Relict darter
(Etheostoma chienense)

5-Year Review:
Summary and Evaluation

USFWS Photo (Brent Harrel)

U.S. Fish and Wildlife Service
Southeast Region
Kentucky Ecological Services Field Office
Frankfort, Kentucky

5-YEAR REVIEW

Relict darter (*Etheostoma chienense*)

I. GENERAL INFORMATION

A. Methodology used to complete the review:

We provided public notice of this five-year review in the *Federal Register* on September 21, 2007 (72 FR 54057) and opened a 60-day comment period. During this comment period, we obtained information on the status of this species from several experts; additional data was obtained from the draft recovery plan, peer-reviewed scientific literature, and our state partners. Once all known literature and information was collected for this species, Dr. Michael A. Floyd, lead Recovery Biologist with the Kentucky Ecological Services Field Office (KFO), completed the review. The draft document was peer-reviewed by Matthew Thomas, Kentucky Department of Fish and Wildlife Resources (KDFWR), Frankfort, Kentucky; Ryan Evans, Kentucky State Nature Preserves Commission (KSNPC), Frankfort, Kentucky; and Dr. Kyle Piller, Southeastern Louisiana University, Hammond, Louisiana; and comments received were incorporated as appropriate (see Appendix A).

B. Reviewers

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

Lead Field Office: Kentucky Ecological Services Field Office: Dr. Michael Floyd, 502-695-0468 x102.

Peer Reviewers: Dr. Kyle Piller, Southeastern Louisiana University
Dr. Matthew Thomas, KDFWR
Michael Compton, KSNPC

C. Background

1. Federal Register Notice citation announcing initiation of this review:
September 21, 2007 (72 FR 54057)

2. Species status: Stable. Threats continue to impact the species, but based on repeated observations of the species (surveys by consultants, observations by Service, KSNPC, and KDFWR biologists) and continued conservation efforts, the species status appears to be stable. Range-wide, qualitative surveys were completed in October 2010, followed by more intensive, quantitative surveys in October 2011 and 2012. Cooperators included personnel from KSNPC, KDFWR, KY Transportation Cabinet, TNC, and KFO. The species was present at all historical sites reported in the 1995 survey by Piller and Burr (1996, 1998). Also, the species' relative abundance and population estimates were about the same as those observed by Piller and Burr (1996; 1998). The Service continues to implement stream and riparian habitat restoration projects in the upper Bayou du Chien (especially Jackson Creek) watershed where this species occurs in order to help stabilize potential breeding habitat, and other potential projects are being developed. These projects have consisted of bank repair, head-cut

removal, riparian plantings, cattle exclusion, and other best management practices that will reduce/control sedimentation and bank erosion within the Bayou du Chien watershed.

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

4. Listing history

Original Listing

FR notice:	58 FR 68480
Date listed:	December 27, 1993
Entity listed:	species
Classification:	endangered

5. Associated rulemakings: None.

6. Review History:
Recovery Plan: Draft Recovery Plan, 1994 (not finalized)
Recovery Data Call: 2013 - 1998

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

8. Recovery Plan
Name of Plan: [draft plan has not been finalized] Technical/Agency Draft Recovery Plan for the Relict Darter (*Etheostoma chienense*)
Date Issued: July 1994

II. REVIEW ANALYSIS

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

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

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

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? No.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features, or demographic trends:

Abundance and Population Trends. Initial surveys of the Bayou du Chien watershed by Webb and Sisk (1975) and Warren et al. (1994) revealed that the relict darter was restricted to about 28 stream kilometers (km) (17.4 miles (mi)) in the Bayou du Chien system and was known to spawn in only one tributary (Jackson Creek) in the upper reaches of the watershed. Warren et al. (1994) estimated the extent (in meters (m)) of suitable habitat at the two sites where relict darters were most abundant, Jackson Creek at Lawrence Road and Bayou du Chien at KY 1283. Their calculations determined that approximately 160 m (525 feet (ft)) of suitable habitat were present at these two sites, with an estimated population size of 200 individuals (an average of about 1.25 individuals for every 1 m (3.28 ft) of suitable habitat). At remaining sites where Warren et al. (1994) observed the species, they estimated the presence of about 35 m (115 ft) of suitable habitat.

Piller and Burr (1998) completed a comprehensive survey effort for the relict darter, visiting all known historical sites and several new sites. Individuals were found at 16 of 28 sites sampled (Appendix B), with darters inhabiting a total of 47.1 linear km (29.3 mi) of stream. Their population estimate taken in the spring of 1996 suggested that the system supported between 9,553 and 31,293 individuals. The most viable populations were found in areas having gently flowing water, good undercut bank habitat, low silt load, and suitable quantities of spawning substrata and instream cover. Based on their study results, Piller and Burr (1998) asserted that *E. chienense* was maintaining an effective population size.

During April and May 2006, the KDFWR sampled at two sites where relict darters had previously been reported (Dr. Matthew Thomas, KDFWR, personal communication, 2008). On April 27, 2006, they captured a total of 35 individuals (28 females, several in gravid condition, and 7 males, all in nuptial condition) at the KY 1283 bridge crossing of Bayou du Chien in Graves County. Previous sampling efforts at this site by Piller and Burr (1998) yielded a population estimate of 60 individuals. On May 25, 2006, the KDFWR and Kentucky Division of Water observed 28 individuals at the US 51 bridge crossing of Bayou du Chien in Hickman County, a slight increase in abundance compared with previous population estimates. Previous collections at this locality yielded low numbers of individuals (population estimate of 46), presumably due to a lack of available spawning habitat (Piller and Burr 1998).

During October 2010, the KSNPC, KFO, The Nature Conservancy, and the Kentucky Transportation Cabinet (KYTC) completed qualitative surveys (via seine hauls) at 13 of 16 historic sites in the Bayou du Chien system. The three remaining historic sites, Cane Creek (upper site), Sand Creek, and an unnamed tributary of Bayou du Chien (at Rose Road), were not surveyed due to a lack of

flow (channels were dry or pooled). Relict darters were captured at all historic sites reported previously by Piller and Burr (1998), and darter abundance was similar to that reported by Piller and Burr (1998). In addition to these historic sites, 6 relict darters were observed at a new site on Jackson Creek – 1 km (0.60 mi) downstream of Lawrence Road, approximately 100 meters upstream of its confluence with Bayou du Chien. This was not surprising as Jackson Creek continues to support a robust population within the species' range.

During October 2011 and 2012, the KFO, KSNPC, KDFWR, and KYTC completed quantitative surveys at a total of 4 100-m reaches on Jackson Creek and 12 150-m reaches on the Bayou du Chien mainstem. At present, this research is unpublished, but a brief summary of the methods and results is presented here and in Appendix C. Sampling reaches were chosen via a stratified random approach (Compton and Taylor 2013) and were restricted to the Bayou Chien mainstem and Jackson Creek. Sampling reaches were limited to the Mississippi Loess Plain Ecoregion (Woods et al. 2002) based on the species' historical records and habitat affinities. The number of reaches in each stream was determined based on their overall coverage within the study area (proportional to the total stream length in each stream). At each of the four Jackson Creek sampling reaches, 10 consecutive 2- X 5-m plots were surveyed, with each consecutive plot being separated by 3 m. At the 12 Bayou du Chien reaches, 10 consecutive 2- X 10-m plots were surveyed, with each consecutive plot being separated by 5 m. Within each survey reach, sampling plots were positioned along the left bank, channel center, or right bank. Grid positions varied throughout the sampling reach, and each plot position was chosen randomly.

For Jackson Creek, we observed a total of 92 relict darters and calculated a mean population size of 1,526 with a 95% confidence interval of 171 - 2,883 individuals. We observed a mean darter density in Jackson Creek of 0.26 darter/m^2. For the Bayou du Chien mainstem, we observed 87 relict darters and calculated a mean population size of 13,108 with a 95% confidence interval of 3,854 – 22,362 individuals. We observed a mean darter density of 0.04 darter/ m^2. Our population ranges for both streams were large; however, this was not unexpected based on our small number of survey reaches and the lack of relict darter captures at several sites. Our mean population estimate for the Bayou du Chien mainstem was similar to that generated by Piller and Bur (1998) for the entire system, with similar ranges (18,508 individuals vs. 21,740 individuals).

Quantitative surveys completed from 2011-2012 and the qualitative surveys completed in 2010 indicate that the species continues to occupy portions of the basin where it was reported by previous researchers (Warren et al. 1994; Piller and Burr 1998). The species also continues to be abundant in some reaches. The strongest population (based on mean density) occurs in Jackson Creek (0.26 darter/m^2), but the species also appears to be stable within portions of the Bayou du Chien mainstem, specifically an 18-km (11.3-mi) reach that extends from just downstream of the US 51 bridge crossing in Hickman County upstream to the confluence with Jackson Creek (Appendix D). Within this reach, we observed mean densities ranging from 0.06 – 0.11 darters/ m^2 (Reaches 3-8).

Reproduction. The only information on reproductive habits of the species was provided by Piller and Burr (1999) during their investigation in 1995 and 1996. Spawning occurred from mid-March to early June at water temperatures ranging from 11 to 22°C (52 to 72°F). A total of 166 nests were observed on 16 different substrate types. Most nests were located on natural materials such as small rocks, woody debris, and live tree roots, but 37 percent of nests were found on anthropogenic materials such as rubber tires, plastic, roof shingles, glass, concrete blocks, metal road signs, and concrete slabs. Nests were found at a mean depth of 16.9 cm (6.6 inches [in]) (range: 4.5 to 38 cm [1.8 to 15 in]), and the cavity between the stream bottom and the spawning substrate averaged 2.9 cm (1.1 in) (range: 2 to 5 cm [0.79 to 1.9 in]). Nests with clutches of eggs attached to naturally occurring materials contained a range of 12 to 789 eggs (mean = 255) in 1995 and from 12 to 1,275 eggs (mean = 343) in 1996.

Because natural spawning substrates were limited in the drainage, Piller and Burr (1999) seeded several reaches with ceramic tiles to increase relict darter reproductive success. Between 25 and 88 percent of tiles were utilized for spawning at least once during the study and several were used multiple times. The number of eggs deposited on introduced tiles was significantly larger than the number deposited on natural substrates. Piller and Burr (1999) also performed two laboratory experiments to attempt to determine nest preferences of the species. Female relict darters were provided spawning substrates of different sizes. Six of eight laboratory spawnings occurred on the larger substrates, but these size differences were not statistically significant. In the second experiment, females were added to aquaria with a large (68 to 72 mm [2.7 in to 2.8] standard length [SL, from the tip of the snout to the base of the tail fin] and a small (60 to 64 mm [2.4 to 2.5] SL) male. Seven of eight spawning events occurred with the larger male - a statistically significant result. Several spawnings were videotaped in the laboratory (Piller and Burr 1999), and spawning occurred between 20 and 21°C (68 to 70°F). Males and females were positioned in a head-to-head, inverted pattern for 1.5 to 3 seconds, during which time ova were released.

According to Piller and Burr (1999), the relict darter limits its activities to undercut banks or other near bank areas. Some adult males leave undercut banks in spring to guard territories beneath instream objects, but seining indicated that many nuptial males and gravid females remained beneath undercut banks and may attach eggs to the ceilings of these habitats. Males were darkened and had dorsal fins knobbed, while females would release eggs with the slightest pressure on their abdomens.

Length frequency estimates by Piller and Burr (1998) revealed four age classes and an estimated life expectancy of 3+ years. Males were approximately 40 mm (1.6 in) standard length (SL, from the tip of the snout to the base of the tail fin) by age 1, 52 to 62 mm (2.0 to 2.4 in) SL at age 2, and 63 to 76 mm (2.5 to 3.0 in) SL at age 3. Females were slightly smaller at each class. Age 1 females were almost 35 mm (1.4 in) SL, 47 to 54 mm (1.8 to 2.1 in) SL at age 2, and 55 to 68 mm (2.2 to 2.7 in) SL at age 3. Piller and Burr (1998) observed no larval relict

darters during their study, and only a few juveniles were captured in late spring and early summer.

Our quantitative surveys in 2011 (Jackson Creek) and 2012 (Bayou du Chien) also indicated a life span of 3+ years and revealed similar age class patterns (Appendix E). Consecutive years of recruitment were observed in both streams.

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

No information is available on genetics or genetic variation of the relict darter.

c. Taxonomic classification or changes in nomenclature:

The relict darter is 1 of 10 recognized species in the *Etheostoma squamiceps* complex (subgenus *Catonotus*, family Percidae) (Page et al. 1992). It was first discovered in the Bayou du Chien by Webb and Sisk (1975, reported as *Etheostoma squamiceps*), but it was not recognized as a distinct species and described until 1992 (Page et al. 1992). It can be differentiated from the other members of the *E. squamiceps* complex only by the color and morphology of the dorsal fins of breeding males *(*Page et al. 1992). The relict darter is unique in that the second dorsal fin of each breeding male has two equal branches per ray that are tipped with small white knobs.

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

The relict darter is endemic to the Bayou du Chien watershed in Fulton, Graves, and Hickman counties, Kentucky. At the time of listing in 1993, the species was known from only nine sites in the basin (Webb and Sisk 1975; Warren and Burr 1991; Warren et al. 1994). Later work by Piller and Burr (1998) revealed the presence of the relict darter at 16 of 28 sites surveyed, including 6 new sites (Appendix 1). Relict darters were observed at sites on the Bayou du Chien mainstem, South Fork Bayou du Chien, Jackson Creek, Cane Creek, and Sand Creek. Historic collection localities, including two sites near Moscow, Fulton County, Kentucky, remained void of relict darters (Piller and Burr 1998). Our recent surveys (2010-2012) indicate that the species continues to be present within the Bayou du Chien mainstem, Jackson Creek, and downstream portions of other small tributaries. Based on these records, the species occupies at least a 25.7-km (16-mi) reach of the Bayou du Chien mainstem that begins midway between the US 51 and KY 239 bridge crossings in Hickman County and extends upstream to the Pea Ridge Road bridge crossing in Graves County. The most robust and viable population occurs in Jackson Creek (the type locality and best reproductive site for the species), but good numbers can be found in the Bayou du Chien mainstem, especially an 18-km (11.3-mi) reach that extends from just downstream of the US 51 bridge crossing in Hickman County upstream to the confluence with Jackson Creek (Appendices C and D).

The endemism of the relict darter in Bayou du Chien is unique (Warren et al. 1994) as no other fish species shares a similarly restricted distribution anywhere on the northern Gulf Coastal Plain of Arkansas, Kentucky, Missouri, or

Tennessee (Pflieger 1975; Burr and Warren 1986; Robison and Buchanan 1988, Etnier and Starnes 1993). Other species restricted to the northern Gulf Coastal Plain, such as the least madtom (*Noturus hildebrandi*) and firebelly darter (*Etheostoma pyrrhogaster*) are not known from Bayou du Chien and are distributed in at least two other Mississippi River tributaries (Warren et al. 1994).

Warren et al. (1994) speculated that the relict darter was more widespread in the Bayou du Chien basin prior to human settlement, but it was likely restricted to reaches of the watershed lying upstream of the Mississippi River floodplain (presently from about Moscow and upstream). Based on historic and current collection records, they reported that there was no documented evidence that the relict darter ever occurred outside the Bayou du Chien basin (Warren et al. 1994). In fact, they asserted that it was extremely unlikely that additional populations would be found outside the Bayou du Chien basin because of (1) the habitat affinities of the species, (2) the complete allopatry (separation) between it and its closest relatives, (3) the absence of any other species in the *E. squamiceps* complex in Mississippi River tributaries in Kentucky and Tennessee, and (4) the availability of summaries of species composition in these drainages that did not record the relict darter (Etnier and Starnes 1993; Burr and Warren 1986).

e. Habitat:

The relict darter occupies the same general habitat as most members of the *E. squamiceps* complex (USFWS 1994). Adults are concentrated in headwaters of streams in slow flowing pools (0.2-0.6 m/sec), usually over gravel mixed with sand and under or near cover such as fallen tree branches, undercut banks, or overhanging riparian vegetation (Warren et al. 1994; Piller and Burr 1998). At sites along the Bayou du Chien mainstem, the species has shown an affinity for undercut banks and adjacent narrow side channels (2-3 m) underlain by gravel mixed with sand (Warren et al. 1994). Individuals were occasionally collected by Piller and Burr (1998) in mid-stream areas with slow flowing water, but rarely was the species collected in riffle habitats. Piller and Burr (1998) observed the most viable populations of relict darters in areas having gently flowing water, good undercut bank habitat, low silt load, and a suitable quantity of spawning substrata or instream cover. Adults occurred almost exclusively in reaches with appropriate cover and spawning substrata and were absent or in low abundance at sites that lacked these features.

Historically, Bayou du Chien was presumably a free-flowing stream with alternating areas of riffles, runs, and pools; however, a few of these reaches remain because much of the stream has been channelized and converted to a deep ditch with uniform depth, velocity, and substrate (Piller and Burr 1998). Based on previous surveys by Warren et al. (1994) and Piller and Burr (1998) and recent surveys by the Service and its partners (2010-2012), Jackson Creek is the least modified stream in the basin and has the most robust population of relict darters. An abundance of woody debris in Jackson Creek provides a sufficient supply of spawning substrata, and consequently, the stream harbors

the most viable population of the species. Piller and Burr (1998) considered the species to be “abundant” (commonly collected in large numbers, one of the dominant species) at this site (Appendix 1). Piller and Burr (1998) considered the species to be “common” (collected regularly and usually found in moderate to large numbers) at four additional sites that had been only moderately modified in the past. These areas still had adequate quantities of spawning materials and instream cover, and the species was doing well at these sites. At the 11 remaining sites where the relict darter was detected by Piller and Burr (1998), the species was reported as “uncommon” (captured semi-regularly but usually only in small numbers) or “rare” (species captured or vouchered only once or very infrequently). These stream reaches had been radically modified and lacked suitable riparian zones and instream cover. Consequently, these sites supported low numbers of relict darters.

f. Other:

Within the upper reaches of the Bayou du Chien basin, the relict darter is most commonly associated with creek chub (*Semotilus atromaculatus*) and blackspotted topminnow (*Fundulus olivaceus*) (Piller and Burr 1996; Warren et al. 1994). Creek chubs have been reported as the most common fish species in Jackson Creek (Piller and Burr 1996) and could represent a potential predator of the relict darter. Several studies (Barber and Minckley 1971; Newsome and Gee 1978; and Keast 1985) have shown that creek chub individuals greater than 81 mm (3.2 in) SL are predominately piscivores, with as much as 70 percent of the diet consisting of fish (Piller and Burr 1996). Creek chub individuals of this size were observed by Piller and Burr during their study. Direct evidence of predation by largemouth bass (*Micropterus salmoides*) was provided by Piller and Burr (1996), who observed the caudal region of a female relict darter protruding from a bass’ mouth. They determined that the female was partially digested and gravid. Additional frequent associates reported by Warren et al. (1994) in the Bayou du Chien mainstem included the saddleback darter (*Percina vigil*), suckermouth minnow (*Phenacobius mirabilis*), and freckled madtom (*Noturus nocturnus*).

The relict darter’s food habits are unknown, but it is assumed that their diet is similar to other members of the *E. squamiceps* complex (USFWS 1994). As noted by Page (1980), the diet of related darters consists mainly of aquatic insects and small crustaceans. Juveniles feed on copepods, cladocerans, ostracods, and chironomids, while adults feed mainly on amphipods, isopods, chironomids, and caddisflies.

To guard against a potential catastrophic extirpation event in the Bayou du Chien basin, a captive breeding population was established (via Service funding) in the late 1990s by Conservation Fisheries, Inc. (CFI), a non-profit fish propagation facility in Knoxville, Tennessee (Rakes and Shute 1999). Relict darters (19 individuals) were first collected in September 1999 at two sites on Bayou du Chien, Graves County, Kentucky and transported to CFI’s facility. The species proved to be relatively easy to propagate and maintain in captivity. With the exception of an apparent sensitivity to declines in pH, the species was

hardy in aquaria, easily spawned, and the eggs and young amenable to already well developed incubation and rearing protocols. The species also appeared to live far longer in captivity than in the wild (4+ years). Excess adults (a total of 190 individuals) were transferred to Wolf Creek National Fish Hatchery (Wolf Creek NFH) below Wolf Creek Dam, Russell County, Kentucky in February 2001 and April 2002. The project was concluded at CFI in April 2002. In May 2008, the Kentucky Department of Fish and Wildlife Resources (KDFWR) transported 74 excess darters from Wolf Creek NFH to the Bayou du Chien system and released them at three sites in the basin (Matthew Thomas, KDFWR, personal communication, 2008). Wolf Creek NFH continues to maintain 20 adults at their facility (James Gray, Wolf Creek NFH, personal communication, 2008).

2. Five-Factor Analysis

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

Channelization / riparian vegetation removal

The primary threats to the relict darter and its habitat are (1) channelization of the Bayou du Chien mainstem and its tributaries; (2) the removal and lack of shade-producing riparian vegetation; (3) increased siltation associated with poor land-use practices; (4) deforestation and drainage of riparian wetlands; and (5) pollutants originating from municipal wastewater plants or agricultural livestock operations (Warren et al. 1994; Piller and Burr 1998; Jackson Purchase RCD Foundation 2009). Stream channelization is a common land practice that is primarily aimed at controlling flooding, increasing the drainage rate of agricultural land, and maximizing the amount of tillable land (Piller and Burr 1998). Unfortunately, the extensive alteration of habitats within the Bayou du Chien basin has reduced both relict darter numbers and the amount of suitable habitat for feeding and reproduction. Channelization has impacted the Bayou du Chien system by changing stream flow patterns, reducing instream flows (especially during drier periods), decreasing aquatic habitat complexity, and reducing stream bank and floodplain (riparian) vegetation (Piller and Burr 1998). Channelized reaches have higher stream velocities during high flow periods (which leads to channel instability and bank erosion), less instream cover and habitat for aquatic organisms (decreased habitat complexity), less riparian vegetation and correspondingly reduced canopies (reduced shade), and below normal flows during drier periods (Warren et al. 1994; Piller and Burr 1998). The relict darter is extremely susceptible to reductions in riparian vegetation because these losses reduce the amount of woody material that is available for cover and reproduction.

Siltation

The Bayou du Chien basin is extensively farmed and much of the area has been deforested. These alterations and practices result in a fairly high silt load within the Bayou du Chien system that continues to degrade habitat and impact the species. Sediment (siltation) has been listed repeatedly by the Kentucky Natural Resources and Environmental Protection Cabinet (Division of Water) as one of the most common stressors of aquatic communities in the Bayou du Chien

watershed (KDOW 2008; KDOW 2010). The primary sources of sediment were identified as agriculture (crop production), loss of riparian habitat, impacts from hydrostructure flow regulation and modification, dredging, and channel erosion/incision. Several streams within the Bayou du Chien system have been identified as impaired due to siltation and have been included on Kentucky's 303(d) list of impaired waters (KDOW 2008). These streams include Cane Creek (stream kilometer [km] 0 to 8.5 [mile 0 to 5.3]), Little Bayou du Chien (km 0 to 2.1 and 16.1 to 19.8 [mile 0 to 1.3 and 10 to 12.3]), and South Fork Bayou du Chien (km 0 to 11.9 [mile 0 to 7.4]). Sediment has been shown to abrade and or suffocate bottom dwelling algae and other organisms, reduce aquatic insect diversity and abundance (the relict darter's prey), and, ultimately, negatively impact fish growth, survival, and reproduction (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fishes, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency.

Drainage of riparian wetlands

With increased agricultural activity in the Bayou du Chien basin over the last century, much of the basin has been cleared and many riparian wetlands have been drained to make additional lands available for farming. This has caused an overall reduction in the groundwater level and base flows within Bayou du Chien and its tributaries. Warren et al. (1994) observed that many small streams in the watershed were completely dry or consisted of isolated pools by the early fall months. These conditions serve to isolate populations and subject both the adults and juveniles to increased pressure from predators (USFWS 1994). Warren et al. (1991) asserted that dispersal of the species upstream of the Jackson Creek area or into many downstream tributaries may be limited by instream flow conditions.

Other Pollutants

In addition to sediment, the Kentucky Natural Resources and Environmental Protection Cabinet (Division of Water) has identified other common stressors (point-source and nonpoint-source pollutants) of aquatic communities in the Bayou du Chien watershed (KDOW 2010). These stressors included iron, lead, excess nutrients, and eutrophication stemming from two suspected sources – municipal point source discharges and agriculture. Three streams, Bayou du Chien (mile 8.8-14.3), Cane Creek (mile 0 to 5.3), and South Fork Bayou du Chien (mile 0 to 7.4), were identified as impaired due to these stressors (KDOW 2008). The impacts of lead and iron inputs are unknown, but nutrient inputs and eutrophication can lead to excessive algal growths and instream oxygen deficiencies that can seriously impact aquatic species, including the relict darter.

Two sewage treatment plants, City of Fulton Treatment Works (KPDES# KY0026913) and Hickman East Sewage Treatment Plant (KPDES# KY0028436), occur within the Bayou du Chien basin and discharge treated wastewater directly into the Bayou du Chien mainstem. (Vicki Prather, Kentucky Division of Water, personal communication, 2008). Their discharge

points are located downstream of areas known to support relict darters, so they likely have little impact on the species.

Other permitted discharges in the Bayou du Chien basin include stormwater permits for SGL Carbon LLC (KPDES# KY0000094), a manufacturer of cathodes in Hickman, Kentucky; two sand and gravel operations, Harold Coffey Construction Company, Inc. in Crutchfield (KPDES# KYG840167) and Ford Construction Company in Water Valley (KPDES# KYG840160); and one clay extraction operation, Boral Bricks Inc., in Fulgham (KPDES# KYG840136). Parameters listed on each of these permits include pH, total suspended solids, oil and grease, and flow. Only the Ford Construction Company discharge has the potential to impact the species because of its location in the Jackson Creek watershed.

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

The relict darter is not believed to be utilized for commercial, recreational, scientific, or educational purposes. When the species was described and listed in the early 1990s, it was suggested that the species' rareness would make it desirable to private and institutional collectors; however, since that time, over-collecting has not become a threat.

c. Disease or predation:

The relict darter is undoubtedly consumed by predators as direct evidence was provided by Piller and Burr (1996); however, there is no evidence that predation is a significant threat to the species. The species has evolved with various predators over thousands of years and has continued to persist within the watershed. Disease is not known to be a threat to the species.

d. Inadequacy of existing regulatory mechanisms:

The relict darter and its habitats are afforded some protection from water quality and habitat degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.), Kentucky's Forest Conservation Act of 1998 (KRS 149.330-355), Kentucky's Agriculture Water Quality Act of 1994 (KRS 224.71-140), and additional Kentucky laws and regulations regarding natural resources and environmental protection (KRS 146.200-360; KRS 224; 401 KAR 5:026, 5:031). The species is also afforded protection by the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq*), which requires federal agencies to consult with the Service when activities they fund, authorize, or carry out may affect a listed species. The Act requires federal permits for any activity that may result in "take" of a listed species.

The relict darter has been designated as an endangered species in Kentucky (KSNPC 2005), but the designation conveys no legal protection. Kentucky law prohibits the collection of the species for scientific purposes without a valid state-issued collecting permit (KRS 150.183), but this regulation provides no protection to the species' habitat. Within Kentucky, persons who hold a valid KDFWR fishing license are prohibited from using listed fish species such as the relict darter as bait (KDFWR 2008).

Despite the limited protection afforded by the laws and corresponding regulations cited above, the relict darter continues to be impacted by poor water quality and habitat degradation resulting from stream channelization, reductions in riparian cover, siltation caused by poor land use practices, and by other nonpoint-source pollutants (see discussion under Factor A above). Existing regulatory mechanisms have been inadequate to protect the species and its habitat from these impacts.

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

The majority of relict darter populations observed by Piller and Burr (1996) were characterized as uncommon or rare, generally consisting of 1 to 23 individuals. This low abundance makes these populations much more vulnerable to extirpation from toxic chemical spills, habitat modification, progressive degradation from land surface runoff (nonpoint-source pollutions), and natural catastrophic changes to their habitat (*e.g*., flood scour, drought). The relict darter's largest and most significant breeding population in Jackson Creek is also vulnerable to stochastic events; a single toxic chemical spill or an extremely dry summer could have devastating effects on population numbers in this stream (Piller and Burr 1996) and could threaten the long-term viability of the species.

The reduced abundance of relict darters observed by Piller and Burr (1998) suggests that these populations contribute little to recruitment and rarely interbreed. This prohibits the natural interchange of genetic material between these populations, and the small population size reduces the reservoir of genetic diversity within populations. This can lead to inbreeding depression and reduced fitness of individuals (Soule 1980; Hunter 2002). It is likely that some of the relict darter populations are below the effective population size required to maintain long-term genetic and population viability (Soule 1980; Hunter 2002).

Climate change has the potential to increase the vulnerability of the relict darter to random detrimental events (e.g., McLaughlin et al. 2002; Thomas et al. 2004). Climate change is expected to result in increasing frequency, duration, and intensity of droughts and storms (Thomas et al. 2004). Severe droughts like the one that affected western Kentucky in 2007 could be intensified in future years.

D. Synthesis

The relict darter is a Kentucky endemic that is restricted to the upper Bayou du Chien basin in Graves and Hickman counties. Based on recent surveys, the species occupies an approximate 30.5-km (19-mi) reach of the Bayou du Chien mainstem (beginning at about the Deweese Road bridge crossing in Hickman County and extending upstream to the Pea Ridge Road bridge crossing in Graves County) and five of its tributaries (total of 16.5 km or 10.3 mi) - Cane Creek, Jackson Creek, Sand Creek, South Fork Bayou du Chien, and an unnamed tributary. The strongest population (based on mean densities observed in 2011) occurs in Jackson Creek (0.26 darter/m^2), but the species also appears to be stable within portions of the Bayou du Chien mainstem, specifically an 18-km

(11.3-mi) reach that extends from just downstream of the US 51 bridge crossing upstream to the confluence with Jackson Creek (Appendices C and D). Within this reach, mean densities ranged from 0.06 – 0.15 darter/ m^2.

Population estimates calculated by Piller and Burr (1998) ranged from about 9,500 to over 31,200 individuals. Our recent population estimates were similar but were limited to Jackson Creek and the Bayou du Chien mainstem. For Jackson Creek, we calculated a mean population size of 1,526 individuals with a 95% confidence interval of 171 - 2,883 individuals. Mean darter density was 0.26 darter/m^2. The mean population size for the Bayou du Chien mainstem was 13,108 with a 95% confidence interval of 3,854 – 22,362 individuals). Mean darter density was 0.04 darter/ m^2.

Historically, Bayou du Chien was presumably a free-flowing stream with alternating areas of riffles, runs, and pools. Since that time, much of the basin has been channelized and converted to a deep ditch with uniform depth, velocity, and substrate. These areas typically lack the type of cover (e.g., undercut banks, submerged roots, woody debris) that relict darters utilize for sheltering, feeding, and reproduction. This paucity of habitat has limited the distribution of relict darters within the Bayou du Chien mainstem and its tributaries. The largest and most viable populations of the species occur in those areas that have been modified the least (e.g., Jackson Creek), while the least viable populations occur in areas that have been radically modified and lack suitable habitat.

Three of the five listing factors considered by the Service pose threats to the relict darter: the present or threatened destruction, modification or curtailment of its habitat or range; the inadequacy of existing regulatory mechanisms; and other natural or manmade factors affecting its continued existence. The species' habitat and range have been severely degraded and limited by the following: (1) channelization of the Bayou du Chien mainstem and its tributaries; (2) the removal and lack of shade-producing riparian vegetation; (3) increased siltation associated with poor land-use practices; (4) deforestation and drainage of riparian wetlands; and (5) pollutants originating from municipal wastewater plants, resource extraction activities, or agricultural livestock operations. Current regulatory mechanisms have been inadequate to prevent these impacts. Due to the species' limited range and endemic nature, it is also vulnerable to stochastic events such as toxic chemical spills that could cause the extirpation of the species from portions of the Bayou du Chien mainstem or its tributaries. The low abundance of relict darters in some portions of the Bayou du Chien system (especially small tributaries such as Sand Creek) suggests that these populations contribute little to recruitment and rarely interbreed (Piller and Burr 1998). This prohibits the natural interchange of genetic material between these populations, and the small population size reduces the reservoir of genetic diversity within populations. This can lead to inbreeding depression and reduced fitness of individuals. It is likely that some of the relict darter populations are below the effective population size required to maintain long-term genetic and population viability.

Based on the best available information regarding the species' current status and threats, the species continues to be impacted by poor water quality and habitat deterioration resulting from stream channelization, reductions in riparian cover, siltation caused by poor land use practices, and by other nonpoint-source pollutants. Their limited distribution also makes them vulnerable to toxic chemical spills and limits the natural

genetic exchange between and within populations. Because of their restricted distribution and continued vulnerability to these threats, we believe that the species continues to meet the definition of endangered (in danger of extinction throughout all or a significant portion of its range).

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendation: Complete a final recovery plan.

A draft recovery plan was completed for the species in 1994, but a final plan has not been completed. A significant amount of information has become available regarding distribution and threats since the draft plan was completed. A revised plan will assist local and State entities in planning watershed and ecosystem actions to recover habitat needed for eventual downlisting efforts.

Recommendations for specific recovery actions (modified from Piller and Burr 1996):

The following recovery actions should be made a priority over the next five years:

1) Determine habitat preferences of juvenile and larval relict darters. The biology of larvae is unknown, and recruitment estimates are lacking.

2) Determine the level of genetic exchange between populations. Information on darter movements within the basin would provide important information on the long-term viability of the species.

3) Continue to protect, restore, and enhance habitat quality throughout the drainage. Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, etc.) to restore and protect habitats, especially those areas where reproduction has been documented (Jackson Creek). The number of permits granted to snag, channelize, or modify the existing watershed should be limited.

4) Consider the use of artificial spawning substrate (ceramic tiles, etc.) to enhance reproduction. As shown by Piller and Burr (1996), artificial spawning substrate provides an effective management tool that increases nest productivity and presumably enhances survivorship and recruitment.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Relict darter (*Etheostoma chienense*)

Current classification: Endangered

Recommendation resulting from the 5-Year review: No change is needed.

Review conducted by: Dr. Michael A. Floyd, Kentucky Field Office, Frankfort, Kentucky

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Virgil Lee Anchor Date 6/11/13

REGIONAL OFFICE APPROVAL

for Lead Regional Director, Fish and Wildlife Service

Approve Sarah Higgins Date 8/9/13

APPENDIX A: Summary of peer review for the 5-year review of the relict darter (*Etheostoma chienense*)

A. Peer Review Method: The draft document was peer-reviewed by Matthew Thomas, Kentucky Department of Fish and Wildlife Resources (KDFWR), Frankfort, Kentucky; Michael Compton, Kentucky State Nature Preserves Commission (KSNPC), Frankfort, Kentucky; and Dr. Kyle Piller, Southeastern Louisiana University, Hammond, Louisiana.

B. Peer Review Charge: Peer reviewers were asked to read the 5-year review and provide any comments, both editorial and content related. They were not asked to comment on the recommendation regarding listing status.

C. Summary of Peer Review Comments/Report:

Peer reviews were mainly editorial in nature with very minor comments on the content. The only substantive comments regarding content dealt with the omission of a reference, Piller and Burr (1998), and some recommended text changes related to the 2012 survey protocols. The unpublished version of this peer-reviewed article, Piller and Burr (1996), had been cited in the draft five-year review, so the 1998 published paper was added to each of the citations as suggested by the peer reviewer.

D. Response to Peer Review

Peer review comments received were evaluated and incorporated into the 5-year review as appropriate (refer to C above).

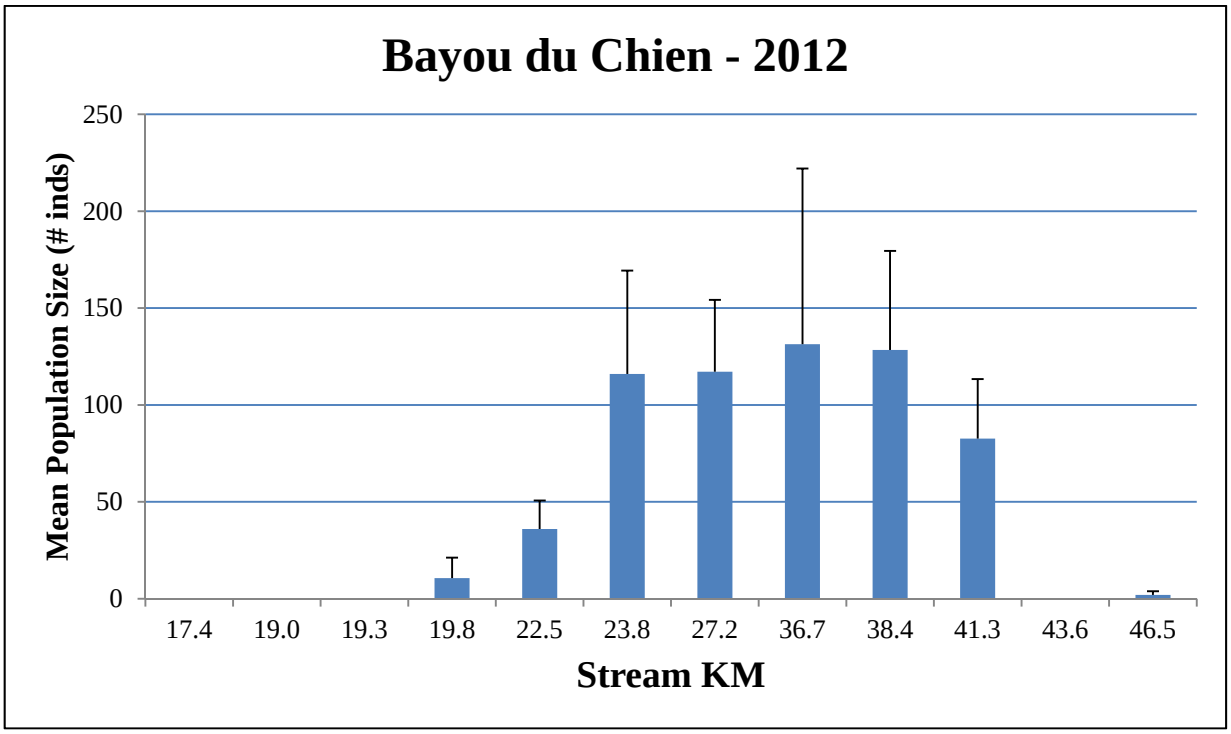
Appendix B. Summary of historical distributional records for the relict darter in the Bayou du Chien watershed (Webb and Sisk 1975; Warren et al. 1994; Piller and Burr 1998); darter abundance based on population estimates by Piller and Burr (1994-1996) and qualitative surveys by KSNPC/USFWS (October 2010).

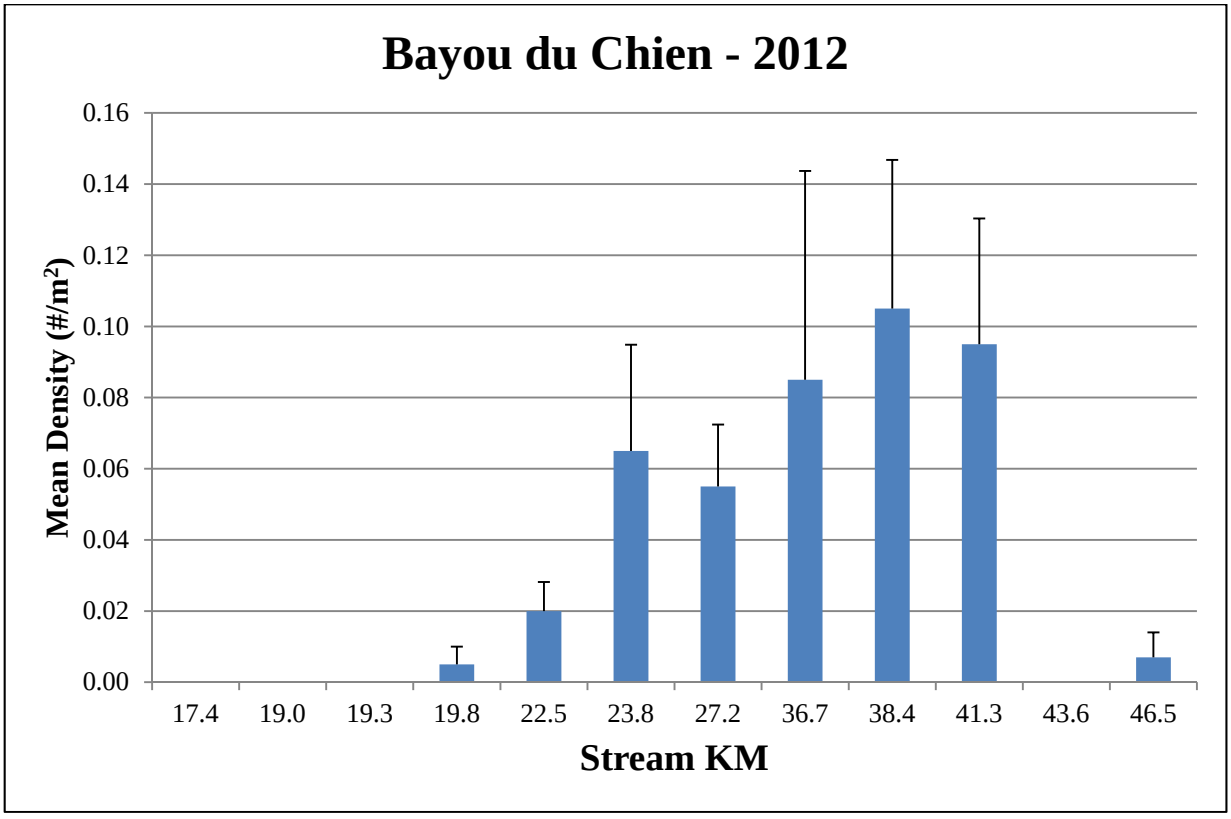
		# Darters		
County	**Stream / Locality**	**1994-96**	**2010**	**Comments**
Graves	Unnamed Trib Bayou du Chien, Rt. KY 94/US 45 (Site 1)	0	0	Nests observed by Piller and Burr (1998) but no darters captured; Habitat modification and degradation acute; no darters observed in October 2010, habitat poor.
Graves	South Fork Bayou du Chien, Kingston Rd (Site 2)	2	2	1 male and 1 female observed by Piller and Burr (1996); suitable habitat and cover limited with sand substrates.
Graves	South Fork Bayou du Chien, Pea Ridge Rd (Site 3)	8	4	Darters not captured by Webb and Sisk (1975) or Warren et al. (1994); instream habitat limited w/ no riparian vegetation.
Graves	Bayou du Chien, KY 2422 (Site 4)	15	2	Stream channelized, entrenched, poor habitat.
Graves	Bayou du Chien, Bard Rd (Site 5)	1	---	Channelization obvious, most modified site observed by Piller and Burr (1998); not surveyed in 2010.
Graves	Bayou du Chien/Jackson Creek/South Fork Bayou du Chien (Site 6)	2	8	Piller and Burr (1996) observed a single male guarding a nest (under a rubber tire); habitat limited.
Graves	Jackson Creek, Lawrence Rd (Site 7)	106	23	Type locality and best population observed by Piller and Burr (1998) and others; Good instream habitat and riparian zones.
Graves/ Hickman	Bayou du Chien, KY 1283 (Site 8)	60	26	Some spawning habitat observed by Piller and Burr (1998); spring influenced site, narrow riparian but good instream habitat (best Bayou du Chien site).
Hickman	Unnamed Trib Bayou du Chien, Rose Road (Site 9)	10	0	Darters not observed by Webb and Sisk (1975) or Warren et al. (1994); Piller (1998) observed spawning habitat and inds in May; channel dry in October 2010.
Hickman	Bayou du Chien, KY 307 (Site 10)	65	4	Darters captured by all previous studies; good habitat present but channel entrenched; Oct 2007 collections by Third Rock Consultants, LLC (Lexington, KY) produced 31 individuals.
Hickman	Sand Creek, KY 307 (Site 11)	0	0	Piller and Burr (1998) observed nests but no darters, species last observed in 1994; intermittent nature of site limits darter production; good habitat available but channel dry in 2010.
Hickman	Bayou du Chien, Davis Rd (Site 12)	49	8	Darters captured by all previous studies, nesting observed by Piller and Burr (1996); channelization evident but habitat available.
Hickman	Bayou du Chien, Howell Rd (Site 13)	7	4	Two nests observed by Piller and Burr (1996); channelization obvious and habitat limited.
Hickman	Bayou du Chien, US 51 (Site 14)	23	2	Most downstream site of occurrence reported by Piller and Burr (1998); channelization obvious and habitat limited.
Hickman	Cane Creek, Howell Rd (Site 15)	20	0	Nests observed by Piller and Burr (1998); stream channelized and habitat limited with silt substrates.
Hickman	Cane Creek, Coolie Rd (Site 16)	7	0	Two unguarded nests observed by Piller and Burr (1998); some habitat available but stream dry in 2010.
Hickman	Bayou du Chien, KY 239 nr Moscow	0	1	Historical site reported by Webb and Sisk (1975); no darters collected by Piller and Burr (1998); 1 ind observed in 2010.

Appendix C. Summary of quantitative relict darter surveys in Jackson Creek (2011) and Bayou du Chien (2012).

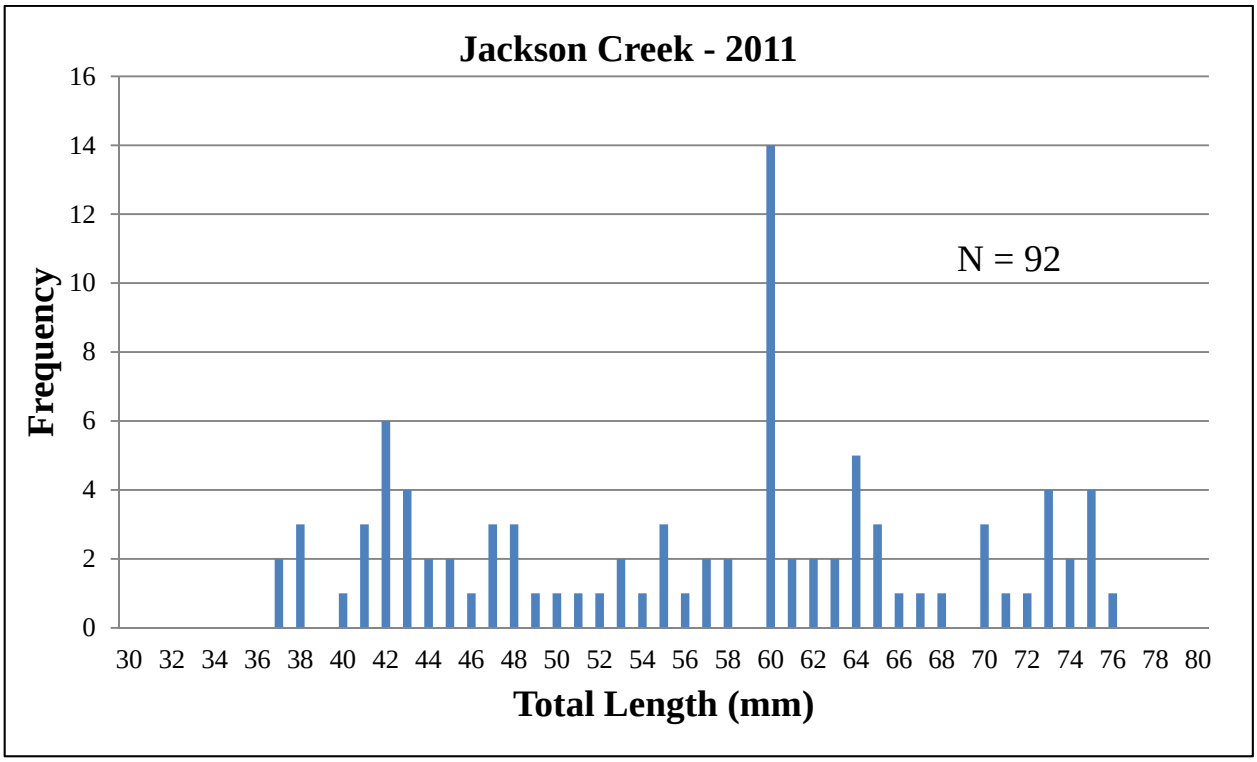
Reach #	Stream km	# Darters Observed	Mean density (#darter/m^2)	Population Estimate
Jackson Creek (2011)				
4	3.7	21	0.30	35.7
3	3.1	41	0.43	138.0
2	2.3	28	0.31	71.3
1	0.8	2	0.02	8.0
Bayou du Chien (2012)				
12	46.5	1	0.01	1.8
11	43.6	0	0.00	0.0
10	41.3	19	0.10	82.7
9	38.4	30	0.11	128.3
8	36.7	19	0.10	131.3
7	27.2	11	0.06	117.2
6	23.8	13	0.07	116.0
5	22.5	4	0.02	36.0
4	19.8	1	0.01	10.6
3	19.3	0	0.00	0.0
2	19.0	0	0.00	0.0
1	17.4	0	0.00	0.0

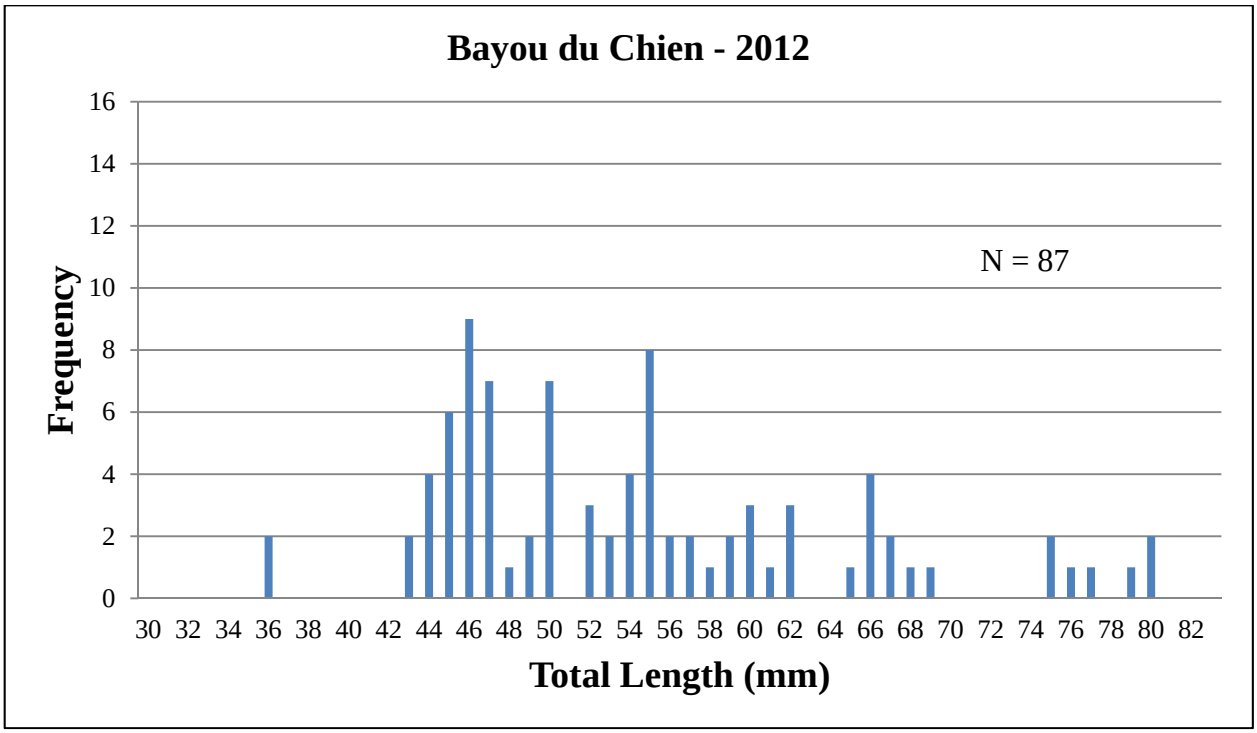
Appendix D. Mean population size (top) and mean density (bottom) of relict darters within 150-m stream reaches located on the Bayou du Chien mainstem (October 2012). Error bars indicate standard error.





Appendix E. Length-frequency histograms of relict darters captured during quantitative surveys in 2011 (Jackson Creek) and 2012 (Bayou du Chien).





Appendix E (continued). Length-frequency histograms of relict darters captured during quantitative surveys in 2011 (Jackson Creek) and 2012 (Bayou du Chien).