

Slackwater Darter (*Etheostoma boschungii*)

**5-Year Review:
Summary and Evaluation**

**U.S. Fish and Wildlife Service
Southeast Region
Mississippi Ecological Services Office
Jackson, Mississippi**

5-YEAR REVIEW

Slackwater darter (*Etheostoma boschungii*)

I. GENERAL INFORMATION

A. Methodology used to complete the review

In conducting this 5-year review, we relied on available information pertaining to historic and current distributions, the life history, and habitats of this species. We also published an announcement in the *Federal Register* requesting information on this species in conjunction with a 90-day not warranted petition finding (70 FR 46465). A 60-day comment period was opened. We specifically solicited information from knowledgeable individuals, agencies, academia and conservation organizations. Our sources include the final rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by Service, State and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. We sent this 5-year review to thirteen different agencies, individuals in academia and non-government conservation organizations for peer review. Only one minor comment was received and it was evaluated and incorporated into this document as appropriate (refer to peer review summary on page 14).

B. Reviewers

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

Lead Field Office – Jackson, MS, Ecological Services: Daniel J. Drennen, 601-321-1127

Cooperating Field Office – Cookeville, TN, Ecological Services, Geoff Call, 931-528-6481, Ext. 213

Cooperating Field Office - Daphne, AL, Ecological Services, Jeff Powell, 251-441-5858.

C. Background

1. **FR Notice citation announcing initiation of this review:** August 10, 2005: 70 FR 46465

2. **Species status:** 2005, 2006, and 2007 Recovery Data Call

The species is decreasing or declining due to increased sedimentation and habitat alterations including urbanization, road/bridge repair and maintenance, and agricultural practices specifically targeted at water removal (the “slack water”) from farm fields during the winter months.

3. Recovery achieved: 2005, 2006, and 2007 Recovery Data Call 1 (0-25% recovery objectives achieved).

4. Listing history

Original Listing

FR notice: 42 FR 45526

Date listed: September 9, 1977

Entity listed: Species

Classification - Threatened

5. Associated rulemakings:

NA.

6. Review History:

90-Day Finding on a Petition to Delist the Slackwater Darter and Initiation of a 5-Year Review. Volume 10, Number 153, pages 46465.

Recovery Data Call: 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, 1998, and 1997.

5-Year Review. July 7, 1987 (52 FR 25522) (In this review, different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors, threats, *etc.* as they pertained to the different species' recovery. The notice summarily listed species and stated that no changes in the designation of these species were warranted at that time. In particular, no changes were proposed for the status of the darter)

U.S. Fish and Wildlife Service. 1984. Slackwater Darter Recovery Plan. Atlanta, Ga. 45 pp.

7. Species' Recovery Priority Number at start of review (48 FR 43098): 8; the degree of threat is moderate and there is a high potential for the recovery of the species.

8. Recovery Plan or Outline

Name of plan: Slackwater Darter Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, GA. 45 pp.

Date issued: March 8, 1984.

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 re-consider the classification of this species with regard to designation of DPSs?
No
- B. Recovery Criteria
 1. Does the species have a final, approved recovery plan? Yes
 2. Does the recovery plan contain recovery (i.e., downlisting or delisting) criteria? Yes
 3. Adequacy of recovery criteria.
 - a. Do the recovery criteria reflect the best available (i.e., most up-to-date) information on the biology of the species and its habitat? Yes.
 - b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)?
Yes. Even though the 1984 Recovery Plan is not formatted with a specific section on recovery criteria as related to the 5 factors, analysis shows the factors are appropriately addressed in the recovery criteria.
 4. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing supporting information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5-listing factors are not relevant to this species, please note that here.

The objective of the plan is to delist the slackwater darter (*Etheostoma boschungii*), and criteria to reach that goal are:

1. Establishment and protection of one or more specific habitat areas (to be determined based on data from Tasks 1.1, 2.1, and 3 out of the recovery plan) in at least three different tributary systems of the Tennessee River where the slackwater darter is known to occur with specific spawning areas protected by purchase or cooperative agreement.

The Slackwater darter is currently known or has been known from the following six tributary streams to the south bend of the Tennessee River: Buffalo River, Lawrence County, Tennessee; Shoal Creek, Lawrence

County, Tennessee; Flint River, Lincoln County, Tennessee and Madison County, Alabama; Limestone Creek, Madison County, Alabama, Swan Creek, Limestone County, Alabama; and the Cypress Creek Watershed, exclusive of Little Cypress Creek, Wayne County, Tennessee and Lauderdale County, Alabama. Recent survey information is inconclusive; however, the slackwater darter has been sporadically collected in the Shoal Creek, Buffalo River, Brier Fork, Cypress Creek systems (McGregor, Geological Survey of Alabama, 2006 pers. comm., Johnston 2002 and Yokley 2001) in Tennessee. In Alabama, slackwater darters have been collected very rarely in the Flint River and Swan Creek systems since 1997 (Mettee and O'Neil 1997, McGregor 2006 pers. comm.) or in tributaries to the Elk River (McGregor 2006 pers. comm.). Powell (2003) collected one individual in Limestone Creek (Madison County, Alabama) in 1999 and recently, G. Dinkins (Dinkins Biological Consulting 2006 pers. comm.) re-collected slackwater darters from Lindsey Creek (Cypress Creek system in Alabama). Johnson (2006) did not find the species in Lindsey Creek nor Cypress Creek and several tributaries off of the Natchez Trace Parkway. No darters were recollected in Threet Creek (Dinkins 2006 pers. comm.).

Lindsey Creek and Threet Creek are protected on the Natchez Trace Parkway and are the only officially protected sites for the species. No sites have been purchased to protect the slackwater darter, nor cooperative agreements established.

2. Collecting data to indicate that the populations are stable or increasing in number.

Information is inconclusive concerning population numbers, the stability or condition of the populations, location of specific sites necessary for spawning, and some basic natural history information that is imperative for determining the level of protection for spawning sites. Surveys since 2001 indicate several historical spawning and breeding habitat sites have been destroyed, damaged or are not being used by slackwater darters (Dinkins 2006 pers. comm., Johnston 2006, Dinkins and Daniel 2003; Johnston and Hartup 2001, 2002) and declines have occurred both in the number of sites being utilized by the slackwater darter and in actual numbers of individuals (Johnson and Hartup 2001, 2002; McGregor, 2004 pers. comm.). However, the slackwater darter is still sporadically present, in both breeding and non-breeding habitats, within the Buffalo River and Shoal Creek (Lawrence County) and Cypress Creek (Wayne County) watersheds of Tennessee (Johnson and Hartup 2001, 2002). Hartup (2005) assessed persistence of the slackwater darter using population viability analysis models at the Dodd site (Wayne County, Tennessee) and calculated that the species should persist at this site for an additional 30 years given current conditions. However, the Dodd site is threatened by

over grazing and trampling of essential emergent vegetation within the small spring fed stream necessary for the slackwater's survival (D. Drennen, U.S. Fish and Wildlife Service, 2005, pers. observ.).

Even though the U.S. Fish and Wildlife Service, the U.S. Park Service (Natchez Trace Parkway), Auburn University, the Geological Survey of Alabama and others, periodically conduct or assist in surveys of imperiled fish species in the Tennessee River Basin, none of the populations of slackwater darters are being measured or monitored annually. cursory surveys of sites indicate that numbers of slackwater darters may be decreasing throughout its range, particularly in Alabama (Drennen, 2005 pers. observ.) and long-term monitoring is needed throughout the range to accurately assess population trends. Efforts are being made to preserve a small population of individuals in captivity. Conservation Fisheries, Inc. has incubated eggs and raised some larvae from slackwater darters from the Dodd site in Wayne County and the Buffalo River in Lawrence County, Tennessee. A minimal population of approximately 50 individuals will be maintained in captivity (Pat Rakes, Conservation Fisheries, Inc., 2006 pers. comm.).

3. Collecting water quality and ecological data to indicate that the environment is suitable and stable or improving.

The primary threat to the slackwater darter is habitat degradation resulting in a decline in water quality. The main causes of habitat and water quality degradation is sedimentation. Sedimentation is believed to have been the main cause for the decline of slackwater darter populations. Excessive sedimentation renders stream and "slack water" (from wet winter months) habitat unsuitable for feeding and reproduction. Sediment wears away and suffocates periphyton (organisms that live attached to objects underwater); disrupts aquatic insect communities, and negatively impacts fish growth, physiology, behavior, reproduction and survivability (Waters, 1995; Knight and Welch, 2001). Increases in sedimentation may increase embeddedness levels that decrease the space between substrate particles and limit the available area and cover for small fish, macroinvertebrates and periphyton (Sylte and Fischenich, 2003). Increased turbidity, suspended sediment concentrations, and bedload sediments have deleterious effects on fish (Kundell and Rasmussen, 1995).

Nephelometric Turbidity Units and Total Suspended Solids (units used to measure sediment in water and abbreviated NTU and TSS respectively) greater than 10 NTU and 15 mg/ L can decrease primary production of sources for fish foods, decrease fish feeding activity and reduce fish species diversity (Henley *et al.* 2000). Sediment sources within the current range of the slackwater darter include activities that disturb the land surface, bankside or stream bottom. Urbanization impacts of the

surrounding habitat within the watershed includes construction and land alteration, bridge and road construction, lack of effective storm water management, maintenance of mentioned activities, ditching to drain areas with shallow groundwater and, in general, changes in stream hydrology and geomorphology. The mentioned are also examples of point and non-point source sediment sources. The amount and impact of sedimentation on the slackwater darter's habitat can be locally correlated with land use practices such as construction, urbanization, road maintenance, and soil type (Drennen, 2005 pers. observ.).

Only one watershed within the range of the slackwater darter, the Buffalo River system, Lawrence County, Tennessee, has been rated high in water quality, fully supporting a designated use by the Water Quality Control Board (Tennessee Rivers Assessment Project 1998). Therefore, more quantitative data is needed on water quality and quantity to determine if the habitat for the slackwater darter is stable, declining or improving, however qualitative information obtained from visual threats and cursory surveys suggest that the habitat of the slackwater darter is declining.

The slackwater darter recovery group formed in August 2005 is composed of four federal, three state of Alabama agencies, academia and non-governmental conservation organizations. More than twenty action items were developed to enhance and contribute to the existing Slackwater Darter Recovery Plan (U.S. Fish and Wildlife Service 1984). Many of those action items are incorporated into the Recommendations for Future Actions (Section IV) of this report.

C. Updated Information and Current Species Status

1. Biology and Habitat

Etheostoma boschungi is a migratory species and has two distinct, but adjacent habitats: non-breeding and breeding. For most of the year, they live in gravel-bottomed pools of creeks where they burrow under piles of old leaf litter or detritus that accumulate where water flow is slow (Wall and Williams, 1974; Boschung, 1976a; 1976b; McGregor and Shepard, 1995). Streams inhabited during most of the year are usually 0.6 to 12 m wide and 0.15 to 2 m deep with high dissolved oxygen levels (8.1 to 12.4 parts per million). In November, *E. boschungi* migrates approximately 3 to 6 km to the breeding habitat. The breeding habitat is shallow water (5 to 10 cm deep), which originates in spring seeps, spring boils or flooded fields that slowly runs off into adjacent streams and forms the "slack water". Once winter rains increase water levels in the streams, the darters have access to these shallow waters. *Etheostoma boschungi* spawn from late February to late March (Boschung, 1976a; 1976b). McGregor (2005 pers. comm.) stated *E. boschungi* is opportunistic and will spawn in vegetation found in stream channels as long as there is enough flowing water to keep eggs oxygenated, even in

landscaped yards, lawns, or similar areas. In April to early May, juveniles migrate to the non-breeding habitat (Boschung, 1976a).

The total population size of the species was estimated in a 1976 study to contain 3,600 individuals (Boschung, 1976a). Boschung determined that the life span of *E. boschungi* is no more than four years and they reach a maximum size of 65 mm standard length (SL) (Boschung, 1976a; Etnier and Starnes, 1993; Page, 1983). Standard length is a typical measurement for fishes and is the distance from the tip of the snout to the hypural plate. Juvenile *E. boschungi* range in size from 10 to 12 mm SL by early April and by the end of their first year are 30 mm \pm 2 mm SL (Boschung, 1976a). Boschung estimated fecundity to be an average of 320 ripe eggs from three specimens (Boschung, 1976a; Boschung and Nieland, 1986).

In 2005, slackwater darter adults were captured at the Dodd Site (Wayne County, Tennessee) and from Buffalo River (Lawrence County, Tennessee). Eggs were recovered and incubated in aquaria, producing larvae. A temporary ark for this species was established and is being maintained by Conservation Fisheries, Inc. In the event of a catastrophic disaster, these fish would be used to rebuild the population (Rakes 2006 pers. comm.).

The Dodd site is an extremely important location for the species. Hartup (2005) assessed persistence of the slackwater darter using population viability analysis models at the Dodd site (Wayne County, Tennessee) and calculated that the species should persist, at this site, for at least 30 years, to approximately the year 2035, if habitat conditions do not decrease and production and recruitment of juveniles into the population continues.

2. Five Factor Analysis

a. The present or threatened destruction, modification, or curtailment of its habitat or range.

The slackwater darter is rare, sporadically distributed, and known from only six tributary streams to the south bend of the Tennessee River in the southwestern Highland Rim of the Nashville Basin in Tennessee and northern Alabama (Boschung and Nieland 1986; Etnier and Starnes 1993).

The slackwater darter is predominately a migratory species and occurs in non-breeding and breeding habitat (Boschung 1979a; Boschung 1979b; Boschung and Nieland 1986). Some populations of slackwater darters may require the non-breeding habitat to flood while other populations at other sites may not (Rakes 2006 pers. comm.), indicating that some populations may not require the traditional “slack water” habitat.

Surveys (Johnson 2006, Dinkins and Daniel 2003; Johnston and Hartup 2002, 2001) indicate several historical spawning and breeding habitat sites have been destroyed or damaged and are not being used by slackwater darters, and that reproductive success and recruitment may be declining. Specifically, 5 of 31 historical sites have been lost or degraded to a point that they no longer provide suitable habitat for slackwater darters

(U.S. Fish and Wildlife Service 1984; Drennen 2003 pers. observ.; McGregor, 2004 pers. comm.). Surveys in 2001, 2002, and 2004 indicate declines in actual numbers of individuals (Johnson and Hartup 2001, 2002; McGregor, 2004 pers. comm.).

Threats to the populations in Alabama and Tennessee have not decreased substantially and, in some cases, have increased. For example, Swan Creek in Alabama has been severely altered in the past decade. Much of the forest alongside the stream has been removed and heavy impacts to the stream bank continue to occur, resulting in channel modifications and the complete loss of in-stream aquatic vegetation. Repair and replacement of bridge crossings on the Natchez Trace Parkway, at sites known to have remnant populations of slackwater darters, have the potential to add significant sedimentation to Lindsey and Threet Creek in Lauderdale County, Alabama (Dinkins and Daniel 2003). Cattle impacts on slackwater darter spawning habitat have increased significantly. For example, the Dodd site in Middle Cypress Creek, Wayne County Tennessee, has been seriously impacted by cattle degrading bank sides and stream bottoms and consuming streamside vegetation (Drennen 2005 pers. observ.). Reducing threats to the habitat must be accomplished through a broad application of measures that focus on protecting stable natural stream channels and riparian zones, and protecting or improving water quality and quantity by reducing sedimentation caused by urbanization and other anthropomorphic occurrences. Effective watershed conservation will reduce habitat threats to the slackwater darter.

The Tennessee Rivers Assessment Project (1998) scored the Buffalo River watershed in Lawrence County, high as fully supporting designated uses assigned to it by the Water Quality Control Board. No other habitats of the slackwater darter in Tennessee and Alabama have official designation, TMDL establishment, or are listed on that states Section 305 (b) lists. Nevertheless, degradation of water quality by sedimentation is believed to be a significant factor in the disappearance of slackwater darter populations from their historic habitat. Based on qualitative information obtained from visual threats and cursory surveys of the species, the current condition of slackwater darter habitat, suggest that the habitat of the slackwater darter may be declining. However, with adequate best management practices such as erosion and sediment control, along with maintaining of winter “slack water” areas, there is a high potential to recover the species.

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

Overutilization is not believed to be a factor in the decline of this species.

c. Disease or predation.

Disease or predation is not known to be a factor in the status of this species.

d. The inadequacy of existing regulatory mechanisms. Current laws and regulations require future federally funded projects that may cause impacts to the

slackwater darter's habitat be assessed concerning need, environmental impact, possible alternatives and costs. The State of Alabama classifies the slackwater darter as endangered (Johnston 2004). Laws and regulations cannot guarantee the least damaging project choice to the watershed. Enforcement of current laws and regulations are essential to the species survival.

e. Other natural or manmade factors affecting its continued existence. No new information in our files suggests that other natural or manmade factors are affecting the species continued existence.

D. Synthesis –Sporadic survey results indicate erratic occurrences of the darters, showing that the species may be experiencing reductions of range and habitat. Additionally, the slackwater darters limited and patchy distributions and small population size render the species vulnerable to random natural or human induced events such as droughts and toxic spills. Long-term and consistent monitoring would accurately assess population trends across species range. However, with adequate best management practices such as erosion and sediment control, along with maintaining of winter “slack water” areas, there is a high potential to recover the species. Therefore, the slackwater darter based on the best available information continues to meet the definition of a threatened species under the Act. See Section IV for additional recovery actions that should be implemented for the slackwater darter based on available resources.

III. RESULTS

A. Recommended Classification:
No, no change is needed.

B. New Recovery Priority Number - no change

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- a. A monitoring plan should be developed and implemented for the slackwater darter.
- b. Current and historical habitats for this species should be assessed, prioritized, and monitored.
- c. Habitat, including spawning and non-spawning, such as seasonal seepages and springs should be inventoried and protected through cooperative agreement, conservation easement, fee title purchase or other means to guarantee safeguards to the water quality, especially turbidity, water quantity, geomorphology, hydrology and other aspects of the habitat and natural history of the species. Specifically, the Dodd site in Wayne County, Tennessee, is very important and should be protected through purchase or conservation easement.

- d. Landowners need to be made aware of the importance of spring seepages, spring runs and “slack water”.
- e. Establish a catalog of potential restoration sites and lands.
- f. Existing regulations and land management laws should be enforced.
- g. Propagation studies and efforts should continue.
- h. All other recovery tasks should be implemented.
- i. Revise the Recovery Plan to reflect new information and threat concerns.

V. REFERENCES

- Boschung, H.T. 1976. An evaluation of the slackwater darter Etheostoma boschungi, relative to its range, critical habitat, and reproductive habitat in Cypress Creek watershed and adjacent stream systems. Auburn, Alabama. U.S.D.A. Soil Conservation Service, 50 pp.
- Boschung, H.T. 1979a. Notes on the distribution and life history of the slackwater darter Etheostoma boschungi (Percidae), Abstract: Association of Southeastern Biologists Bulletin, v. 26, no. 2, pp. 67.
- Boschung, H.T. 1979b. Report on the breeding habits of slackwater darter (Percidae: Etheostoma boschungi) in the Cypress Creek Watershed: Auburn, Alabama. U.S.D.A. Soil Conservation Service, 26 pp.
- Boschung, H.T. and D. Neiland. 1986. Biology and conservation of the slackwater darter, Etheostoma boschungi (Pisces:Percidae). Southeastern Fishes Council Proceedings. Vol. 4, No. 4, 4 pp.
- Boschung, H.T. and R. Mayden. 2004. Fishes of Alabama. Smithsonian Books. Washington, D.C. 736 pp.
- Conservation Fisheries, Inc. 2002. Spring has Sprung. Newsletter No.11, April.
- Conservation Fisheries, Inc. 2002. March Update. Newsletter No.10.
- Dinkins, G. and J. Daniel. 2003. Survey for protected fish in Lindsey Creek and Threats Creek in the Vicinity of the Natchez Trace Parkway, Lauderdale County, Alabama. Dial Cordy and Associates, Inc.
- Etnier, R. A. and W. C. Starnes. 1993. The Fishes of Tennessee. University of Tennessee Press. Knoxville, TN. 681 pp.
- Hartup, W.W. 2005. Assessing Persistence of Two Rare Darter Species Using Population Viability Analysis Models. Masters Thesis. Auburn University. 74 pp.

- Henley, W.E., M.A. Patterson, R.J. Neves and A. D. Lemly. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. *Reviews in Fisheries Science* 8(21): 125-139.
- Johnson, C. 2006. Slackwater Darter Sampling Sites of the Natchez Trace. Report to the U.S. Fish and Wildlife Service. Jackson Field Office. 1 page.
- Johnston, C.E. 2004. Slackwater darter. Etheostoma boschungii. pg 186. in R.E. Mirarchi, , J. T. Garner, M. F. Mettee, P. E. O'Neil, eds. 2004. Alabama wildlife. Volume 2. Imperiled aquatic mollusks and fishes. The University of Alabama Press, Tuscaloosa, AL.
- Johnston, C. E. and W. W. Hartup. 2001. Proximity to spawning habitat and reproductive success in Etheostoma boschungii: how far can darters migrate? Report to Section 6 Program, Montgomery, AL. 7 pp.
- Johnston, C. E. and W. W. Hartup. 2002. Status survey for Etheostoma boschungii, slackwater darter. Report to U.S.F.W.S., Jackson, MS., 12 pp.
- Knight, S. S. and T.D. Welch. 2001. Ecological and Water Quality Effects of the Mississippi Delta Management Systems Evaluation Area on Oxbow Lakes. Proceedings of the Thirty-First Mississippi Water Resource Conference. April 10-11. Water Resources Research Institute. MS State Univ., MS State, MS. pp. 131-143.
- Kundell, J.E. and T.C. Rasmussen. 1995. Recommendations of the Georgia Board of Regents' Scientific Panel on evaluating the erosion measurement standard defined by the Georgia Erosion and Sedimentation Act. Georgia Water Resources Conference. University of Georgia
- McGregor, S. W. and T. E. Shepard. 1992. Investigations of slackwater darter, Etheostoma boschungii, populations in the Cypress Creek, Swan Creek, and Flint River Systems of North Alabama, 1991-92. Geological Survey of Alabama. 48 pp.
- McGregor, S. W. and T. E. Shepard. 1995. Investigations of slackwater darter, Etheostoma boschungii, populations, 1992-94. Geological Survey of Alabama Circular 184. 33 p.
- Mettee, Maurice. F. and Patrick. E. O'Neil. 1997. Status Survey of Protected and Other Species of Uncommon Occurrence in the Southern Bend of the Tennessee River Drainage in Alabama. Geological survey of Alabama. Tuscaloosa, AL. 38 pp.
- Mettee, M. F., P. E. O'Neil, and J. M. Pierson. 1996. Fishes of Alabama. Oxmoor House, Birmingham, AL. 820 pp.

- Mirarchi, R. E. , J. T. Garner, M. F. Mettee, P. E. O'Neil, eds. 2004. Alabama wildlife. Volume 2. Imperiled aquatic mollusks and fishes. The University of Alabama Press, Tuscaloosa, AL. 255 pp.
- Murphy, B.R. and D.W. Willis, eds.1996. Fisheries Techniques. 2nd ed. American Fisheries Society. MD. P 355-358.
- O'Neil, Patrick E., Thomas E. Shepard, Stuart W. McGregor and Maurice F. Mettee.1995 Survey of the Fishes in the Eastern Tennessee River Drainage of Alabama for Rare Species. Geological Survey of Alabama. Tuscaloosa, AL. 31 pp.
- Powell, J. 2003. Response of Fish Communities to Cropland Density and Natural Environmental Setting in the Eastern Highland Rim Ecoregion of the Lower Tennessee River Basin, Alabama and Tennessee, 1999. U.S. Geological Survey. Water Resources Investigation Report 02-4268. Nashville, TN. 48 pp.
- Ramsey, J.S. 1976. Freshwater fishes, in Boschung, H.T., ed., Endangered and threatened plants and animals of Alabama: Tuscaloosa, Bulletin of the Alabama Museum of Natural History, v.2, pp. 53-65.
- Shaw, Kathleen Anne.1996. Phylogenetic Analysis and Taxonomy of the Oligocephalus Group of Darters (Teleostei: Percidae). Diss. Univ. of Kansas. 261pp.
- Spellerberg, I.F. 1991. Monitoring Ecological Change. Cambridge Univ.Press. NY. P. 81-85.
- Sylte, T. and G. Fischenich. 2003. Evaluation of Techniques for Measuring Substrate Embeddedness. Stream Notes. Streams System Technology Center. USDA. CO.
- Tennessee Dept. of Environment and Conservation. 1998. Tennessee Rivers Assessment Project, Summary Report 1998. Nashville. 7 pp.
- U.S. Fish and Wildlife Service. 1984. Slackwater Darter Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 45 pp.
- U.S. Fish and Wildlife Service. 2005. Endangered and Threatened Wildlife and Plants: 90-Day Finding on Petition to Delist the Slackwater Darter and Initiation of a 5-Year Review. Volume 10, Number 153, pages 46465-46467.
- Wall, B.R. and J.D. Williams. 1974. Etheostoma boshungi, a new percid fish from the Tennessee River drainage in northern Alabama and western Tennessee. Tulane Studies in Zoology and Botany 18(4): 172-182.
- Warren, Melvin L., Jr., Brooks M. Burr, Stephen J. Walsh, Henry L. Bart, Jr., Robert C. Cashner, David A. Etnier, Byron J. Freeman, Bernard R. Kuhajda, Richard I. Mayden, Henry W. Robison, Stephen T. Ross and Wayne C. Starnes. 2000.

Diversity, distribution, and conservation status of the native freshwater fishes of the Southern United States. Fisheries, 25(10): 7-31. American Fisheries Society. Bethesda, MD. 23 pp.

Waters, T. F. 1995. Sediment in Streams: Sources, Biological Effects and Control. Am. Fish. Soc. Mono. 7. 251 pp.

Williams, J.D., and H.W. Robison. 1980. Ozarka: a new subgenus of Etheostoma (Pisces:Percidae). Brimleyana 4:149-156.

Yokley, Paul, Jr. 2001. Biological Survey and Assessment of Cypress Creek, Lauderdale County Road Bridge 8 Site for the Slackwater Darter for Project No. Br-3914 LCP 39-92-00. Report to Alabama Dept. of Transportation. 1 pp.

Peer Review Summary

Stuart W. McGregor. Geological Survey of Alabama. Decatur, Alabama.
Minor grammatical and factual errors were corrected

U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of *Ethcostoma boschungii*

Current Classification Endangered

RECOMMENDATION resulting from the 5-Year: No Change

Review Conducted By:
Daniel J. Drennen

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 6/24/08

Cooperating Field Supervisor, Fish and Wildlife Service

Concur Do Not Concur

Signature _____ Date _____

Cooperating Field Supervisor, Fish and Wildlife Service

Concur Do Not Concur

Signature _____ Date _____

REGIONAL OFFICE APPROVAL:

for Lead Regional Director, Fish and Wildlife Service

Approve  Date 6/24/08