Rocky River are underway and have yet to reach a stage to be deemed likely successful or not.

The recovery plan states that the Cape Fear Shiner will be considered for delisting when the following criteria have been achieved:

1. *Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, <u>a total of six distinct viable populations</u> exist in the Cape Fear River basin.*
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 or are likely to be successful.*
3. *No foreseeable threats exist that would likely threaten survival of any of these six populations.*
4. *Noticeable improvements in water and substrate quality have occurred to the species' habitat and the species has responded through natural means or with human assistance to successfully recolonize other streams and stream reaches within the Cape Fear River basin.*

Since we do not believe that reclassification criteria have been achieved yet, we are not going to summarize progress toward delisting criteria. We provided updates in Section C (below).

C. Updated Information and Current Species Status

1. Biology and Habitat

(a) Information on the Species Biology and Life History:

Diet

The Cape Fear Shiner has widely been described as an herbivore due to its unique intestine morphology. Analysis of stomach contents and dietary studies revealed that the species is actually omnivorous (Snelson 1971). Protein may be important in early growth stages of the Cape Fear Shiner, suggested by growth studies on different diets conducted at the North Carolina Zoo (Groves 2000).

Reproduction

Spawning by captive and wild populations of Cape Fear Shiners begins in early spring and can run through the summer (Groves 2000). Spawning has been initiated in laboratory settings with and without cover. Temperature of water does seem to be important in the onset of spawning (Groves 2002). Temperatures below 68°F do not seem to be conducive to egg laying. In a captive setting, 72°F was required for the onset of spawning. Cape Fear Shiners are broadcast spawners; thus the female scatters her eggs over the gravel substrate for fertilization by the male (Groves 2000). It takes approximately three days for eggs to hatch. At hatching the larvae are 5 mm in length, including the yolk sack upon which they feed for the first five days of life (CFI 1999). Shiners may be able to produce up to three broods per year but this aspect of life history is still under investigation (John Groves, North Carolina Zoological Park, personal communication 2009).

Demography

Cape Fear Shiners reach reproductive maturity after one year (Groves 2000). Under laboratory conditions, individuals can reach seven years of age (Groves 2004). Presumably they live one to two years in the wild (Groves 2000). Captive Cape Fear Shiners are still capable of reproducing at age six (Groves 2004). It is unclear yet at what age fecundity begins to decline. Also, it is not yet known how many eggs or offspring a female can produce during a spawning period. However, Conservation Fisheries, Inc. (CFI) tracked the approximate number of eggs it propagated in captivity using a founding population of 31 wild Cape Fear Shiners. That founding population produced approximately 5,200 eggs, with the approximate number of eggs per breeding batch ranging between 130 and 750 (CFI 1999).

(b) Species' abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends

It is difficult to report stability, increases or declines in population sizes of the Cape Fear Shiner due to the different sampling techniques and sampling areas over the decades. One estimate of population size originates from the genetic study by Gold et al. (2004). Gold and his colleagues sampled Cape Fear Shiners at three locations in the Deep River: 1) at the confluence of the Deep and Rocky Rivers (Confluence), 2) below High Falls Dam (High Falls), and 3) at the bridge for State Road 1456 (SR-1456). Gold et al. (2004) estimated allelic variation among the three research populations to establish effective population sizes (i.e., the number of individuals in a population that contribute offspring to the next generation) and detect population changes for the Cape Fear Shiner. For the Confluence population, Gold et al. (2004) estimated the effective population size at 2,063 individuals (95% confidence interval = 1,884 to 2,267 individuals); for the High Falls population at 1,314 individuals (95% confidence interval = 1,197 to 1,460 individuals); and for the SR-1456 population at 2,972 individuals (2,729 to 3,248 individuals). These research populations are believed to be the largest and most stable populations of Cape Fear Shiners (Gold et al. 2004).

Hewitt et al. (2009) reported that fish were locally abundant in the Deep and Rocky rivers, although densities varied among surveyed tracts. Using the strip transect method, Hewitt et al. (2009) identified high densities of Cape Fear Shiners in both the Rocky River (mean of 1,393 fish/ha or 6,270 fish/km) and Deep River immediately above High Falls Dam (mean of 1,056 fish/ha or 7,392 fish/km). The Shiner density was relatively lower in the section of the Deep River below its confluence with the Rocky River (mean of 795 fish/ha or 4,768 fish/km). Hewitt et al. (2009) found no Cape Fear Shiners at their Deep River site immediately below Coleridge Dam.

Pottern (2009) reviewed the collection history of Cape Fear Shiners from 1949 to 2007 and assessed the Shiner's abundance trend for specific segments of the Deep, Rocky, Haw, and Cape Fear rivers. Pottern (2009) used the following abundance trend categories to report his assessment:

- None – 0 Cape Fear Shiners per collection
- Rare – 1 to 4 Cape Fear Shiners per collection
- Uncommon – 5 to 15 Cape Fear Shiners per collection
- Common – at least 16 Cape Fear Shiners per collection

Overall, since the 1984 - 1986 survey period Cape Fear Shiners have been common along the Deep River between its confluence with the Rocky River and Lockville Dam and along the Rocky River between the Rocky River Hydroelectric Dam and its confluence with the Deep River (Pottern 2009). Additionally, during a habitat survey in June 2010, Cape Fear Shiners were observed as relatively common in Bear Creek, a tributary of the Rocky River below the Rocky Hydroelectric Dam (Sarah McRae, formerly with NCNHP, personal communication June 2010). The shiner also has attained common status along two additional segments of the Deep River: (1) between High Falls Dam and the former Carbonton Dam and (2) from Lockville Dam to US Highway 1. Since the 1984 - 1986 survey period, the Cape Fear Shiner has become common in some areas along the Deep River stretch between the former Carbonton Dam site and the river's confluence with the Rocky River. For instance, fish surveys by the North Carolina Wildlife Resources Commission and North Carolina State University indicated that Cape Fear Shiners are common directly below the former Carbonton Dam site and downstream of the Highway 421 bridge crossing. See Table 1 for a complete list of the shiner's abundance trends among all four rivers. See Figure 1 for a map displaying all river segments discussed in Table 1.

Table 1: Summary of Cape Fear Shiner collection history and abundance by river segment (prepared by Pottern 2009), with additional data from North Carolina Wildlife Resources Commission (NCWRC) (2008-2016)

River Segment (including tributaries)	Miles	1949 – 1983	1984 – 1986	1987 – 2006	2007	2008 - 2016
Haw River						
Saxapahaw to Bynum Dam	17.4	none	none	rare	rare	not surveyed
Bynum Dam to Jordan Lake	4.7	rare	none	rare	none	not surveyed
Robeson Creek to Jordan Lake Pool	4.9	uncommon	none	none	none	not surveyed
Rocky River						
Siler City to Rocky River Hydro Dam	16.0	common	rare	none	none	uncommon*
Rocky Hydro Dam to Deep River	5.5	common	common	common	common	common
Deep River						
Randleman to Coleridge Dam	21.6	none	none	none	none	not surveyed
Coleridge to High Falls Dam	18.9	none	rare	uncommon	rare	not surveyed
High Falls Dam to Carbonton Dam	21.9	none	rare	uncommon	common	common
Carbonton Dam to Rocky River	22.0	none	uncommon	uncommon	uncommon	
Rocky River to Lockville Dam	3.5	none	common	common	common	common
Lockville Dam to US Highway 1	0.3	none	uncommon	uncommon	common	not surveyed
Cape Fear River						
Confluence of Cape Fear, Deep, and Haw Rivers to Buckhorn Dam	12.7	none	none	none	none	not surveyed
Buckhorn Dam to Lillington	14.0	uncommon	rare	none	none	not surveyed
Lillington to Erwin	11.5	none	none	none	rare	not surveyed

* species observed in upper Rocky River post augmentation

The North Carolina Natural Heritage Program has its own database of Cape Fear Shiner occurrences, which it used to estimate the following viability rankings (or probability of persistence) (Sarah McRae, NCNHP, personal communication on 4 September 2009 and 10 June 2010):

- Deep River, stretching from High Falls Dam (Moore County) to Lockville Dam (Lee County), and Rocky River below the hydroelectric dam (Chatham County) = Excellent. This group of Cape Fear Shiners is likely to persist for at least 20-30 years.

- Deep River above High Falls Dam (Randolph and Moore Counties) = Good/Fair. This group of Shiners may or may not persist in its current condition.

- Haw River (Chatham County) = Fair/Poor. This group of Cape Fear Shiners may be at risk of extirpation in the foreseeable future; however, restoration is deemed feasible/plausible.

- Upper Cape Fear River, from Buckhorn Dam (Lee County) through Harnett County = Fair/Poor. This group of Cape Fear Shiners may be at risk of extirpation in the foreseeable future; however, restoration is deemed feasible/plausible.

- Upper Rocky River, south of Siler City to the hydroelectric dam (Chatham County) = Possibly Extirpated. There is evidence that this group of Shiners may no longer exist.

(c) Genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.)

Although Cape Fear Shiners tend to be locally abundant, the previously mentioned research populations in the Deep River (Confluence, High Falls Dam and SR-1456 populations) do not appear to be genetically impoverished (Burridge and Gold 2003; Gold et al. 2004). This eliminates a concern of extinction due to lack of genetic variability in the near-term in this particular river system. However, Gold et al. (2004) did find a significant difference in the allele and genotype distributions between the Confluence and High Falls Dam populations, as well as between the Confluence and SR-1456 populations. This difference suggested restricted gene flow between the Cape Fear Shiner populations. Lastly, Gold et al. (2004) found evidence of a recent population decline (about 50 years ago) in the Confluence and High Falls Dam populations. This finding indicates these two Cape Fear Shiner populations are not in mutation/drift equilibrium (i.e., have not maintained an effective population size through time). Cape Fear Shiners within the SR-1456 population are on the verge of displaying a significant reduction in effective population size (Gold et al. 2004). Hence dams in the Deep River do threaten the long-term genetic health of the

Cape Fear Shiner and represent an important stressor. However, the genetic differences Gold et al. (2004) observed among the three shiner populations remain minor at the moment.

Saillant et al. (2004) compared the frequency and distribution of alleles and haplotypes (mtDNA) between the Confluence and High Falls Dam populations of Cape Fear Shiners. The researchers found relatively high genetic diversity in both Cape Fear Shiner populations, even higher than what has been reported for other freshwater fish species. However, due to the differences they observed in allele and haplotype distributions between the Confluence and High Falls Dam populations, Saillant et al. (2004) believe Cape Fear Shiners rarely, if at all, move between the two populations.

Overall, the genetic studies of Cape Fear Shiner populations in the Deep River indicate that no population is genetically impoverished. The studies do indicate, however, small differences among the populations currently separated by dams. As the distance increases between Shiner populations, the observed genetic differences become more pronounced. Hence, dams are a threat to the long term genetic health of Cape Fear Shiner populations and represent an important stressor.

No genetic studies have been conducted for Cape Fear Shiners in the Cape Fear or Haw, and samples from the Rocky River have not yet been processed but are being held at the NC Museum of Natural Sciences.

(d) Taxonomic classification or changes in nomenclature

There have been no changes to the Cape Fear Shiner's taxonomic classification or nomenclature since the species was listed as endangered (ITIS 2017).

(e) Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historical range (e.g. corrections to the historical range, change in distribution of the species within its historical range, etc.)

Cape Fear Shiners have been found in the mainstem reaches and some tributaries of the Cape Fear, Deep, Haw, and Rocky rivers and in Bear Creek in Chatham, Harnett, Lee, Moore, and Randolph counties (Snelson 1971). As an endemic to the Cape Fear River basin, the Cape Fear Shiner's range has always been restricted; however, its range and population size apparently decreased as recently as 50 years ago (Gold et al. 2004; Pottern and Huish 1985, 1986 and 1987; Saillant et al. 2004).

According to the June to October 2007 survey (Pottern 2009) and the April to June 2010 survey (Sarah McRae, NCNHP, personal communication June 2010), the Cape Fear Shiner is mostly found in the Deep River below Coleridge Dam and in the Rocky River below the Rocky River Hydroelectric Dam. Removal of Carbonton Dam on the Deep River promoted dispersal of Cape Fear Shiners into previously unoccupied areas (Pottern 2009), including expansion into tributaries to the Deep River, including Big Governors Creek in 2012, and McLendons Creek in 2011 and 2012 (NCWRC 2017). The highest density of Cape Fear Shiners has been commonly recorded at the confluence of the Deep and Rocky rivers (Howard 2003; Hewitt et al. 2009; Pottern 2009). In June 2010, Alderman Environmental Services also found Cape Fear Shiners further upstream in Bear Creek than they have in previous surveys (Sarah McRae, NCNHP, personal communication June 2010; Alderman and Alderman 2010). Within the upper stretch of the Rocky River (above Rocky Hydroelectric Dam), no Cape Fear Shiners were collected since the mid-1980s (Pottern 2009). However, in 2013-2014 a collaborative augmentation project translocated ~350 shiners to the Critical Habitat stretch of the Rocky River above the hydroelectric dam. Follow-up surveys in 2015 documented Cape Fear Shiner presence and successful reproduction in the upper Rocky River (NCWRC 2015).

Since Pottern and Huish's 1984-1986 survey, no shiners have been recorded in the Cape Fear River below Buckhorn Dam or in Neills Creek (a tributary of the Cape Fear River). Since 1962, no Cape Fear Shiners have been recorded in either Parkers Creek (Cape Fear River tributary) or Kenneth Creek (Neills Creek tributary). Nor have Cape Fear Shiners been found in the Cape Fear River below Daniels Creek since 1975 or in Neills Creek since 1986 (Pottern 2009). In 2007, however, Pottern (2009) did find one Cape Fear Shiner in the Cape Fear River near the Town of Erwin, approximately 10 miles downstream from Neills Creek.

Within the Haw River in 1993 and 2000, NCWRC collected two Cape Fear Shiners approximately 2.5 miles upstream of Bynum Dam (Pottern 2009). Below Bynum Dam in 1992, NCWRC collected three Cape Fear Shiners over a 4.7-mile stretch between the dam and the head of Jordan Lake. Those three collections remain the only recorded sightings of Cape Fear Shiner in the Haw River below Bynum Dam (Pottern 2009). During the fall of 2005 a team of biologists surveyed Cape Fear Shiners along a ten-mile reach of the Haw River that spanned all previous capture sites. However, the biologists failed to detect any Cape Fear Shiners (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication July 2010). Yet in 2007, Pottern (2009) did collect a Cape Fear Shiner in a location that was 1.5 miles further upstream of NCWRC's collection sites in 1993 and 2000. Overall, Cape Fear Shiners have a very low detection probability in the Haw River.

(f) New information addressing habitat or ecosystem condition (e.g. amount, distribution, and suitability of the habitat or ecosystem)

The Cape Fear Shiner generally is associated with gravel, cobble, and boulder substrate, and it has been observed inhabiting slow pools, riffles, and slow runs of clean water. The shiner is often associated with American water willow *(Justicia americana)* beds, but it is not always indicative of the Cape Fear Shiner's presence (Snelson 1971; Pottern and Huish 1985, 1986; Howard 2003). The shiner may be attracted to river features that also support water willow, which may offer some benefits such as protection (Howard 2003). Spawning habitat does not necessarily have to include cover because Cape Fear Shiners can spawn without it (Howard 2003; John Groves, North Carolina Zoological Park, personal communication 2009). Usually Cape Fear Shiners are found in schools with other *Notropis* species (Howard 2003). Occasionally adult and juvenile Cape Fear Shiners may occupy a tributary creek of the Deep, Rocky, Haw, and Cape Fear rivers. However, the shiners typically stay within two miles of the creek's confluence with the larger river (Pottern 2009).

Stream depth and velocity are among factors that seem to determine suitable Cape Fear Shiner habitat. During non-breeding periods, adult Cape Fear Shiners are primarily found in velocity breaks where fast water and slow water meet. However, spawning habitat is associated with shallower depths and slower velocities. Stream depth does not appear to be a limiting factor for the Cape Fear Shiner overall, based on a depth comparison of streams in which the shiner is rarely found and streams in which the shiner is commonly found. Hence other factors apparently influence why Cape Fear Shiner densities are high in certain stream reaches. However, Cape Fear Shiners do tend to favor shallower depths (20-29 cm) when spawning compared to the post-spawning season (40-49 cm). During spawning, the shiners also favor slower water velocities (0.08-0.11 m/s) compared to the post-spawning season (0.16-0.19 m/s) (Howard 2003).

One potential limiting factor may be stream substrate. After comparing sparsely populated and well populated sites, Howard (2003) found that the sparsely populated sites had less gravel available in the stream bed. Gravel substrate plays an important role in feeding and spawning. Female Cape Fear Shiners deposit their eggs on gravel substrates. Shiners also feed on detritus and algae found along the gravel bottom.

Quality habitat is limited within the Cape Fear River basin (Howard 2003). There are few areas that have all of the necessary suitable characteristics of velocity, substrate, and water quality to support Cape Fear Shiners. In fact, water quality may be an important limiting factor in Cape Fear Shiner habitat. For instance, compared to caged Cape Fear Shiners in the Deep and Rocky rivers, Howard (2003) found significant reductions in survival and growth rates among caged Cape Fear Shiners in the Haw River. Although the combinations of physical and chemical factors affecting differential survival in the field are not known, these reductions were associated with particularly high concentrations of metals (cadmium, cooper, zinc, mercury, lead) and organic contaminants (PAH, PCB, DDT, chlordane) in the shiner's tissue and the Haw River's sediment and water. However, Howard (2003) also discovered that most concentrations of the organic and inorganic contaminants she measured were within the U.S. Environmental Protection Agency's freshwater chronic continuous criterion for all three rivers.

In 2005, the North Carolina Division of Water Quality (NCDWQ) reported that most of the mainstem of the Haw River in Chatham County supports its designated use for aquatic life survival and propagation, based on benthic macroinvertebrate and fish community sampling. The northern section of this river stretch also revealed a 57%

decline in total phosphorous, based on trend analyses conducted between 1985 and 2003. The NCDWQ attributed this significant phosphate decline to a recent ban on phosphate detergents and Pittsboro's improved waste water treatment techniques. However, further down the Haw River NCDWQ identified significant violations of a Bynum Waste Water Treatment Plant's pH permit limit during its final two years of water quality study (NCDWQ 2005). Bynum Dam also precludes Cape Fear Shiner movement along the entire stretch of the Haw River flowing through Chatham County. The NCDWQ (2005) also found evidence of nutrient enrichment within the 2.4-mile stretch of Robeson Creek between Pittsboro Lake and State Road 1951. This nutrient enrichment, which originated from urban runoff and the spray fields of Townsend Foods, created fair benthic community ratings for Robeson. Note, according to Pottern (2009), Cape Fear Shiners have not been recorded in Robeson Creek since the creation of Jordan Lake in 1982.

To resolve water quality concerns in the Haw River, emphasis should be placed on attaining existing numeric water quality standards for the State of North Carolina, with consideration given to additional protections for pollutants with non-numeric standards. Even if chemical contaminants are addressed in the Haw River, however, several other key stressors may continue to be limiting factors, such as sediment loading, flow alteration, and dams. Also, Howard et al. (2006) evaluated only two sites on the Haw River. It would be prudent to conduct a follow-up habitat assessment using the caged fish exposure design of Howard et al. (2006) but with more spatial resolution.

With regard to the Cape Fear River section between Buckhorn Dam and the Town of Erwin in Harnett County, NCDWQ (2005) found most of the river's mainstem to support aquatic life, yielding a good to fair benthic community rating. However, between Daniels Creek and the Upper Little River, NCDWQ did find turbidity levels that exceeded water quality standards in 10% of its samples. Additionally, the Erwin Waste Water Treatment Plant had significant violations of its fecal coliform bacteria limits. A majority of the water impairments occurred within the creeks flowing into the Cape Fear River. Nearly 13 miles of Neills Creek yielded poor to fair benthic community ratings at two sampling sites. The NCDWQ is unsure if the impairment was due to drought conditions or a disturbance event. However, the nearly 2-mile stretch of Neills Creek that flows into the Cape Fear River did support aquatic life (NCDWQ 2005) and this is the main stretch that Cape Fear Shiners have been known to use (Pottern 2009). The NCDWQ (2005) also reported a poor benthic community rating and a good fish community rating at separate sites along the 3.9-mile stretch of Kenneth Creek flowing between the Wake/Harnett County line and Neills Creek. Overall, NCDWQ viewed this stretch of Kenneth Creek as impaired and found significant violations of fecal coliform bacteria permit limits by one NPDES permittee during the last two years of NCDWQ's study.

Water quality conditions would not preclude population enhancement in the Deep and Rocky rivers. Particularly in the Rocky River, Hewitt et al. (2006) suggested that emphasis should be placed on meeting the State of North Carolina's water quality standards; addressing areas of impairment that will benefit the Cape Fear Shiner, particularly nonpoint sources of metals (e.g., copper and zinc).

During 2009, NCWRC surveyed 93 sites along 75.6 miles of the Deep River flowing between the Town of Ramseur in Randolph County and the Town of Moncure in Chatham County. This survey section included two of the Cape Fear Shiner's three critical habitat areas as well four dams (Ramseur, Coleridge, High Falls and Lockville). The NCWRC found that unrestricted livestock access to the Deep River posed substantial Cape Fear Shiner habitat problems, primarily due to increased sedimentation from bank erosion, for 19 of the 93 surveyed sites. A highway bridge crossing and dirt boat ramps posed additional serious sedimentation and erosion problems at 4 additional sites, and wastewater concerns possibly existed at a fifth site. Almost all surveyed tributaries had steep, eroded banks and some level of clearcutting. Overall, only 13 sites had intact riverbanks, little (if any) signs of soil erosion, and wide, forested riparian buffers. Over 40 sites had moderate to extreme riverbank problems, characterized by large riparian breaks or complete loss of the riparian buffer and moderate to heavy levels of streambank erosion, sometimes yielding banks with cliff-like appearances (Jones 2009).

Although NCWRC found evidence of multiple stream bank problems along the Deep River, the agency also found multiple river sections demonstrating quality habitat for Cape Fear Shiners – clean instream complexes of runs, riffles and pools along with intact forested riparian buffers. These higher quality habitat areas exist both up- and downstream of the Deep River's confluence with the Rocky River, along stream reaches immediately below Coleridge Dam and below High Falls Dam, and within a small stream segment below the Plank Road bridge crossing (Jones 2009).

In addition to the negative effects of gene flow interdiction, the dams along the Deep River have likely had a positive effect on local habitat conditions by serving as settling basins for sediments. However, this beneficial outcome will diminish over time as the settling basins continually fill with sediment. For instance, the settling basin adjoining Lockville Dam will likely cease to provide a useful pool of water for local Cape Fear Shiners within the next two to three decades, based on how much sediment has already settled in the dam's basin (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication July 2010).

During a habitat assessment survey in April 2010, the NCNHP and Alderman Environmental Services, Inc. found evidence of potential water quality issues and subsequent habitat deterioration in Deep River shoals immediately downstream of the Deep's confluence with the Rocky River. In the past, this area has consistently harbored robust numbers of healthy adult Cape Fear Shiners during the spawning season. However, the 2010 surveys found spawning shiners only in the upstream reach of the lower Rocky River; none were present in the Deep River shoals below the confluence. The NCNHP also found evidence of habitat degradation in this section of the Deep River – (1) sediment impacting beds of American water willow; and (2) no aquatic snail recordings when previous surveys revealed numerous snail observations (Sarah McRae, NCNHP, personal communication June 2010; Alderman and Alderman 2010).

Most of the Rocky River watershed remains undeveloped. Agricultural production is the dominant land use in the watershed's northeastern section and forestry is the dominant land use in the southeastern section (Triangle Land Conservancy 2010). During its habitat assessment efforts in 2004, Tetra Tech (2005) identified declining water quality conditions in all major contributing streams of the Rocky River's upper and middle hydrologic units. Urban and agricultural runoff was the main source of nonpoint pollution for the watershed. Elevated levels of fecal coliform bacteria were found in many of the watershed's streams, which Tetra Tech (2005) attributed to pet waste, cattle access to streams, and upland runoff from agricultural operations. Loves Creek downstream of the Siler City Wastewater Treatment Plant exhibited the highest degree of point and nonpoint pollution. Agricultural operations near Upper Bear Creek may have contributed to low dissolved oxygen measurements on two sampling occasions (Tetra Tech 2005). With regard to aquatic habitat conditions, less than 74% of the sites surveyed in Bear Creek and the upper and middle Rocky River hydrologic units had stream conditions comparable to reference conditions. Tetra Tech (2005) recorded the highest habitat condition scores for stream reaches yielding the lowest predicted risk for stream erosion. Areas yielding the highest scores for streambank erosion typically occurred in rural areas where agricultural pastures afforded livestock with direct access to a stream. Only five of the 50 sites surveyed for streambank erosion had low erosion scores (Tetra Tech 2005). Note Cape Fear Shiners had not been observed in the Rocky River above the Rocky Hydroelectric Dam since the mid-1980s (Pottern 2009). However, during its 2002 and 2010 surveys the NCNHP did observe robust numbers of other fish species in the upper Rocky River (Sarah McRae, NCNHP, personal communication June 2010).

In December 2005, Restoration Systems in partnership with the North Carolina Ecosystem Enhancement Program, demolished the Carbonton Dam on the Deep River in Chatham and Lee Counties. This allowed Cape Fear Shiners to recolonize formerly impounded areas. The Catena Group collected over 40 specimens of the shiner in eight locations during its post-dam demolition survey in 2007 (presentation by J. Adam Riggsbee of Restoration Systems, LLC, www.bae.ncsu.edu/programs/extension/wqg/srp/pdfs/riggsbee.pdf). Biologists with NCWRC and North Carolina State University also have collected Cape Fear Shiners during a separate Carbonton Dam removal assessment study (Ryan Heise and Brena Jones, NCWRC, personal communication June 2010). Lastly, within this formerly impounded reach of the Deep River, several shoal areas have already reformed and display clean substrates. As these shoals continue to redevelop they may support even more concentrations of Cape Fear Shiners in the future (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication July 2010).

In March 2009, the Service received a request from the Chatham County Board of Commissioners to restore the Rocky River's biological integrity upstream of the hydroelectric dam by reintroducing the Cape Fear Shiner to this type locality. Since the 1984-1986 survey period, there had been no collections of Cape Fear Shiners between Siler City and the Rocky Hydroelectric Dam (also referred to as Hoosier Dam) (Pottern 2009). However, the Service did not dismiss the possibility that past population survey efforts simply failed to detect individual Cape Fear Shiners that may be present in the waterway. Although nutrient and sedimentation problems exist along the upper Rocky River (near Siler City, NC), the NCNHP and Alderman Environmental Services did find healthy populations of multiple fish species in the Rocky River between the NC Highway 902 bridge crossing and the hydroelectric dam during fish surveys in 2002 and 2010 (Sarah McRae, former NCNHP, personal communication June 2010; Alderman and Alderman 2010).

In the spring of 2013, NCWRC and the Service began an augmentation project that re-located Cape Fear Shiners to the designated Critical Habitat section upstream of the Hoosier Dam (NCWRC 2012). Three batches of Cape Fear Shiners, totaling 97 individuals, were collected from three locations in Chatham County. All fish were translocated to the release site just below the Pittsboro-Goldston Road crossing of the Rocky River. Twenty-five of the collected fish were fin-clipped for later genetic analyses.

- One collection site was located at the confluence of the Rocky and Deep rivers.
- The second collection site was in Bear Creek and the Rocky River below the Hoosier Dam.
- The third collection site was at the Hwy 15/501 crossing of the Rocky River.

Monitoring of this translocation effort was conducted in July 2013. One individual was recaptured within a shoal of congeneric shiners approximately 200 m upstream of the release site and fin-clipped for genetic material. In mid-October, a second collection effort at the confluence of the Rocky and Deep rivers gathered another 97 Cape Fear Shiners which were translocated and fin-clipped before release at the same location as the spring group. In 2014, 156 individuals were collected from the source site, released into Rocky River, and 50 of these individuals were fin clipped. Sixty-one Cape Fear Shiners, mean TL 71.2 mm (n=25), were collected in the spring and 95 individuals, mean TL 64.2 mm (n=25), were collected in the fall. The mean number (2013-2014) of Cape Fear Shiners collected per hour of seining at the Deep River source site was 47.6 individuals. Monitoring of the translocated fish occurred on April 14 and June 26, 2014 of this reporting period. One adult Cape Fear Shiner was captured during each of these surveys and the catch per unit effort is 1 per hour. These two individuals were collected 20-200 meters upstream of the release site in schools of congeneric shiners and TL was 73-84 mm. A fin clip was also taken from each of these fish. In September 2015, NCWRC collected one individual from 20 m upstream of the SR 1010 bridge and seven from 100 m upstream of the bridge for a total of 8 individuals. These Cape Fear Shiners were much smaller and ranged from 44-59mm TL (mean=51.4) and are from natural reproduction in the Rocky River. The capture of these 8 young individuals is very encouraging and continued surveys in the augmentation site will be planned so that the persistence of this population of Cape Fear Shiners can be documented. The NCWRC discontinued any additional translocations efforts because of the impending Hoosier Dam removal project which is planned for 2017.

(g) Other relevant information

Research of the Cape Fear Shiner's life history, habitat usage, and movement still need more thorough investigation. To accomplish this, we need to identify research techniques that are practical and pose little to no harm for individual fish. Research tools that have been used for Cape Fear Shiner studies include museum specimens, captive reared individuals, electroshocking, strip transects, and surrogate species.

Estimating population numbers is an essential parameter in determining the status of a Cape Fear Shiner population. Numerous sampling methods have been used for this purpose but some are not appropriate at this time due to their detrimental effects on individual fish. Howard (2003) used line transects to estimate densities of Cape Fear Shiner populations. She snorkeled through the shiner's habitat and marked detections of individual fish (or a group of fish) to estimate the shiner's population density. Electroshocking, under proper circumstances, has been demonstrated to be a viable tool for Cape Fear Shiner sampling with minimal adverse effects (Holliman et al. 2003). Estimating Cape Fear Shiners through removal techniques are not recommended at this time.

Alternatives to studies requiring the harvesting of live wild fish from the current populations are museum specimens, captive reared individuals, and surrogate species. Captive reared individuals have been used to determine the Cape Fear Shiner's life history and habitat parameters (Howard 2003; Groves 1998). Museum specimens also have been used to determine feeding preferences and fecundity potentials of Cape Fear Shiners (Groves 1998). Museums that have type specimens and additional materials of the Cape Fear Shiner include the U.S. National Museum (Smithsonian Institution), Cornell University, Tulane University, the University of Florida, the University of Michigan – Museum of Zoology, and the North Carolina Museum of Natural Sciences.

Biologists have successfully reproduced plentiful numbers of Cape Fear Shiners in captivity. Conservation Fisheries, Inc. in Knoxville, Tennessee initially began captive propagation of the Cape Fear Shiners in 1997 using 31 wild caught fish to assist the Service with its ecotoxicology studies. Since the conclusion of the Service's toxicology studies, CFI has ceased its propagation efforts and simply maintains the captive Cape Fear Shiners that naturally reproduce. That population currently totals less than 20 individuals (J.R. Shute, CFI, personal communication June 2010). The North Carolina Zoological Park in Asheboro has successfully reared captive Cape Fear Shiners for research and educational purposes, with population numbers ranging between 450 and 600 Cape Fear Shiners (John Groves, North Carolina Zoological Park, personal communication June 2010).

Surrogates are a viable alternative to using Cape Fear Shiners for contaminant and bacteriological studies. Sandbar Shiners *(Notropis scepticus)* appear to be suitable surrogates for bacteriological exposure of Cape Fear Shiners; however, further investigation is needed because some parasitic, viral, and nonhepatic histological lesions were found more commonly in Sandbar Shiners than in Cape Fear Shiners (Chittick et al. 2001). Combinations of Rainbow Trout *(Oncorhynchus mykiss)* and water fleas *(Ceriodaphnia dubia)* are more sensitive to the contaminants tested than Cape Fear Shiners and can aid habitat suitability assessments (Dwyer et al. 1999; Dwyer et al. 2005a; Dwyer et al. 2005b).

2. Five Factor Analysis

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

Dam construction along the upper Cape Fear, Deep, and Haw rivers as well as their tributaries has probably had the most serious impact on the Cape Fear Shiner. These dams have fragmented the shiner's populations. Even though recent studies reveal promising signs of genetic diversity among Cape Fear Shiner research populations in the Deep River, the studies also reveal how dams may have restricted gene flow among those researched populations (Gold et al. 2004; Saillant et al. 2004). The existing dams present a physical barrier that would prevent or reduce recolonization of certain areas. This blockage would problematic if a catastrophic event (e.g., chemical spill) occurred that resulted in significant population reductions in part of the Cape Fear Shiner's range.

The dams of the upper Cape Fear River Basin also alter stream flows, inundate rocky riverine habitat, and prevent the downstream movement of substrate and organic material. As the research of Howard (2003) and Hewitt et al. (2009) indicate, Cape Fear Shiners have specific habitat requirements that are not conducive to impounded rivers. Cape Fear Shiners typically favor stream reaches containing gravel substrate, especially when spawning. They also tend to favor shallow, high velocity riffles that connect to slightly deeper pools with slower moving water. Shallower depths and lower velocities are particularly important during spawning (Hewitt et al. 2009).

Urban sprawl and its associated effects also have likely exacerbated the Cape Fear Shiner's decline. The five-county area that encompasses the shiner's range faces increasing pressure from development in the Triad communities (Greensboro, Burlington, and High Point) and Triangle communities (Raleigh, Chapel Hill, and Durham), and recently (2014) with the development of Chatham Park which purports to expand the Town of Pittsboro's population from 4,000 people to over 60,000 people. Water withdrawal and waste water discharge affect water quantity and quality. Overall, best management practices need to be in place to help alleviate impacts from the following activities and to minimize the negative impact of urban sprawl on Cape Fear Shiners:

- Agricultural, road, and storm-water runoff
- Road construction
- Impoundments for hazardous and non-hazardous waste containment

- Waste water discharge from municipalities and industry
- Chemical spills
- Stream channel modification
- Stream flow change due to hydroelectric power production

Sedimentation is another water quality problem for the Cape Fear basin; however its effect on Cape Fear Shiners is not yet understood. But as previously mentioned, attaining the State of North Carolina's existing numeric water quality standards will facilitate Cape Fear Shiner recovery in the Deep, Rocky, Haw, and Upper Cape Fear rivers.

(b) Over-utilization for commercial, recreational, scientific, or educational purposes:

Currently, over-utilization is not a threat for the Cape Fear Shiner.

We collaborate with all research and conservation partners. The North Carolina Zoological Park used Cape Fear Shiners raised in captivity to produce an educational exhibit. Some of these individuals were transferred to the NC Museum of Natural Sciences for additional educational exhibit use in 2013.

Cape Fear Shiners are not pulled from the wild repeatedly to conduct research; for example, the shiners that Chittick et al. 2001 collected for their health risk assessment were also used in Saillant et al. 2004 and 2005 for their separate genetic investigations. Further, all water quality studies used Cape Fear Shiners raised in captivity (Dwyer et al. 1999, 2005a and 2005b; Howard 2003; Hewitt et al. 2006 and 2009). All of the shiners used in these studies remain preserved and can be used for future genetic studies.

(c) Disease or predation:

Chittick et al. (2001) conducted a health risk assessment of Cape Fear Shiners collected in the Deep River above and below High Falls Dam and in the confluence of the Deep and Rocky rivers. Although their assessment revealed low levels of parasitism and gill aneurysms, Chittick et al. (2001) believed their observations of mild telangectasis (small dilated blood vessels) and focal erythema (areas of redness caused by dilated blood vessels) on the Shiner's gills warranted pathogenic study. The researchers also recommended an etiological study of an unidentified parasitic gill cyst. The greatest health risk that Chittick et al. (2001) found, however, is the formation of lesions on the Cape Fear Shiner's liver. Termed as hepatocellular vacuolization, this lesion has been known to result from chronic stress, dietary problems, and environmental contamination. Chittick et al. (2001) observed mild to moderately severe hepatic vacuolization among 22 of the 40 sampled Cape Fear Shiners.

Chittick et al. (2001) also assessed the health risks of Sandbar Shiners. The researchers found a granuloma in one Sandbar Shiner that revealed a disseminated mycobacterial infection. This Sandbar Shiner was collected in the Deep River below High Falls Dam. Although Chittick et al. (2001) found no *Mycobacteria* spp. in the Sandbar Shiner's gastrointestinal cultures, simply detecting the mycobacterial infection is troubling because it would be nearly impossible to treat (primarily due to inability to capture and treat all affected fish) and could decimate small populations of fish, thus potentially interfering with Cape Fear Shiner recovery efforts. In the Haw River where the Cape Fear Shiner population was too small to sample, Chittick et al. (2001) observed trichodinid and *Chilodonella*-like organisms infesting the gills of Sandbar Shiners. The researchers therefore recommended exploring the pathogenic potential of ciliate gill parasites on Cape Fear Shiners.

At the time of listing, there was no evidence of predation being a threat to the Cape Fear Shiner. The shiner's natural predators include amphibians, reptiles, and other fish species using the same habitat. To date, there has been no study of whether predation poses a threat to the Cape Fear Shiner's recovery. However, the introduction of non-native predators may pose a conservation concern for Cape Fear Shiners. Roanoke bass *(Ambloplites cavifrons)* has been introduced to the upper Cape Fear River basin, whereas flathead catfish *(Pylodictis olivaris)* has been introduced to just the upper Cape Fear River (Hewitt et al. 2009). Young catfish do feed on smaller fish species that occur within the same size range of Cape Fear Shiners. Younger catfish also commonly occupy the shoal areas that Cape Fear Shiners typically use (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication July 2010). Scientists have determined that the introduction of non-native species has played a significant role in the decline of some native fish species (Hewitt et al. 2009). It is unknown whether one or both predator species prey upon the Cape Fear Shiner and/or alter the river system's food-web interactions, thereby causing indirect harm to the Shiner. Therefore studies may be needed to evaluate potential effects.

(d) Inadequacy of existing regulatory mechanisms:

The North Carolina endangered species protection law allow the NCWRC to identify, document, and protect any animal species that is considered rare or in danger of extinction. Illegal activities include take, transport, export, processing, selling, offering for sale, or shipping species, and the penalty for doing so is a misdemeanor crime, usually resulting in a fine of no more than $1,000 or imprisonment not to exceed a year (Pellerito 2002, entire). In the North Carolina statute, there are no mechanisms for recovery, consultation, or critical habitat designation other than conservation plans that must be developed for all state listed species (Pellerito 2002, Snape and George 2010). In addition, nothing in the North Carolina Endangered Species Act "shall be construed to limit the rights of a landholder in the management of his lands for agriculture, forestry, development, or any other lawful purpose" (NC GS 113-332).

Section 401 of the federal Clean Water Act (CWA) requires that an applicant for a federal license or permit provide a certification that any discharges from the facility will not degrade water quality or violate water-quality standards, including state-established water quality standard requirements. Section 404 of the CWA establishes a program to regulate the discharge of dredged and fill material into waters of the United States. Permits to fill wetlands and fill, culvert, bridge or re-align streams or water features are issued by the U.S. Army Corps of Engineers under Nationwide, Regional General Permits or Individual Permits.

North Carolina has undergone regulatory review and reform that is worthy of mention because of implications to stream habitat protections for aquatic species in the state, particularly areas that are the strongholds for species like the Cape Fear Shiner. In the past six years (since 2010), there have been several changes to state regulations, described in legislation titled "Regulatory Reduction Act." These changes have far reach and the most recent reforms have affected significant environmental programs and protections, including (see Smith 2013-2016 for detailed review of applicable Session Laws, House and Senate Bills, and enacted Legislation):

- revision of the State Environmental Policy Act review process (from NCDEQ's website):

  > "Session Law 2015-90...overhauled the criteria under which a SEPA review of a proposed project is evaluated. Prior to the passage of SL 2015-90, if a proposed project involved any amount of public funds, involved the use of public lands, or had significant environmental impacts as determined by the minimum criteria, then a SEPA review was necessary. With the passage of SL 2015-90, two key criteria must now be considered to determine if a proposed action may require a SEPA review. The first is the funding source. If a proposed action involves more than $10,000,000 of funds provided by the State of North Carolina for a single project or action or related group of projects or actions a SEPA review may be necessary. This is a change over the previous requirement which included any public funds (i.e. city, county, bonds, etc.). The second involves direct impacts resulting from the proposed project. If the proposed action will result in substantial, permanent changes to the natural cover or topography greater than or equal to ten acres of public lands a SEPA review may be required. This is a change over previous requirements that required a SEPA review for impacts to any type or amount of public lands" (NCDEQ 2016, entire);

- eliminating or limiting stormwater and stream buffer rules (and allowing unlimited development in a riparian buffer as long as the project complies with state stormwater requirements) in the Jordan Lake watershed;
- change of state water quality rules to include a new stormwater standard which eliminates on-site stormwater controls, unless they are needed to meet specific state or federal laws;
- reduction of 401 certification/404 permitting requirements by eliminating mitigation for projects impacting less than 300 feet of stream and reduced mitigation rations from 2:1 to 1:1;
- limitation of state environmental agency authorities (G.S. 150B-19.3) and local government authorities.

As the title of the legislation states, these regulatory changes are intended to "improve and streamline the regulatory process in order to stimulate job creation, to eliminate unnecessary regulation, to make various other statutory changes, and to amend certain environmental and natural resource laws" (exact title of HB74 2013). The result of these regulatory changes could impact aquatic species such as the Cape Fear Shiner, as well as the habitats that the species require for survival. For example, reduced resources to inventory, compile, and review data as well as changed criteria for project review, changed rules and standards, and reduced mitigation requirements could all result in project implementation without consideration of impacts to species, thus potentially directly or indirectly impacting the habitats the species depend on, resulting in degradation of stream quality and ultimately in species decline.

(e) Other natural or manmade factors affecting its continued existence:

There are two other factors that may threaten the Cape Fear Shiner's continued existence: climate change and natural gas fracking. First, climate change may lead to periods of prolonged drought, thereby changing the quantity of water available to Cape Fear Shiners. As mentioned in the Poff et al. 2002 (pp. ii-v) report on Aquatic Ecosystems and Global Climate Change, likely impacts of climate change on aquatic systems include:

- Increases in water temperatures that may alter fundamental ecological processes, thermal suitability of aquatic habitats for resident species, as well as the geographic distribution of species. Adaptation by migration to suitable habitat might be possible, however human alteration of dispersal corridors may limit the ability of species to relocate, thus increasing the likelihood of species extinction and loss of biodiversity.
- Changes and shifts in seasonal patterns of precipitation and runoff will alter the hydrology of stream systems, affecting species composition and ecosystem productivity. Aquatic organisms are sensitive to changes in frequency, duration, and timing of extreme precipitation events such as floods or droughts, potentially resulting in interference of reproduction. Further, increased water temperatures and seasonally reduced streamflows will alter many ecosystem processes, including increases in nuisance algal blooms.
- Climate change is an additional stressor to sensitive freshwater systems, which are already adversely affected by a variety of other human impacts, such as altered flow regimes and deterioration of water quality.
- Aquatic ecosystems have a limited ability to adapt to climate change. Reducing the likelihood of significant impacts will largely depend on human activities that reduce other sources of ecosystem stress to ultimately enhance adaptive capacity; these include maintaining riparian forests, reducing nutrient loading, restoring damaged ecosystems, minimizing groundwater (and stream) withdrawal, and strategically placing any new reservoirs to minimize adverse effects.
- Specific ecological responses to climate change cannot be easily predicted because new combinations of native and non-native species will interact in novel situations.

The following systematic changes are expected to be realized to varying degrees in the Southeastern US (NCILT 2012; IPCC 2013):

- More frequent drought
- More extreme heat (resulting in increases in air and water temperatures)
- Increased heavy precipitation events (e.g., flooding)

- More intense storms (e.g., frequency of major hurricanes increases)
- Rising sea level and accompanying storm surge

The southeast Drought Monitor has shown the upper Cape Fear River Basin to be "abnormally dry" to "moderate drought" to "extreme drought" in 2001-2002, 2005-2011, 2015, and 2017 (USDA 2017). These drought conditions will become more problematic as urban development continues in the upper Cape Fear River Basin with an increase in the human population's water demands.

In addition to climate change, shale gas extraction is an emerging threat. There are potentially exploitable reserves of shale gas within Chatham County, particularly in the Deep River Basin. Extraction of shale gas within this area would require hydraulic fracturing, a technique that uses large volumes of surface waters (therefore altering flows) and subsequent potential pollution of discharged waters to the Rocky and Deep Rivers and their tributaries. Applications for fracking permits have been received by the State of North Carolina, however no permits have been issued due to pending lawsuits.

Synthesis

The Cape Fear Shiner is a vertebrate species endemic to the upper Cape Fear River Basin. The Cape Fear Shiner's taxonomic classification has not changed since its listing. While downlisting recovery criteria have not yet been met, progress has been made towards improving connectivity of populations via dam removals as well as implementation of management strategies in the Deep and Rocky rivers. Although dams remain a major threat to Cape Fear Shiner movement, recent genetic research indicates that existing dams within the river basin have not created genetically-isolated populations of the shiner.

Recent habitat assessments throughout the Cape Fear Shiner's historical range indicate that water quality and riparian degradation pose substantial threats to the shiner's recovery. However, multiple ecotoxicology studies on the shiner indicate that existing numeric water quality standards for the State of North Carolina are generally adequate for survival and growth of the Cape Fear Shiner, but that water quality still falls short of the State's standards in some previously or currently occupied Cape Fear Shiner habitats. Additionally, establishment of riparian buffer rules for the upper Cape Fear River basin (beyond the Haw River via the Jordan Lake Nutrient Strategy) as well as reclassification of the basin's water resources to High Quality or Outstanding Resource Waters (at least for the Deep, Rocky, Haw, upper Cape Fear rivers, and tributaries like Buffalo Creek and McLendon's Creek) and site-specific water quality management planning can further improve the Cape Fear Shiner's recovery.

Appendix B lists the studies conducted on the Cape Fear Shiner. In addition to the water quality studies already mentioned, the Service has accumulated scientific information about the shiner's life history, habitat use preferences, and genetic composition. In summary, we now know that the Cape Fear Shiner is omnivorous and a broadcast spawner. The shiner favors gravel substrates for spawning and foraging but has slightly different preferences for water velocity and depth during its breeding (relatively deeper and faster stream reaches) and non-breeding (relatively shallower and slower stream reaches) seasons. We also know that complete genetic divergence has not occurred among the Cape Fear Shiner locations; however, the research findings do indicate that genetic differences do increase as the distance between dams increases. Hence removing non-essential dams within the upper Cape Fear River basin would improve Cape Fear Shiner movement throughout its range. Indeed, population surveys have revealed that Cape Fear Shiners readily recolonized sites upstream of the Carbonton Dam on the Deep River after the dam was demolished in 2005.

In addition to dams (stream channel and stream flow modification) and water quality (pollution, chemical spills, impoundment for waste water management), other threats of the Cape Fear Shiner include roadway construction, climate change, and potentially shale gas development. Diseases attributed to gill parasites and liver lesions also may threaten Cape Fear Shiners. In spite of these various threats, however, historical and recent collection surveys indicate the Cape Fear Shiner remains common at the confluence of the Deep and Rocky rivers, in the lower Rocky River (below Hoosier Dam), along the Deep River between High Falls Dam and the former Carbonton Dam, and along the lower Deep River between Lockville Dam and US Highway 1.

III. RESULTS

A. Recommended Classification:

__X_ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTION-

In 2010, the Service collaborated with the NCWRC, NCNHP, Chatham Conservation Partnership and fisheries scientists at North Carolina State University to develop a Strategic Habitat Conservation Framework for the Cape Fear Shiner. Recommendations for future management actions have been generated through that process and are articulated below. In addition, based on new information, we may consider revising the Cape Fear Shiner recovery criteria and/or plan in the near future to incorporate a different approach to looking at existing populations.

Additional research is needed to investigate the Cape Fear Shiner's biological and ecological requirements, conduct formal threat analyses, and develop techniques for reestablishing the shiner throughout its historical range. Specifically, these studies include the following:

- Estimate the current population size of each Cape Fear Shiner location or site to generate a baseline against which population increases or decreases can be determined.
- Develop population viability models for each Cape Fear Shiner location or site.
- Investigate the Cape Fear Shiner's larval and juvenile dispersal ability.
- Determine the Cape Fear Shiner's fecundity and demography.

- Examine the Cape Fear Shiner's dispersal and habitat-use patterns to assess extent of interaction between Cape Fear Shiner locations.

- Assess biotic interactions between Cape Fear Shiners and introduced predators (Roanoke Bass and Flathead Catfish).

- Assess the potential for disease transmission and/or predation during a Cape Fear Shiner reintroduction or translocation event (whether captive or wild shiners are used for the population augmentation event).

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[Note: The Service also has a full annotated bibliography for Cape Fear Shiner at http://www.fws.gov/raleigh/es_tes.html]

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- July 15, 2014: Status of Regulatory Reform Legislation
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- April 30, 2015: What is the SEPA Problem?
- May 7, 2015: Reforming Riparian Buffers Out of Existence
- July 13, 2015: Regulatory Reform 2015: A New NC Senate Proposal
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- January 12, 2016: 2015 in Review – Legislation

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U.S. Fish and Wildlife Service

5-Year Review
Cape Fear Shiner (*Notropis mekistocholas*)

Current Classification Endangered

Recommendation resulting from the 5-Year Review

_X___ No change is needed

Review Conducted By Kathryn Reis and Sarah McRae, Raleigh Ecological Service Field Office, Raleigh, NC.

FIELD OFFICE APPROVAL

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

Approve ______________________ Date 11July17

REGIONAL OFFICE APPROVAL

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

for Approve ______________________ Date 21 Aug 17

Matthew P. Dekar

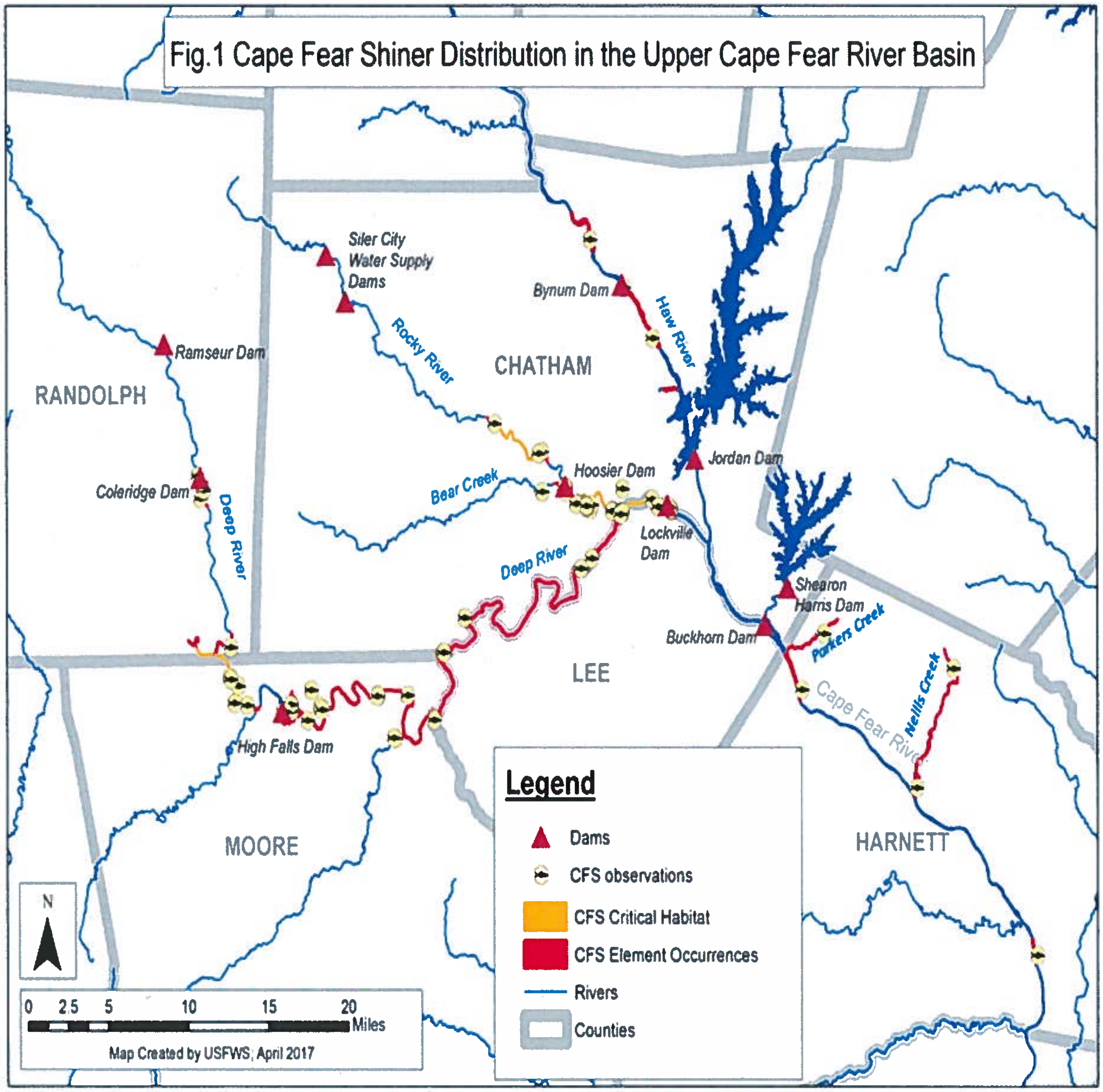

Fig.1 Cape Fear Shiner Distribution in the Upper Cape Fear River Basin
Siler City Water Supply Dams
Bynum Dam
Haw River
Rocky River
Ramseur Dam
CHATHAM
RANDOLPH
Jordan Dam
Hoosier Dam
Coleridge Dam
Bear Creek
Deep River
Lockville Dam
Deep River
Shearon Harris Dam
Buckhorn Dam
Parkers Creek
LEE
Cape Fear River
Nellis Creek
High Falls Dam
MOORE
HARNETT
Legend
Dams
CFS observations
CFS Critical Habitat
CFS Element Occurrences
Rivers
Counties
N
0 2.5 5 10 15 20 Miles
Map Created by USFWS, April 2017

APPENDIX A

Summary of Original Peer Review for the 5-Year Review of the Cape Fear Shiner *(Notropis mekistocholas)* conducted in 2009 and 2017

Special Note: Due to an error made in our 2009 draft 5-year Review where we attempted to revise concepts in an active recovery plan and subsequently sought peer review, we released this revised review for peer review after correcting that error and have summarized both peer reviews below.

A. Peer review method

In 2010, the Raleigh Field Office sent an e-mail to the following individuals requesting their review of the Cape Fear Shiner 5-year review document: (1) Sarah McRae (North Carolina Natural Heritage Program, working at the time for NCNHP and now works with USFWS); (2) Ryan Heise/Brena Jones (North Carolina Wildlife Resources Commission); (3) Wayne Starnes (North Carolina Museum of Natural History); and (4) Tom Kwak (North Carolina Cooperative Fish and Wildlife Research Unit). In 2017, the Asheville Field Office sent another e-mail on behalf of the Raleigh Field Office to the following individuals requesting their official peer review of the revised 5-year review document (per the Service's revised Peer Review Policy): (1) Brena Jones (NCWRC), (2) Judith Ratcliffe (NC Natural Heritage Program), and (3) Bryn Tracy (NC Division of Water Resources). Each individual received via e-mail the cover letter and peer review guidance provided in Section B below.

B. Peer review charge

2010 Cover letter

We request your assistance in serving as a peer reviewer of the U.S. Fish and Wildlife Service's (Service) 5-year status review of the endangered Cape Fear Shiner *(Notropis mekistocholas)*. The 5-year review is required by section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act). A 5-year review is a periodic process conducted to ensure the listing classification of a species as threatened or endangered on the Federal List of Endangered and Threatened Wildlife and Plants is accurate. The initiation of the 5-year review for the Cape Fear Shiner was announced in the *Federal Register* on July 6, 2009.

The enclosed draft of the status review has been prepared by the Service pursuant to the Act. In keeping with Service directives for maintaining a high level of scientific integrity in the official documents our agency produces, we are seeking your assistance as a peer reviewer for this draft. Guidance for peer reviewers is enclosed with this e-mail. If you are able to assist us, we request your comments be received in this office on or before June 28, 2010. Please send your comments to Kathryn Reis via fax to (919) 856-4556 or by e-mail to Kathryn_Reis@fws.gov.

In addition to learning what your thoughts are about the document in general, we would like to know the following:

1. What is your reaction to how we have defined the recovery units for the Cape Fear Shiner? Should High Falls Dam be the divider between the two Deep River recovery units?

2. Do you have new collection data that needs to be incorporated into our discussion about the Shiner's abundance and population/demography trends?

We appreciate your assistance in helping to ensure the Service's decisions continue to be based on the best available science. If you have any questions or need additional information please contact me at (919) 856-4520 ext. 31. Thank you for your assistance.
Sincerely,
Kathryn Reis
Fish and Wildlife Biologist

Enclosures
Guidance for Peer Reviewers of Five-Year Status Reviews
U.S. Fish and Wildlife Service, Raleigh Ecological Services Office
1 September 2008

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with Service policy.

Peer reviewers should:

1) Review all materials provided by the Service.

2) Identify, review, and provide other relevant data apparently not used by the Service.

3) Not provide recommendations on the Endangered Species Act (Act) classification (e.g., endangered, threatened) species.

4) Provide written comments on ...

    a. Validity of any models, data, or analyses used or relied on in the review.

    b. Adequacy of data (e.g., are the data sufficient to support the biological conclusions reached). If data are inadequate, identify additional data or studies that are needed to adequately justify biological conclusions.

    c. Oversights, omissions, and inconsistencies.

    d. Reasonableness of judgments made from the scientific evidence.

    e. Scientific uncertainties, by ensuring that they are clearly identified and characterized and that the potential implication of uncertainties for stated technical conclusions are clearly made.

    f. Strengths and limitation of the overall product.

5) Keep in mind the requirement that we must use the best available scientific data in determining the species' status. This does not mean we must have statistically significant data on population trends or data from all known populations.

All peer reviews and comments will be public documents, and portions may be incorporated verbatim into our final decision document with appropriate credit given to the author of the review.

Questions regarding this guidance, the peer review process, or other aspects of the Service's recovery planning process should be referred to Kathryn Reis, U.S. Fish and Wildlife Service, at 919-586-4520 ext. 31, or via e-mail at Kathryn_Reis@fws.gov.

2017 Cover Email
Dear Cape Fear Shiner experts:

On July 6, 2009, the U.S. Fish and Wildlife Service published a notice in the *Federal Register* (74 FR 31972) announcing a five-year review of 23 federally listed species, including the Cape Fear Shiner. The purpose of five-year reviews is to ensure that the classification of species as threatened or endangered is accurate and reflects the best available information.

Following Service current policy and guidelines on the process to conduct independent peer review, I am assisting our Raleigh Field Office to complete peer review of the science in the 5-year review for the Cape Fear Shiner. You may have provided data used to review the status of the Cape Fear Shiner and you are knowledgeable about the species. Therefore, in order to ensure that the best available information has been used to conduct this five-year review, we now request your peer review of the attached document.

Specifically we ask for comments on:
· Have we assembled the best available scientific and commercial information?· Is our analysis of this information correct and properly applied?, and
· Can you identify any additional new information on the Cape Fear Shiner that has not been considered in this review?

Please note that we are not seeking your opinion of the legal status of this species, but rather that the best available data and analyses were considered in reassessing its status. While we welcome your peer review comments in any format you are most comfortable using, it would be especially helpful if you could use the Comment Matrix Excel spreadsheet we have created. This will make it easier to compile and keep a record of all the comments received and then incorporate them into our report.

As part of the peer review process, we must evaluate the potential for conflicts of interest with the subject species or the action. We therefore ask that you fill out the enclosed Conflict of Interest form and return it to this office with any notes, comments, or questions that you are willing to provide as your review.

We appreciate your interest in furthering the conservation of rare plants and animals by becoming directly involved in the review process of our Nation's threatened and endangered species. Your review and comments will become a part of the administrative record for this species, and you can be certain that your information, comments, and recommendations will receive serious consideration.

Thank you for your help with our peer review process. Please send me an e-mail (jason_mays@fws.gov) if you have any questions on this peer review. If you have questions about the information in the 5-year Review, please contact Sarah McRae (sarah_mcrae@fws.gov). Please share your review by email by **May 31, 2017**. Thank you in advance for your assistance.

Sincerely,
Jason Mays
Recovery Biologist
US Fish and Wildlife Service
160 Zillicoa Street
Asheville, North Carolina 28801
Phone: 828-747-2394
Fax: 828 258-5330
Jason_mays@fws.gov

C. Summary of peer review comments / report

A summary of peer review comments from respondents is provided below. The complete set of comments is available at the Raleigh Ecological Services Field Office, U.S. Fish and Wildlife Service, 551-F Pylon Drive, Raleigh, North Carolina, 27606.

The Service accepted all minor edits from peer reviewers (e.g., inserting a concluding statement for a given section, rewriting a sentence to improve message delivery, and including a reference citation for a particular statement). Overall, the reviewers agreed the draft document adequately characterized known information on the status and threats of the Cape Fear Shiner. The following discussion is limited to the use of additional information that was provided.

Sarah McRae (North Carolina Natural Heritage Program)(2009): NCNHP emphasized a need to recognize the stretch of Rocky River above the Rocky Hydroelectric Dam as a recovery unit. The organization also submitted additional data regarding where the North Carolina Natural Heritage Program has observed Cape Fear Shiners and the population viability ratings it has assigned to specific geographic areas throughout the Shiner's range. NCNHP provided additional information regarding water quality concerns and habitat degradation for the Deep River. NCNHP also requested a discussion about the need for buffer rules, water protection reclassification or site specific management planning when addressing the "Inadequacy of existing regulatory mechanisms" in the document's five-factor analysis section. Lastly, NCNHP requested acknowledgment that the Cape Fear Shiner could possibly be reintroduced to the Rocky River above Woody's Dam.

Ryan Heise and Brena Jones (North Carolina Wildlife Resources Commission)(2009): NCWRC recommended combining the separate recovery units for the Rocky and Deep Rivers into one recovery unit. The agency believed such an approach would be more biologically meaningful than relying on High Falls Dam to divide the upper and lower reaches of the Deep River (including the Deep's confluence with the Rocky River). NCWRC submitted its own Cape Fear Shiner observation data, some of which was provided to identify inaccuracies of where the Service reported Cape Fear Shiners are known to occur. The agency's remaining comments requested either clarification of a specific message/statement or correction to an interpretation of biological papers.

Wayne Starnes (North Carolina Museum of Natural History) (2009): The Museum provided additional information about previous Cape Fear Shiner collection efforts and general natural history information. The Museum echoed NCNHP's dual request to include the upper Rocky River (the stretch above Rocky Hydro Dam) in the recovery unit definitions and to consider reintroducing the Cape Fear Shiner to this river region. Lastly, the Museum inquired why a particular study about the Cape Fear Shiner reproduction process was not reported in Section 2.3.1.1 (New information on the species' biology and life history).

Bryn Tracy (North Carolina Division of Water Resources) (2017): Several minor edits were provided (and incorporated). Comments focused on providing up-to-date information, specifically regarding DWR Cape Fear River basinwide reports and special study reports.

D. Response to peer review

In 2009, the Service accepted nearly all of the suggestions North Carolina Natural Heritage Program and North Carolina Wildlife Resources Commission submitted during the peer review process and modified the draft 5-year review document accordingly. The only recommendation that the Service did not directly address in 2009 was the NCNHP's and Museum's request to acknowledge the potential for reintroducing the Cape Fear Shiner to the Rocky River above Woody's Dam. At the time of response, the Service acknowledged that it is preparing a Strategic Habitat Conservation Framework for the Cape Fear Shiner with multiple partners, including NCHNP. It is during the development of this framework that the Service determined the specific actions it can take to improve Cape Fear Shiner habitat and increase Cape Fear Shiner numbers within all identified recovery units. Regarding the specific reproduction study the Museum noted as missing in Section 2.3.1.1, the Service did not report the findings of this study due to technical flaws biologists at NCWRC and North Carolina State University/Cooperative Fish and Wildlife Research Unit identified in the study's methodology.

Appendix B
Annotated Bibliography for Cape Fear Shiner

Burridge, C. P., and J. R. Gold. 2003. Conservation genetic studies of the endangered Cape Fear Shiner, *Notropis mekistocholas* (Teleostei: Cyprinidae). Conservation Genetics 4:219-225.

ABSTRACT: Genetic variation at ten microsatellite loci and one anonymous-nuclear locus was assayed for three geographic samples of the critically endangered North American cyprinid *Notropis mekistocholas* (Cape Fear Shiner). Despite low abundance of this species, there was little suggestion of small population effects; allele diversity and heterozygosity were relatively high, F_{IS} values within samples were non-significant, and genotypes were distributed in frequencies according to Hardy-Weinberg expectations. Genetic divergence among samples was minimal despite the presence of dams, constructed in the early 1900s, that separate the sample sites. This suggests that recent gene flow has been sufficient to inhibit genetic divergence or that gene flow has been reduced but there has been insufficient time for genetic divergence to develop. Tests of heterozygosity excess were non-significant, suggesting that *N. mekistocholas* in the localities sampled have not undergone recent reductions in effective population size. Future studies employing larger sample sizes to provide more robust tests of population structure and temporally separated samples to estimate contemporaneous N_e are warranted.

Abstract provided with kind permission from Springer Science and Business Media (www.springeronline.com)

Chittick, B., M. Stoskopf, N. Heil, J. Levine, and M. Law. 2001. Evaluation of Sandbar Shiner as a surrogate for assessing health risks to the endangered Cape Fear Shiner. Journal of Aquatic Animal Health 13:86-95. (75KB)

ABSTRACT: The health status of the endangered Cape Fear Shiner *Notropis mekistocholas* and the suitability of using the sympatric Sandbar Shiner *N. scepticus* as an investigative surrogate were evaluated. Forty Cape Fear Shiners from three sites and 50 Sandbar Shiners from five sites were examined. Findings on gill biopsies, fin biopsies, and skin scrapings were limited to low levels of parasitism and gill aneurysms. Eighty-three bacterial isolates representing 13 aerobic species were cultured from the gastrointestinal tracts. A picornavirus was isolated from one pooled sample of Sandbar Shiners at one site. Forty-three percent of Shiners (12 Cape Fear Shiners, 27 Sandbar Shiners) had granulomas in various tissues of the body, 26% (6 Cape Fear, 17 Sandbar) had encysted trematodes, 16% (2 Cape Fear, 12 Sandbar) had protozoal aggregates in muscle or connective tissue, and 26% (22 Cape Fear Shiners, 1 Sandbar Shiner) had mild, moderate, or moderately severe hepatic vacuolization. Other microscopic lesions included mild parasitism and degrees of inflammation in various tissues. Sandbar Shiners appeared to be suitable surrogates for the Cape Fear Shiner in bacteriological sampling; however, parasitic, viral, and nonhepatic histological lesions were more common in Sandbar Shiners. Findings from this study warrant further investigation of Sandbar Shiners as a conservative bioindicator species for the presence of potential health risks to Cape Fear Shiners.

Abstract provided with kind permission from American Fisheries Society (www.fisheries.org)

Dwyer, F. J., D. K. Hardesty, C. G. Ingersoll, and D. W. Whites. 1999. Assessing contaminant sensitivity of Cape Fear Shiner and spotfin chub: Interim report. U.S. Geological Survey, Biological Resources Division, Columbia Environmental Research Center, Columbia, MO.

SUMMARY: The sensitivity of the endangered spotfin chub (*Hybopsis monacha*) and Cape Fear Shiner (*Notropis mekistocholas*) was tested to determine effects and suitable levels of five chemicals potentially found in streams. The sensitivity of surrogates (rainbow trout (*Oncorhynchus mykiss*) and fathead minnow (*Pimephales promelas*)) was also tested and compared to the sensitivity of the endangered fish. The results indicate that the Cape Fear Shiner and spotfin chub have similar sensitivities to the rainbow trout. Although the fathead minnow is of closer relation to the two endangered fish, the fathead minnow was much less sensitive to the chemicals tested and would not make a good surrogate test fish.

Dwyer, F. J., D. K. Hardesty, C. E. Henke, C. G. Ingersoll, D. W. Whites, T. Augspurger, T. J. Canfield, D. R. Mount, and F. L. Mayer. 2005. Assessing contaminant sensitivity of endangered and threatened aquatic species: III. Effluent toxicity tests. Archives of Environmental Contamination and Toxicology 48:174-183.

ABSTRACT: Toxicity tests using standard effluent test procedures described by the U.S. Environmental Protection Agency were conducted with *Ceriodaphnia dubia*, fathead minnows (*Pimephales promelas*), and seven threatened and endangered (listed) fish species from four families: (1) Acipenseridae: shortnose sturgeon (*Acipenser brevirostrum*); (2) Catostomidae; razorback sucker (*Xyrauchen texanus*); (3) Cyprinidae: bonytail chub (*Gila elegans*), Cape Fear Shiner (*Notropis mekistocholas*) Colorado pikeminnow (*Ptychocheilus lucius*), and spotfin chub (*Cyprinella monacha*); and (4) Poecillidae: Gila topminnow (*Poeciliopsis occidentalis*). We conducted 7-day survival and growth studies with embryo-larval fathead minnows and analogous exposures using the listed species. Survival and reproduction were also determined with *C. dubia*. Tests were conducted with carbaryl, ammonia—or a simulated effluent complex mixture of carbaryl, copper, 4-nonylphenol, pentachlorophenol and permethrin at equitoxic proportions. In addition, Cape Fear Shiners and spotfin chub were tested using diazinon, copper, and chlorine. Toxicity tests were also conducted with field-collected effluents from domestic or industrial facilities. Bonytail chub and razorback suckers were tested with effluents collected in Arizona whereas effluent samples collected from North Carolina were tested with Cape Fear Shiner, spotfin chub, and shortnose sturgeon. The fathead minnow 7-day effluent test was often a reliable estimator of toxic effects to the listed fishes. However, in 21 % of the tests, a listed species was more sensitive than fathead minnows. More sensitive species results varied by test so that usually no species was always more or less sensitive than fathead minnows. Only the Gila topminnow was consistently less sensitive than the fathead minnow. Listed fish species were protected 96% of the time when results for both fathead minnows and *C. dubia* were considered, thus reinforcing the value of standard whole-effluent toxicity tests using those two species. If the responses of specific listed species are important for management decisions, our study supports the value in developing culture and testing procedures for those species.

Abstract provided with kind permission from Jim Dwyer of FWS/Columbia Ecological Services Field Office.

Dwyer, F. J., F. L. Mayer, L. C. Sappington, D. R. Buckler, C. M. Bridges, I. E. Greer, D. K. Hardesty, C. E. Henke, C. G. Ingersoll, J. L. Kunz, D. W. Whites, T. Augspurger, D. R. Mount, K. Hattala, and G. Neuderfer. 2005. Assessing contaminant sensitivity of endangered and threatened aquatic species: I. Acute toxicity of five chemicals. Archives of Environmental Contamination and Toxicology 48:143-154.

ASTRACT: Assessment of contaminant impacts to federally identified endangered, threatened and candidate, and state identified endangered species (collectively referred to as "listed" species) requires understanding of a species' sensitivities to particular chemicals. The most direct approach would be to determine the sensitivity of a listed species to a particular contaminant or perturbation. An indirect approach for aquatic species would be application of toxicity data obtained from standard test procedures and species commonly used in laboratory toxicity tests. Common test species (fathead minnow, *Pimephales promelas*; sheepshead minnow, *Cyprinodon variegatus*; and rainbow trout, *Oncorhynchus mykiss*) and 17 listed or closely related species were tested in acute 96-hour water exposures with five chemicals (carbaryl, copper, 4-nonylphenol, pentachlorophenol, and permethrin) representing a broad range of toxic modes of action. No single species was the most sensitive to all chemicals. For the three standard test species evaluated, the rainbow trout was more sensitive than either the fathead minnow or sheepshead minnow and was equal to or more sensitive than listed and related species 81% of the time.

To estimate an LC50 for a listed species, a factor of 0.63 can be applied to the geometric mean LC50 of rainbow trout toxicity data, and more conservative factors can be determined using variance estimates (0.46 based on 1 SD of the mean and 0.33 based on 2 SD of the mean). Additionally, a low- or no-acute effect concentration can be estimated by multiplying the respective LC50 by a factor of approximately 0.56, which supports the United States (U.S.) Environmental Protection Agency approach of multiplying the final acute value by 0.5 (division by 2). When captive or locally abundant populations of listed fish are available, consideration should be given to direct testing. When direct toxicity testing cannot be performed, approaches for developing protective measures using common test species toxicity data are available.

Abstract provided with kind permission from Jim Dwyer of FWS/Columbia Ecological Services Field Office.

Gold, J. R., E. Saillant, C. P. Burridge, A. Blanchard, and J. C. Patton. 2004. Population structure and effective size in critically endangered Cape Fear Shiners *Notropis mekistocholas*. Southeastern Naturalist 3(1):89-102. (78KB)

ABSTRACT: Allelic variation at hypervariable, nuclear-encoded loci and mitochondrial (mt)DNA was studied among three geographic samples (40 individuals) of the critically endangered Cape Fear Shiner, *Notropis mekistocholas*. Genetic variation, as measured by allelic richness and gene (microsatellite) or nucleon (mtDNA) diversity, was similar to that in other fish species. Homogeneity tests of allele and genotype distributions and analysis of molecular variance (AMOVA) at nuclear-encoded loci revealed significant genetic heterogeneity among localities. No differences in mtDNA allele (haplotype) frequencies were detected. The ratio of the number of microsatellite alleles to the range in allele size suggested that significant reductions

in effective size have occurred at two of the three localities. Long-term (inbreeding) effective population size differed among the samples and ranged from ~1,300 to ~3,000. Collectively, these results indicate that (i) Cape Fear Shiners at these localities are not genetically impoverished, (ii) separate populations of Cape Fear Shiners may exist in the Cape Fear drainage, (iii) recent reduction in effective size may have occurred in two of the three localities, and (iv) ancestral populations of Cape Fear Shiners may have been of sufficient effective size to offset extinction due to genetic factors.

Abstract provided with kind permission from Eagle Hill Foundation (www.eaglehill.us)

Hewitt, A.H., W.G. Cope, T.J. Kwak, T. Augspurger, P.R. Lazaro, and D. Shea. 2006. Influence of water quality and associated contaminants on survival and growth of the endangered Cape Fear Shiner (*Notropis mekistocholas*). Environmental Toxicology and Chemistry 25:2288–2298.

ABSTRACT: The Cape Fear Shiner (*Notropis mekistocholas*) is a recently described cyprinid species endemic to the Cape Fear River Basin of North Carolina, USA. Only five populations of the fish remain; thus, it is listed as endangered by the U.S. Government. Determining habitat requirements of the Cape Fear Shiner, including water quality and physical habitat, is critical to the survival and future restoration of the species. To assess water quality in the best remaining and in the historical habitats, we conducted a 28-d in situ bioassay with captively propagated Cape Fear Shiners. Fish were deployed at 10 sites in three rivers, with three cages per site and 20 fish per cage. Water and sediment samples were collected and analyzed for selected metals and organic contaminants. Passive sampling devices also were deployed at each site and analyzed for organic contaminants at test termination. Fish survival, growth (as measured by an increase in total length), and contaminant accumulation were measured on completion of the bioassay. Survival of caged fish averaged 76% (range, 53–100%) and varied significantly among sites and rivers. Caged fish accumulated quantities of cadmium, mercury, polychlorinated biphenyls, and other persistent contaminants over the test duration and grew significantly at only four sites. No apparent relations were observed between exposure to or accumulation of a specific contaminant and reduced growth or survival of fish among all the sites. However, a generalized hazard assessment showed that certain sites exhibited trends in cumulative contaminant presence with reduced fish survival and growth, thereby enabling the identification of the existing riverine habitat most suitable for reintroduction or population augmentation of this endangered fish.

Abstract provided with kind permission from SETAC and Alliance Communications Group (www.setac.org)

Hewitt, A.H., T.J. Kwak, W.G. Cope, and K.H. Pollock. 2009. Population density and instream habitat suitability of the endangered Cape Fear Shiner. Transactions of the American Fisheries Society. 138: 1439 – 1457.

ABSTRACT: The Cape Fear Shiner Notropis mekistocholas is an endangered minnow endemic to the Cape Fear River basin of North Carolina; only five populations remain, all of which are declining. Determining the population densities and habitat requirements of the species is critical to its survival and restoration planning. We conducted population surveys (four sites) and instream microhabitat suitability analyses (six sites) on the Rocky and Deep rivers to (1) estimate the population density of Cape Fear Shiners, (2) quantify the use, availability, and suitability of microhabitats, and (3) determine whether physical habitat alterations were a likely cause of local extirpations and whether instream habitat limits the occurrence and density of this species. Density ranged from 795 fish/ha to 1,393 fish/ha (4,768–7,392 fish/km) at three of the sites surveyed and was too low to be estimated at the fourth site. The fish most frequently occupied riffles and velocity breaks at moderate depths over gravel substrates. It occupied microhabitats nonrandomly with respect to availability; the microhabitats occupied were similar between spawning and postspawning seasons but shallower during spawning. Comparisons of suitable habitat among sites where the fish is extant, rare, or extirpated suggest that suitable substrate (gravel) is lacking where the fish is rare and that suitable microhabitat combinations, especially with respect to water velocity, are rare at all sites. Potential reintroduction sites where the species is rare or extirpated were shallower than extant sites, and one site where the fish is extirpated contained suitable physical habitat but lacked adequate water quality. Another site where the species is rare would require substrate alteration to improve conditions. The survival and recovery of the Cape Fear Shiner is dependent on the protection of remaining suitable physical habitat with approaches that consider instream habitat, water quality, and biotic interactions as well as human uses and alterations of the river, riparian zone, and watershed.

Abstract provided with kind permission from Tom Kwak.

Holliman, F. M., J. B. Reynolds, and T. J. Kwak. 2003. A predictive risk model for electroshock-induced mortality of the endangered Cape Fear Shiner. North American Journal of Fisheries Management 23:905-912. (58KB)

ABSTRACT: We evaluated the effects of a single electroshock on injury and mortality of hatchery reared Cape Fear Shiners *Notropis mekistocholas* (*N* 5 517), an endangered cyprinid. Groups of 18–22 Cape Fear Shiners were exposed to DC, 120-Hz pulsed DC (PDC), or 60-Hz PDC at voltage gradients of 1.1, 1.9, or 2.7 V/cm for 3 s. Mortality occurred only among fish exposed to 120-Hz PDC (25%) and DC (38%) applied at 2.7 V/cm. Because no mortality occurred in Cape Fear Shiners exposed to 60-Hz PDC, this waveform was selected for further study of electroshock duration (3, 6, 12, 24, or 48 s) and voltage gradient (0.9, 1.6, or 2.3 V/cm). Most fish electroshocked in the experiments were immobilized (ceased swimming motion). No physical injury was detected by necropsy or radiography in any fish. Electroshock-induced mortality of Cape Fear Shiners showed a strong multivariable relationship to voltage gradient, electroshock duration, and fish length. Fish subjected to 60-Hz PDC at 0.9 or 1.6 V/cm for 6 s experienced low mortality (<10%). Our results demonstrate that Cape Fear Shiners can be immobilized by 60-Hz PDC electroshock without injury or significant risk of mortality. We propose that electrofishing may be safely used to sample similar small cyprinids, imperiled or otherwise, when electrofishers select an appropriate waveform (DC pulsed at 60-Hz or less) and use it judiciously (minimal exposure at, or below, the immobilization threshold).

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Howard, A. K. 2003. Influence of instream physical habitat and water quality on the survival and occurrence of the endangered Cape Fear Shiner. M.S. Thesis, North Carolina State University, Raleigh, NC. 133pp. (953KB)

ABSTRACT: The Cape Fear Shiner *Notropis mekistocholas* is a recently described cyprinid fish endemic to the Cape Fear River Basin of North Carolina. Only five declining populations of the fish remain, and therefore, it has been listed as endangered by the U.S. Government. Determining habitat requirements of the Cape Fear Shiner, including physical habitat and water quality, is critical to the species' survival and future restoration. This study integrated the sciences of toxicology and conservation biology, and simultaneously assessed ecosystem level influences of habitat (water and physical environments) on survival, growth, occurrence, and distribution of the Cape Fear Shiner. I conducted an instream microhabitat suitability analysis among five sites on the Rocky and Deep rivers to (1) quantify Cape Fear Shiner microhabitat use, availability, and suitability in extant habitats, (2) determine if physical habitat alterations are a likely cause of extirpation of the Cape Fear Shiner at historical locations and if instream habitat is a limiting factor to occurrence and survival of the species in extant habitats and at potential reintroduction sites, and (3) estimate population density at selected extant sites. I used an in situ 28-day bioassay with captively propagated Cape Fear Shiners to (1) determine if water quality is a limiting factor to the occurrence, growth, and survival of the Cape Fear Shiner, (2) document habitat suitability by assessing inorganic and organic contaminants through chemical analyses and review of existing data, and (3) assess the protectiveness of water quality standards for primary pollutants based on comparisons of laboratory, field toxicity, and water chemistry data.

Cape Fear Shiners most frequently occupied riffles and velocity breaks (i.e., areas of swift water adjacent to slow water), moderate depths, and gravel substrates. They used habitat non-randomly with respect to available habitat, and habitat use was similar between post-spawning and spawning seasons. However, Cape Fear Shiners shifted to shallower depths during the spawning season, suggesting that adequate depth distribution may be an important element of Cape Fear Shiner habitat. Comparisons of suitable microhabitat among river reaches where the Cape Fear Shiner is extant, rare, or extirpated suggest that suitable substrate (gravel) may be lacking where the fish is rare, and that suitable microhabitat combinations, especially for water velocity, are rare at all sites. Cape Fear Shiner density was too low to be estimated in upstream reaches of the Deep River where gravel substrate is limited. Population density ranged from 795 fish/ha to 1,393 fish/ha at three sites surveyed. Potential reintroduction sites had shallower mean depths than those at extant sites, and the extirpated site on the Rocky River contained the most suitable physical habitat, but lacked adequate water quality. A site on the Deep River where the species persists, but is rare, is a candidate reach for habitat restoration, but would require substrate alteration to improve conditions for the Cape Fear Shiner.

After conclusion of the 28-day in situ test, I measured fish survival, growth (an increase in total length), and contaminant accumulation. Survival of caged fish averaged 76% and ranged from 53% to 100%. Sites with the greatest mean survival were on the Deep River (87%), followed by those on the Rocky River (74%), and were lowest on the Haw River (66%). Fish survival was significantly lower at five sites, two in the Haw River, two in the Rocky River, and one in the Deep River. Caged fish grew significantly at four of the 10 sites, and all fish accumulated quantities of Cd, Hg, PCBs, DDTs, and other contaminants over the test duration. Results from the in situ exposures indicate that a reintroduction site on the Rocky River does not have adequate water

quality to support reintroduction, yet results from the instream habitat assessment indicate that physical habitat is similar to extant Cape Fear Shiner locations.
Finally, the survival and recovery of the Cape Fear Shiner is dependent upon the successful protection of remaining suitable physical habitat and water quality that will require broad-scale examination and approaches considering physical instream habitat, water quality and contaminants, biotic interactions with other organisms, as well as human uses and alterations of the river, riparian zone, and watershed.

Abstract provided with kind permission from Amanda Howard Hewitt.

Johnston, C. and A. Henderson. 2009. Habitat use and reproductive behavior of the Cape Fear Shiner (*Notropis mekistocholas*). Report to the U.S. Fish and Wildlife Service. 48 pp.

SUMMARY: Using natural and laboratory settings, the researchers examined the habitat preferences of larval and juvenile Cape Fear Shiners during 2007 and 2008. They collected all field data on the Rocky River, within reaches located 450 meters and 600 meters above the confluence of the Rocky and Deep Rivers. Collectively the field and lab data suggested that larval Cape Fear Shiners (30-54 days post hatch, 5-16 mm in total length) occupy shallow depths of the water column (10-15 cm) and moderate current velocities (0.05-0.10 m/s). The researchers found a statistical relationship between the total length of a larval Cape Fear Shiner and the water depth the Shiner selects. In contrast, the lab data suggested that juvenile Cape Fear Shiners (70-125 days post hatch, 20-36 mm in total length) favor moderate (0.05-0.10 m/s) to swift (>0.13 m/s) water flows and deeper depths of the water column (35-55 cm). The field data also indicated that juveniles measuring 15-25 mm in total length tend to swim with adults. Regardless of life stage, Cape Fear Shiners rarely move and disperse between habitat patches.

Pottern, G. B., and M. T. Huish. 1985. Status survey of the Cape Fear Shiner *Notropis mekistocholas*. Report for U.S. Fish and Wildlife Service. 44 pp.

SUMMARY: This report documents the results of an extensive survey for the Cape Fear Shiner in the Cape Fear River Basin. A detailed search of the Haw, Deep, and Rocky Rivers was conducted; three partially isolated populations of Cape Fear Shiner were found. Qualitative evaluations of habitat where conducted, and the effects of dams, impoundments, and future development are discussed.

Pottern, G. B., and M. T. Huish. 1986. Supplement to the status survey of the Cape Fear Shiner *Notropis mekistocholas*. Report for U.S. Fish and Wildlife Service. 11 pp.

SUMMARY: This supplement reports the results of a follow-up survey to the 1985 status survey by Pottern and Huish. A new population of Cape Fear Shiner was found in the Deep River, upstream of the known population near High Falls.

Pottern, G. B., and M. T. Huish. 1987. Second supplement to the status survey of the Cape Fear Shiner *Notropis mekistocholas*. Report for U.S. Fish and Wildlife Service. 7 pp.

SUMMARY: This second supplement reports results from additional surveys and collections of the Cape fear Shiner from sites visited in earlier reports by Pottern and Huish. Cape Fear Shiners were found at a site where they were believed to have been extirpated.

Pottern, G. 2009. 2007 Status Update of the Cape Fear Shiner *Notropis mekistocholas*. Report for the North Carolina Wildlife Resources Commission. 27 pp.

SUMMARY: Using 6 feet and 10 feet long seines, Pottern's survey team visited 49 sites within the Cape Fear Shiner's known habitat range. End points for each collection site (or river segment) were based on the presence of dams, river confluences or habitat changes. Fourteen of the 49 collection sites were located within the Deep River of Chatham, Lee, Moore and Randolph Counties. Pottern's team captured over 87 Cape Fear Shiners among those Deep River collection sites, and approximately 80% of those captures occurred in or near algae-filled pools among 2 segments of the Deep River in Chatham and Moore Counties. The lower Rocky River sub-basin in Chatham County yielded the second most Cape Fear Shiner captures (13 individual Shiners among 4 collection sites). Pottern also observed algae-filled pools in this section of the Rocky River. Only 1 Cape Fear Shiner was captured in both the Haw River sub-basin (Chatham County) and the Cape Fear River sub-basin (Harnett County). Pottern observed no algae-filled pools in the Haw and Cape Fear sub-basins.

To recover the Cape Fear Shiner species in central North Carolina, Pottern emphasized the protection and restoration of forested riparian habitat and the development of a long-term stream habitat corridor protection plan. The stream habitat plan should address issues of soil erosion, stormwater runoff from construction sites, and general water pollution concerns (e.g., cadmium, lead mercury, DDT, and polychlorinated biphenyls). Planning efforts should be directed first at the surveyed areas showing the strongest Cape Fear Shiner populations.

Saillant E., J. C. Patton, and J. R. Gold. 2005. Genetic variation, kinship, and effective population size in a captive population of the endangered Cape Fear Shiner, *Notropis mekistocholas*. Copeia 1:20–28.

SUMMARY: The purpose of this study was to examine genetic variation, relatedness, and effective population sizes of second generation captive population Shiners as compared to the wild population. The effective population size of the captive population was 1/10 of the wild population. Results from the captive population suggest polygynous and possibly polyandrous mating. The captive population showed lower richness and gene diversity than the wild populations, although, allelic richness was still at sufficient levels as compared to other endangered fish species.

Saillant, E., J. C. Patton, K. E. Ross, J. R. Gold. 2004. Conservation genetics and demographic history of the endangered Cape Fear Shiner (*Notropis mekistocholas*). Molecular Ecology 13, 2947-2958.

SUMMARY: The researchers examined evidence of small population effects due to low fish abundance and population trends to determine if population sizes have always been small. Gene flow between populations is assessed based on heterogeneity of allele distributions. Genetic diversity and small population effects do not seem to be of concern in the

Cape Fear Shiner. However, signs of reduced gene flow were evident, suggesting population separation from dams may be affecting the populations. Significant separation reduces the amount of gene flow between populations thus making them vulnerable to loss of heterozygosity.

Snelson, F. F., Jr. 1971. *Notropis mekistocholas*, a new herbivorous cyprinid fish endemic to the Cape Fear River Basin, North Carolina. Copeia 1971:449-462. (1.2MB)

ABSTRACT: *Notropis mekistocholas* is described as a new species. It is unusual within the genus in exhibiting herbivorous adaptations-an elongate, convoluted intestine and black peritoneum. It is compared with *N. alborus* and *N. procne*, two sympatric relatives that differ in lacking herbivorous modifications, in having seven rather than eight anal rays, and in numerous other features. *N. mekistocholas* is the first known endemic species from the Cape Fear drainage in North Carolina. It has a very restricted distribution in the east-central Piedmont province, being known from only four streams in Chatham and Harnett counties. Intestinal modifications suggestive of an herbivorous diet are reported for *N. anogenus* and some species of the subgenus *Luxilus*. There is no evidence to suggest that *N. mekistocholas* should be aligned with the southwestern genus *Dionda*, which contains herbivorous species superifically similar to *Notropis* species. Closest relatives of *N. mekistocholas* appear to be *N. procne* and *N. stramineus*.

U.S. Fish and Wildlife Service. 1986. Proposal to list the Cape Fear Shiner as an endangered species with critical habitat. Federal Register 51(FR):25219-25223. (446KB)

SUMMARY: This document provides a review of all known information about the Cape Fear Shiner through 1986 and the reasons for proposing to list the species as endangered.

U.S. Fish and Wildlife Service. 1987. Determination of endangered species status and designation of critical habitat for Cape Fear Shiner. Federal Register 52(FR):36034-36039. (773KB)

SUMMARY: Due to the reduction in range, reduction in population sizes, and threats of habitat degradation, the Cape Fear Shiner was federally listed as an endangered species. This document also designates critical habitat in the Deep, Rocky, and Haw Rivers.

U.S. Fish and Wildlife Service. 1988. Cape Fear Shiner recovery plan. Atlanta, GA. 18 pp. (1.1MB)

SUMMARY: The recovery plan outlines actions to be taken to ensure the survival of the species and achieve self-sustaining viable Cape Fear Shiner populations. The actions to be taken include protection of the species and its habitat, biological and ecological studies, and public awareness activities.