Ozark cavefish
(*Amblyopsis rosae* Eigenmann 1898)

Dante Fenolio, Atlanta Botanical Garden

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
Arkansas Ecological Services Field Office
Conway, Arkansas

5-YEAR REVIEW
Ozark cavefish (*Amblyopsis rosae*)

I. GENERAL INFORMATION

A. Methodology used to complete review

This review was completed by the U.S. Fish and Wildlife Service Arkansas Field Office (AFO) in coordination with the U.S. Fish and Wildlife Service's Missouri and Oklahoma Field Offices, the Arkansas Game and Fish Commission, the Missouri Department of Conservation, and the Oklahoma Department of Wildlife Conservation. Literature and documents were researched and reviewed as one component of this evaluation. A data table was constructed at the AFO and sent to cavefish biologists currently involved with on-the-ground conservation activities with a request to complete the table and return it to the AFO Ozark cavefish national lead. A second request was made to the same biologists requesting a list of accomplished and ongoing conservation actions. Recommendations resulting from this review are a result of thoroughly reviewing available literature, ongoing conservation actions, input and suggestions from active cavefish biologists, and the reviewers' expertise on this species. Comments and suggestions regarding the five year review were received from cavefish biologists listed in the peer review section of this document. No part of the review was contracted to an outside party.

Special thanks to private landowners, developers, and communities who with their input, support, and cooperative spirit have made Ozark cavefish conservation efforts successful. To respect private and other landowners' wishes, thereby, not encouraging search of and entry into cavefish locations; cave locations will not be discussed in great detail.

B. Reviewers

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

Lead Field Office – Conway, Arkansas Ecological Services Field Office: David Kampwerth, (501) 513-4477 and Chris Davidson, (501) 513-4481

Cooperating Field Offices – Oklahoma Field Office, Tulsa, Oklahoma: Richard Stark (918) 382-4520; Missouri Field Office, Columbia, Missouri: Heidi Kuska (573) 234-2132

Cooperating Regional Offices – Southwest Region: Wendy Brown, (505) 248-6664; Midwest Region: Carlita Payne, (612) 713-5339

C. Background

1. **Federal Register Notice initiating this review**: September 8, 2006. (71 FR 53127)

2. **Species Status**: Stable (2010 Recovery Data Call) There is no evidence over the past year to indicate population declines. However, 17 of 35 occupied sites have not had a documented cavefish in 6+ years. Sufficient documentation does not exist at this time to indicate whether the loss of these sites is indicative of large-scale population declines or site-specific declines at the extant localities.

3. **Recovery Achieved**: 2 = 25-50% recovery objectives achieved

4. **Listing History**:
   Original Listing
   FR notice: 49 FR 43965
   Date listed: November 1, 1984
   Entity listed: Species
   Classification: Threatened

5. **Review History:**
   Recovery Plan: January 1986; revised November 19, 1989

   Recovery Data Call: 2010, 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, 1998

   Status Reviews:

   The Service conducted a five-year review for the Ozark cavefish 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 change in the fish's listing classification was found to be appropriate.

   Graening, G.O. and A.V. Brown. 1999. Cavefish population status and environmental quality in Cave Springs Cave, Arkansas. Arkansas Water Resources Center. Publication No. 276. 38 pp.

   Romero, A. 1998. Threatened fishes of the world: *Amblyopsis rosae* (Eigenmann, 1898) (Amblyopsidae). Environmental Biology of Fishes 52:434.

Brown, Arthur V. and Todd, C.S. Status review of the threatened Ozark cavefish (*Amblyopsis rosae*). Proceedings, Arkansas Academy of Science. 1987; 41:99-100

Willis, L.D. 1984. Distribution and habitat requirements of the Ozark cavefish, *Amblyopsis rosae*. M.S. Thesis, University of Arkansas. Fayetteville, AR. 35pp.

Jones, Stephen R. and Rimbach, Don. 1983. (ABS) Notes on the status of *Amblyopsis rosae* in southwestern Missouri and water quality data on its habitat. National Speleological Society Bulletin 45: Insert

Brown, A.V., K.B. Brown, L.D. Willis, D.C. Jackson, P.P. Brussock. 1982. Distribution and abundance of the Ozark cavefish *Amblyopsis rosae* (Eigenmann) in Missouri. Final Report submitted to Missouri Department of Conservation. 20pp.

6. **Species Recovery Priority Number at start of review (48 FR 43098):** 8. The "8" indicates a moderate degree of threat and high recovery potential.

7. **Recovery Plan or Outline**
Name of Plan: A Recovery Plan for the Ozark Cavefish (*Amblyopsis rosae*).
Date Issued: December, 17, 1986
Revised: November 19, 1989

II. REVIEW ANALYSIS

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

1. Is the species under review a vertebrate? Yes.

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

3. 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 Plan and Criteria

1. Does the species have a final, approved recovery plan containing objective measurable criteria? Yes

2. Adequacy of recovery criteria

a. **Does the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** No.

Recovery criteria for delisting in the original recovery plan were based on the best available science at the time of listing and may not represent the current status. Ozark cavefish biology and life history are poorly understood with little data available to suggest life span, spawning season, number of eggs, egg survival, mouth brooding or not, population genetics, and various other aspects of its ecology.

b. **Are all of the five listing factors that are relevant to the species addressed in the recovery criteria?** No.

New information from Missouri has revealed Ozark cavefish populations in springs and wells. Recovery criteria do not specifically address protection of springs and wells in groundwater systems that may have no other surface access, albeit protection of recharge areas is addressed in the 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 objective of this plan is to delist the Ozark cavefish by protecting and restoring habitat throughout a significant portion of the historic range. The revised recovery plan indicates that recovery will be achieved when:

1) Nine caves and important components of their recharge areas are protected, and

2) The [Ozark] cavefish population in each of these caves remains stable or increasing as evidenced by systematic observations over at least a 10 year period.

Ozark cavefish are restricted to the Springfield plateau geologic province of the Ozark ecoregion), with current populations spanning eight counties, but historic and rumored accounts acknowledging further distribution in 52 caves in 14 counties (Service 1989).

Populations identified in the listing are being targeted for protection efforts through community outreach, data sharing, and on-the-ground conservation measures. The recharge zones of all recovery caves have either been formally delineated or estimated. Implementation of

conservation actions within these recharge zones is ongoing and has been generally successful. Much work remains to be done within recharge zones, such as developing conservation agreements, land use practice guidance, and encouraging adoption of conservation measures as part of county and community land use plans. Six of the eight sites are protected from human disturbance through the installation of cave gates and fences. Although these sites are protected from human disturbance, vandalism and access to these sites continues, which threatens population viability.

Population goals have been met in Logan (i.e., at least 20 individuals per survey) and Cave Springs (i.e., at least 100 individuals per survey) Caves only over a ten year period. Other caves have generally had less than five individuals per survey visit with 0-2 individuals typically. The majority of sites across the range are unable to meet these goals based on 10-20 years of survey data. One new population has been identified in Greene County, Missouri and of all the sites in Greene County; none have met the survey goal of five cavefish per survey visit.

Additional detail is provided here on progress made under each recovery plan task:

Task 1.1 Determine recharge area for recovery caves

To date, all recovery caves have had their recharge zones either formally delineated using standard dye tracing methods or predicted using aerial photographs, soils/topographic/geology maps, mapped photolineaments (geologic fractures), hydrography, and cave maps where available. Sites with predicted recharge zones were evaluated for dye traces but determined to be extremely difficult to complete and/or cavefish occurrence during monitoring was zero over the last 10 years.

Task 1.2 Determine the extent of continuous habitat in all recovery caves

Of the original recovery caves, only Englebrecht Cave in Oklahoma has not been formally mapped to determine underground cave habitat. Recharge zones have been delineated or predicted, but that only accounts for areas of surface influence and does not account for the entire groundwater basin in which it is believed this species exists. Further assessment of this should occur across the range.

Task 2.1 Obtain conservation agreements with private landowners

Since listing, Logan and Cave Springs Caves were purchased by the U.S. Fish and Wildlife Service (Service) and the Arkansas Natural Heritage Commission, respectively, and specifically managed

for cavefish. Two out of the five Missouri recovery caves are on private land with no conservation agreements in place. Of the other three Missouri recovery caves, one is owned by a regional land trust organization, one by the U.S. Fish and Wildlife Service as part of the Ozark Cavefish National Wildlife Refuge, and one is managed by the Missouri Department of Conservation and all three are managed for Ozark cavefish. One of the Oklahoma caves is private with no management agreement, while the other is owned by the Nature Conservancy and managed for cavefish. Six out of eight recovery caves have management in place for conservation of cavefish.

Task 2.2 Develop and install gates/fences or other methods of limiting access to public and privately owned caves that will not interfere with bats using the caves

Six out of eight sites have had gates and/or fences installed to protect the site from human disturbance. Of these sites, four have had gate vandalism and unauthorized entry. Vandalism and entry at recovery caves continues to be problematic.

Task 2.3 Develop and implement habitat protection strategies for all recovery caves

Specific habitat protection strategies have been developed by the USFWS and their partners for the identified recovery caves and their recharge zones, including development of best management practices (BMP's) for the Cave Springs Cave recharge zone. Both Arkansas caves are publicly owned with entrances and immediately adjacent lands managed under a conservation strategy. This does not include the recharge zone. Missouri has an Ozark cavefish action plan that addresses all caves with general recommendations for the recharge zone and cave entrance, but is not site specific. One of Oklahoma's two recovery caves has a management plan in place developed by The Nature Conservancy, while the other does not. The Nature Conservancy plan does not address site specific recharge zone threats.

Task 2.4 Coordinate with State and private agencies to make spelunkers aware of the harm caving can inflict upon cavefish

Numerous efforts with interested parties have been attempted with moderate success, as evidenced by cave gate and fence vandalism by unknown person(s). Caves with gates or fences are signed indicating closure. Closure of caves for any reason receives scrutiny from locals and the caving community.

Task 3.1 Monitor water quality in recovery caves annually

Annual water quality monitoring has not occurred at recovery caves since listing, but periodic sampling has occurred.

Task 3.2 Monitor cavefish populations in known locations
Population monitoring of cavefish has been accomplished by all three states involved in cavefish conservation and recovery. Most caves are being monitored at two year intervals, while Cave Springs Cave in Arkansas was monitored annually for a short period due to rapidly increasing threats. Several historic sites have been closed due to landowner concerns and development activities. The frequency that historic cavefish sites have been monitored over time is unclear.

Task 3.3 Survey historic and potential Ozark cavefish sites
Monitoring of additional active cavefish sites is ongoing and conducted every 1 to 3 years. Missouri has a list of unconfirmed and potential cavefish sites which they are beginning to evaluate. Missouri has confirmed three new sites since 2000. Arkansas and Oklahoma are pursuing leads which come to their attention with no new locations verified to date.

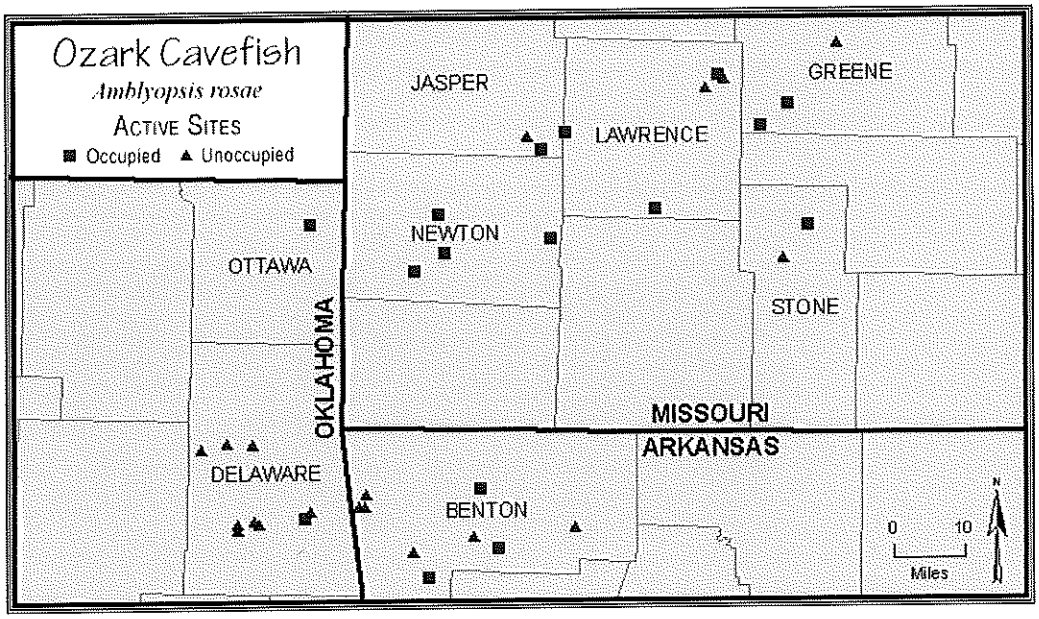
C. Updated Information and Current Species Status

1. Biology and Habitat

a. Spatial distribution, abundance and population trends

Ozark cavefish distribution is restricted to the Springfield plateau geologic province of Arkansas, Missouri, and Oklahoma. The Springfield plateau encompasses approximately 21,000 km^2 and is drained by the White, Neosho, and Osage rivers. Ozark cavefish historically occurred at approximately 52 sites (Brown and Todd, 1987). There are 35 Ozark cavefish caves and wells in Arkansas, Missouri, and Oklahoma that are considered active. These are distributed throughout 8 counties including Benton County in Arkansas; Greene, Jasper, Lawrence, Newton, and Stone Counties in Missouri; and Delaware and Ottawa Counties in Oklahoma. Arkansas has 9 caves, Missouri has 16 caves and wells, and Oklahoma has 10 caves. Of the 35 active sites, 19 have not had a confirmed cavefish sighting for at least six years (Figure 1). Although apparently not occupied for six years or longer, they are considered active sites until studies re-classify them as inactive or historic.

Figure 1. Known Active Ozark Cavefish Sites Across the Range of the Species.



A range-wide estimate of countable cavefish using the most recent population monitoring numbers suggests 213 individuals. It is generally acknowledged that this species is a groundwater obligate and this estimate does not reflect actual numbers. Biologists only count fish in accessible reaches of caves and wells, and are unable to access groundwater conduits where fish may be distributed throughout.

Using monitoring numbers and professional judgment of cavefish biologists for determining population trend, six populations have declined, 19 are undetermined, and 10 are stable. Of populations that are undetermined and/or unoccupied, infrequency of survey and site accessibility issues may be contributing factors. Several active sites in the past were extirpated due to stocking of trout, filling in of cave/sinkhole entrances, contaminant spills, and flooding due to reservoirs.

b. Demographic characteristics

Ozark cavefish are small fish reaching a maximum total length of about 75 mm (about 3 in). Cavefish lack pigment, and appear pinkish-white because their translucent skin reveals blood and organs. Cavefish eyes are vestigial and there is no remnant of the optic nerve in adults. The lower jaw slightly protrudes and the head is flattened. Dorsal and anal fins are located further forward than other fishes and there are no pelvic fins. The caudal fin is rounded and has two to three rows of

sensory pits (papillae) on the lower and upper halves. They can be differentiated from non-cave adapted surface fish in the field by the absence of pelvic fins, pigment, and eyes. It is difficult to distinguish the Ozark cavefish from other cavefish species in the field. Separation of cavefish species is based on differing degrees of cave adaptation. Ozark cavefish differ from the Southern cavefish (*Typhlichthys subterraneus*) and the Northern cavefish (*Amblyopsis spelaeus*) in the absence of a postcleithrum bone, and in the arrangement of cutaneous sense organs, and number of dorsal, anal, and caudal rays (Poulson, 1961; USFWS, 1989; Romero, 1998).

Willis and Brown (1985) found a strong correlation between the presence of Ozark cavefish and the presence of a maternity colony of gray bats, and the presence of cave crayfish and/or the presence of a planktonic or benthic invertebrate community. Graening and Brown (2000a) did not find a correlation between presence of cavefish and presence of bat colonies. Specific breeding habits of Ozark cavefish are unknown, including the number of eggs produced and whether they mouth brood or not. While reproductive season is not documented, Boyd (1997) located 10 mm young of the year cavefish in July in Logan Cave, and Kampwerth (pers. obs. 2005) observed similar sized young of the year in January in Cave Springs Cave. Cavefish diets include small crayfish, isopods, copepods, ostracods, larval salamanders, and young of their own (Poulson 1963).

Bergstrom (1997) conducted genetic analysis of six populations and suggests that based on intraspecific divergence *A. rosae* can be divided into a four subspecies complex. This suggests that each site is a deme with small isolated populations and a degree of cave or watershed endemism which may constitute an Evolutionarily Significant Unit (Noltie and Wicks 2001). Neimiller (pers. comm.), University of Tennessee, Knoxville, found a common haplotype between Logan and Cave Springs Cave genetic samples suggesting contemporary gene flow between populations. Logan and Cave Springs Caves are divided by Osage Creek and approximately 16 km (25.6 miles). Additional work should be conducted to determine population connectivity or isolation, and for a range wide population estimate of all seen and unseen cavefish.

c. Habitat

Cavefish occur in groundwater habitats (the Springfield Plateau Aquifer) within Boone and Burlington Formation limestones, especially in cave streams with chert rubble substrate, and occasionally in wells and sinkholes, and even in the soil phreatic zone (Poulson, 1961, 1963; USFWS, 1986). Woods and Inger (1957) suggest cavefish dispersal occurs through phreatic cave passages. Noltie and Wicks (2001) suggests that due to shale geologic confining units, Ozark cavefish are distributed in near surface and epikarst habitats.

2. Five Factor Analysis (threats)

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

Overall, threats have increased at 14 sites, remained stable at 18, are undetermined at 2 sites, and have decreased at 1 site. Threats at caves/wells and within recharge zones include human entry (discussed under Factor E), agriculture, and urbanization/development.

To respect private landowners wishes and not encourage search of and entry into cavefish locations, locations will not be discussed in great detail. Logan and Cave Springs Caves will be discussed as examples inferring similar threats and issues across the range. Ozark cavefish at these two sites represent approximately 80% of known Ozark cavefish populations.

Agriculture

Of the 35 known sites, agriculture is the primary threat within 17 recharge zones. As lands are converted from forest to pasture, valuable canopy cover for ground temperature regulation and soil moisture retention is lost. Chemicals and fertilizers are applied which rapidly infiltrate during precipitation events into groundwater systems. Graening and Brown (2000) found metals bioaccummulated in surface crayfish removed from Cave Springs Cave and tested. Metals were partially attributed to land application of poultry litter in the recharge zone. Graening further suggests the decline in amphipods and an increase in isopods may be due to an increase in nutrient loads. The Ozarks are a leading producer of poultry in the United States (Natural Resources Conservation Service 2007).

In 1968, 59 percent of the Logan Cave recharge zone was forested, with a decrease to 43 percent by 1987, or a 17 percent decrease. Harvest of mature forest continues to decrease

important surface cover. This 11 square mile recharge zone has approximately 50 hog and poultry facilities (Aley and Aley 1987). As animal production sites generally occur on well drained slopes, potentially high levels of biological and chemical contaminants are rapidly transported, which can influence Logan Cave waters. Metals and other contaminants pass through poultry/livestock and can reach groundwater through land application of wastes.

Urbanization/development

Of the 35 known sites, urbanization/development is suggested as the primary threat in 17 recharge zones. As development increases, areas that allow natural infiltration and percolation are lost or significantly diminished. As impervious surfaces increase, stormwater directed to engineered or natural outlets no longer finds natural groundwater flow paths. Outfalls often lead to adjacent losing streams whereby stormwater is ultimately transported to groundwater. Stormwater runoff contains numerous contaminants including automotive fluids, brake dust, roof tar, pesticides, and herbicides. Stormwater runoff leads to acute pulses of contaminated waters underground, of which some contaminants remain in the system for years. A substantial amount of groundwater contamination occurs from inadequate or un-maintained sewage disposal systems. Increased groundwater withdrawals for home, community, and agricultural use, depletes groundwater and limits available habitat.

Based on aerial photography, in 1990 approximately 2,729 acres or 22 percent of the 15 square mile Cave Springs Cave recharge zone was developed, while in 2006 that number was 6,751 acres or 55 percent, a 33 percent increase. In April 2000, Benton County had a population of 153,406, and in July 2006 a population of 176,756, or a 27.8 percent increase (the highest in Arkansas). The population in Benton County also increased 57.3 percent between 1990 and 2000. Benton County is the only county in Arkansas with Ozark cavefish.

Development within the Logan Cave recharge zone has slowed within the last couple years, although several developments are in the planning process with Service involvement.

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

There is no current evidence to suggest that utilization for any purpose poses a threat. While this was as a threat in the past;

site protection, scientific collection permit regulation and public outreach has reduced this threat. As utilization seems to be negligible, increased recreational caving does pose a threat which is increasing with time (discussed under Factor E).

c. Disease or predation:
Ozark cavefish have few natural predators. Although based on cave use by mammals such as raccoons and invasion of cave streams and springs by surface fishes including sunfish and minnows, predation is possible. No literature is available that suggests disease to be a factor in population viability. Given endemicity of cave species including microbiological communities, there is likelihood that unknown diseases or parasites do exist. Cavefish biologists clean equipment between caves to reduce potential transfer of disease or parasites from one cave to another. With the recent concern in the northeast U.S. of "White Nose Fungus," the Service has developed decontamination procedures for cleaning of cave gear. This threat is something we will continue to monitor.

d. Inadequacy of existing regulatory mechanisms:
While surface streams have water quality standards that are monitored and enforced, groundwater generally does not. Existing regulatory mechanisms regarding the protection of groundwater resources are limited.

Progress is being made by the Arkansas Natural Resource Commission and the Arkansas Department of Environmental Quality (ADEQ) for development of standards for groundwater quantity and quality. ADEQ is supporting groundwater protection strategies through coordination of permit review and comment by the Service prior to issuance. ADEQ conducts groundwater quality monitoring throughout the state, but cavefish sites are not on their scheduled sampling.

Arkansas enacted legislation whereby land application of poultry litter must be conducted under an approved nutrient management plan. That plan is based on soil and vegetative communities present, and recommends distances from water ways that litter should be applied. As enforcement is limited and water quality in caves and wells shows increases in nutrients and metals, it appears adherence to or success of these plans are limited.

Missouri Department of Natural Resources relies on criteria to protect beneficial uses, coordinates with the Service prior to

permit issuance, and is in the process of developing anti-degradation policies whereby no activities would be authorized to lower water quality standards if reasonable alternatives exist.

The Oklahoma Department of Environmental Quality (ODEQ) is responsible for issuing discharge permits for industries and municipalities that dispose of treated wastewater. ODEQ also is responsible for storm water discharge associated with construction and industrial sites. These permits are required for any storm water discharge associated with construction activities that would result in land disturbance equal to or greater than one acre. The Oklahoma Ecological Services Field Office recently completed consultation with the ODEQ on issuance of construction storm water permits in the state. Further coordination with the Service will take place for any proposed activities within a watershed that contains an Ozark cavefish cave. This coordination will facilitate the development and implementation of appropriate BMPs to avoid unnecessary impacts to the cavefish.

Agencies are requiring stormwater management plans under Environmental Protection Agency (EPA) MS4 phase 2 regulations whereby, development activities greater than two acres in size have to develop a stormwater management plan.

The EPA has regulations and standards outlining water quality conditions for groundwater based on human health standards. Regulations and management guidance necessary to protect groundwater from non-point source pollution are not available. The Clean Water Act has improved water quality in many locations and could assist with non-point source pollutants.

Water quality threats are typically non-point source derived and difficult to regulate. In general, regulations are not specific enough to protect, they contain no guidance on how to protect, and enforcement is understaffed.

The Ozark cavefish is listed as endangered by the State of Missouri (Rule 3CSR10-4.111 of the Wildlife Code of Missouri) and certain state statutes are applicable that would not otherwise apply to unlisted species. Missouri Department of Conservation (1999) has developed an Action Plan, similar to a recovery plan, for Ozark cavefish which identifies objectives and strategies to be completed, as staffing allows, no later than June 30, 2010. While no state-level protection is afforded the Ozark cavefish in Arkansas and Oklahoma, the

Ozark Cavefish Working Group is currently (2011) working on a Tri-State Action Plan for the Ozark cavefish.

e. Other natural or man-made factors affecting its continued existence:

Human entry

Of the 35 known cavefish sites, 16 sites are either gated or fenced in an attempt to reduce direct human disturbance. Entry is the primary threat at one site in Arkansas. Six gates/fences have been vandalized with evidence of recent human access. Two of these are receiving continued unauthorized visitation, including Logan Cave which harbors the second largest population. Use at ungated caves is occurring based on evidence such as new paint, foot prints, rafts, and writing found during biannual monitoring surveys. As interest in recreational caving continues to increase, caves supporting cavefish are likely to receive additional unauthorized entry.

Human entry causes increased turbidity decreasing cavefish sensory ability, increases the potential for direct mortality due to trampling of individuals, and can interrupt feeding and breeding behaviors. In the past, removal for scientific purposes and the aquaria trade had a demonstrated impact. This no longer appears to be an active threat as many sites are gated/fenced and signed, and endangered species permits for the take of cavefish are not issued; however, it is something we will continue to closely monitor.

Contaminant spills/accidents

Transportation and pipeline routes can cause sediment and other contaminants to enter the groundwater system. Leaks and spills along roadways do occur and threaten groundwater. A recent spill of 60,000 gallons of gasoline in Benton County Arkansas immediately went underground. Arkansas DEQ conducted well and spring water quality sampling finding no evidence of the fuels' groundwater dispersal. Spill residue may resurface during significant precipitation events whereby it's flushed from karst conduits.

Other Threats

A significant natural gas development activities in the Fayetteville Shale is resulting in millions of gallons of water withdraw/diversion from community water supplies, streams, and wells. Used drilling fluids are land applied and deep well injected. As this activity expands, pipelines and transportation

corridors threatening groundwater habitat also expand. As currently predicted, this activity has limited potential to affect Ozark cavefish.

Recent unpublished water quality studies at springs, wells, and streams in Arkansas, Oklahoma, and Missouri found numerous contaminants at low but detectable levels. Brown et al. (1998) found mean total coliform counts at baseflow of 500 MPN/100ml, and 20,000 MPN/100mL during storm events at Cave Springs Cave. Graening and Brown (2003) consistently found high levels of fecal coliform, excess nutrients, and metals in water, sediment, and tissue samples at Cave Springs Cave. They further identified beryllium, copper, selenium, and zinc at levels exceeding Arkansas MCL's for chronic and acute toxicity to aquatic life.

A U.S. Geological Survey (USGS) study in 2004 found 42 pharmaceuticals and other organic wastewater constituents in selected northern Arkansas stream sites. Most streams in northern Arkansas are considered losing streams that contribute to groundwater. Contaminants identified include antibiotics, antioxidants, detergent metabolites, disinfectants, fire retardants, fragrance/flavor compounds, insect repellant/pesticide, non-prescription drugs, polycyclic aromatic hydrocarbons, plasticizers, solvents, and steroids. Threats from these contaminants as suggested by the USGS include abnormal physiological processes and reproductive impairment, increased incidences of cancer, the development of antibiotic-resistant bacteria and plasmid transfer, and the potential increased toxicity and carcinogenic activity of the chemicals and mixtures of the constituents.

Bidwell (2007, unpublished data), University of Oklahoma, found a range of organic wastewater compounds in Ozark cavefish waters in Arkansas and Oklahoma during a study conducted in 2006 using polar organic chemical integrative samplers and semi-permeable membrane devices. Probable sources of contaminants include wastewater treatment facility discharges, septic systems, land application of livestock litter and biosolids, agricultural chemicals, homeowner application of chemicals, and other unknown sources. Although levels were generally low, pharmaceutical and wastewater constituents presents a concern until more is known about possible effects on cave fauna.

3. Conservation Measures

There is new relevant information regarding implementation of conservation measures that benefit the Ozark cavefish. Arkansas, Missouri, and Oklahoma have completed various conservation measures necessary for cave and recharge zone protection. Two site specific examples are described below from Arkansas, while examples from Missouri and Oklahoma are summarized.

Logan Cave, located on National Wildlife Refuge lands was evaluated under the Comprehensive Conservation Planning process in 2008 (Service 2008), and is currently (December, 2010) undergoing a biological review. Goals and objectives for Refuge lands are based on the needs of subterranean fauna including Ozark cavefish. A recent effort focused on cave radio work delineating the extent of cave passage on adjacent private lands. Data were successfully collected, analyzed, and immediately shared with the landowner and the Benton county planning board to aid in decision making for a hazmat storage site close to identified cave passages. Efforts are focused on landowner outreach within the recharge zone. The Service met with the Benton County road department about road improvements, discussed nutrient management and litter application with poultry growers, established a working relationship with adjacent landowners to the Refuge, funded the installation of a permanent water quality monitoring station, installed a new cave fence and gate, and continue population monitoring efforts. The Nature Conservancy with funding from the Service, installed upgrades to problematic septic tanks, and studied habitat quality and pollution effects. As this area is prime development real estate, diligent involvement in the county planning process and review of permits is paramount to continued conservation within this recharge zone.

The Cave Springs Cave system has had numerous conservation measures conducted successfully since listing. These include acquisition of the cave entrance and 15 acres by The Nature Conservancy with transfer to the Arkansas Natural Heritage Commission and a recent donation of 42 acres through AFO negotiation with developers that included lands immediately over cave passages and along the primary losing stream that contributes water to the cave stream. This recent donation earned three developers the U.S. Fish and Wildlife Service Regional and National Directors Conservation Awards. In 2005, a new easement was granted to the Arkansas Natural Heritage Commission for a bat friendly fence at the cave entrance. That project and land acquisition was completed in 2005. Land above

the known cave passages have been planted with trees in an attempt to convert agricultural field back to forested lands. Groundwater dye trace studies were conducted to determine the potential surface groundwater area of influence, with data used to establish the corridor for an interstate highway which completely avoided the recharge zone.

In 2004, a large partnership was established with numerous agencies, communities, private landowners, engineering firms, attorneys, and academia coming together to develop a mechanism for guidance to conserve groundwater while supporting community growth. One outcome was the development of a document entitled "Community Growth Best Management Practices for Conservation of the Cave Springs Cave Recharge Zone" (Service 2005). This document outlines recommendations for development and construction activities within the delineated recharge zone including establishing conservation zones, stormwater management recommendations, general construction BMP's, and guidance for water and sewer line installation. This document was approved by members of the partnership and subsequently adopted as planning ordinance in the community of Cave Springs. Other communities have yet to adopt the recommendations, although they direct permit requests to the AFO for review prior to approval. Developers and private landowners are implementing conservation measures necessary for the protection of groundwater in the recharge zone.

Through a lengthy informal consultation, a large chlorinated community water line was evaluated for threats and conservation measures were applied to reduce potential risk. In 2007, a dye study was conducted by the city of Rogers wastewater treatment facility to determine if contaminants found during recent water quality work at the cave originated from the plant. Results of this study showed no connectivity to Cave Springs Cave. Continued population monitoring is occurring with members of the Arkansas aquatic threatened and endangered species' team.

Landowner relations at other Ozark cavefish caves and within their respective recharge zones are beneficial. Ownership changes frequently due to land prices and development activity. As development and community growth activities are proposed in recharge zones, many are reviewed by the AFO in coordination with the Arkansas Department of Environmental Quality and/or communities. Conservation measures are being applied, including conservation zone establishment and stormwater management techniques.

Additional conservation efforts in Arkansas:

- development of draft Cave Safe Harbor agreement
- BMP's for Fayetteville Shale Natural Gas activities
- development of BMP's for the Ozark National Forest Plan (Karst)
- developing draft Forest Industry karst BMP's
- conducting educational programs ranging from elementary through college level, holding public meetings with Audubon Society, Ozark Society, canoe club, cave clubs, boy scouts, church groups, statewide attorneys meeting, engineering organizations, and real estate organizations
- leading cave trips for groups discussed above
- and establishing a relationship with Arkansas Highway and Transportation Department whereby recharge zones are considered in development activities.

Conservation efforts in Oklahoma include:

- cave gate and fence installation and monitoring
- survey and monitoring of cavefish populations
- delineation of recharge zones
- land management in coordination with landowners, TNC, and the Ozark Plateau National Wildlife Refuge
- invasive species control within the recharge zone
- coordination with the city of Tulsa and Land Legacy to develop riparian and groundwater protection projects
- water quality studies including pharmaceutical and wastewater compounds
- purchase of caves by TNC
- coordination with the Army Corp of Engineers, the Federal Energy Regulatory Commission, and Grand River Dam
- Authority on reservoir effects and cave gate maintenance
- coordination with local caving organizations to build and monitor cave gates, and map caves to determine land use activities over known cave passages
- and coordination with the Cherokee Nation on survey efforts and management of caves and recharge zones.

Conservation efforts in Missouri include:

- establishment of an Ozark cavefish working group and an Ozark cavefish action plan (MDC 1999)
- consistent monitoring of existing sites
- intensive search for new cavefish locations
- highway realignment based on cavefish recharge zone
- studies

- installation and maintenance of cave gates and fences
- installation of riparian and livestock exclusion fences
- protective well capping where cavefish are found
- pollutant removal from sinkholes in recharge zones
- replacement of failing septic system documented as contaminating an active cavefish site
- provide incentives for implementing groundwater protection practices in recharge zones
- site specific water quality monitoring
- site acquisition and easements
- recharge delineation studies
- cave mapping
- hazard identification and assessment
- creation and distribution of educational articles
- development of outreach materials including coffee mugs, magnets, stickers, and place mats
- public outreach including fair booths, youth programs, and local watershed committee involvement
- holding public meetings for specific caves and recharge zones
- contact landowners with over 10 acres of land in recharge zones through targeted mailing of Ozark cavefish specific information
- apply for and receive grants targeting cavefish conservation actions
- receiving Landowner Incentive Program grant for Ozark cavefish biologist
- grant obtained for easements and long term protection of sensitive areas
- numerous landowner contacts via mailings, phone, and in person
- install selected BMP's to protect groundwater quality and karst habitats within known recharge zones
- and identify two new Ozark cavefish sites based on landowner contacts.

Conservation activities are ongoing and widely applied across the range of Ozark cavefish.

D. Synthesis

At the time of listing, only eight populations were identified for protective measures. Of those sites, only two have met population goals and none have met the goal of all lands within the recharge zone being protected. Ozark cavefish are consistently seen at 16 of the 35 known sites. Cavefish have not been seen at 19 of the 35 sites in six or more years. The top four

sites based on the most recent monitoring counts, include Cave Springs Cave with 123, Logan Cave with 43, Kellhofer's Cave with 12, and a Nature Conservancy cave in Oklahoma with 7 individuals, with Cave Springs and Logan Caves alone representing approximately 80% of all countable Ozark cavefish. The other 12 occupied sites are represented by counts of 1-2 individuals typically, although higher counts have occurred. Although counts are generally small, they are distributed throughout the Ozark cavefish historic range and may be reflective of typical population densities. While it is impossible to determine accurate historic distribution and site locations, recognized historic and rumored sites are being evaluated when landowner permission is acquired. These efforts led to the discovery of three new sites in Missouri since 2000. Diligent effort is focused on locating new sites as well as protecting existing populations and their recharge zones. As groundwater quality and quantity is influenced by increasing population growth in the Ozarks, cavefish conservation efforts targeted at this threat are essential to achieve species recovery.

As urbanization and development are identified as the primary threat within 17 recharge zones, it is critical to establish cooperative partnerships with city and county officials and others with responsibility for planning and development to ensure conservation practices are considered as communities grow. Attendance and active participation at city and county planning board meetings are required for successful conservation measures to be developed in cooperation with these entities. Once conservation practices are identified with interested parties, it is necessary to encourage and support adoption into city and county planning ordinances. For long term protective measures to be effective, city and county ordinance have to specify conservation measures necessary for protection of groundwater through appropriate land management recommendations. One measure might be a required increase in green space to include conservation zones around losing streams, springs, sinkholes, and cave entrances which are the most sensitive features in a recharge zone. Ball fields, trails, other community amenities, and stormwater management concepts could be developed in this green space. The Service and other regulating agencies must cooperate so that notification of and response to permitted activities are coordinated. Establishing common ground between community growth and necessary conservation requires cooperative partnerships between private landowners, communities, interested parties, and agencies.

Unmanaged stormwater runoff poses a significant groundwater contamination threat that can be reduced with site specific management practices. As established development and agricultural activities have limited ability for modification, communities and their partners need to continue development and implementation of guidelines for post

construction stormwater management. New development projects must manage their site's stormwater runoff to reduce the threat to groundwater. This benefits cavefish conservation, the communities that drink groundwater, and private landowners who use it for home, farm, and ranch purposes.

Water quality monitoring and studies targeted on effects from pharmaceuticals and other contaminants should occur as potential risks are identified for Ozark cavefish. Cavefish sites where water quality studies have been conducted show the presence of pharmaceuticals and other contaminants. It is unclear what effects these have on reproduction, recruitment, and survival of cavefish. A recent agreement between the Pharmaceutical Research and Manufacturers of America, the Service, and the American Pharmacists Association should help protect the nation's fish and aquatic resources from improper disposal of medication. The campaign informs people how to safely dispose of medicines and highlights the environmental threat. Additional studies should focus on methods for wastewater treatment facilities, as pharmaceuticals are inappropriately discarded or pass through humans, livestock, and waste water treatment facilities.

Since private landowners are probable owners of unknown Ozark cavefish sites, public outreach, information sharing, and relationship building must continue in order to locate unknown or historic sites. Given limited public lands within the range of Ozark cavefish, if additional populations are found, they likely will occur on private lands. Contacts must be made in person, often with assurances that location information will not be shared with the general public, and there will be limited governmental oversight and no land takes. Many private landowners are cautious of agencies and therefore don't acknowledge sites, but much of this concern can be overcome with agreements, and honest open communication. When private landowners recognize that cavefish are not a liability but an asset in the conservation of groundwater, they often want to assist with conservation efforts. Private landowners are conscientious and concerned with issues surrounding groundwater. Greater effort must be focused on contacting, establishing trust, and building relationships with private landowners.

Additional outreach and information sharing should focus on spelunkers and organized caving clubs. There are approximately 615 members of the National Speleological Society in Arkansas, Missouri, Oklahoma, and many independent spelunkers. These groups and individuals visit thousands of sites each year and have knowledge of rumored, historical, and other potential cavefish sites. Given site endemicity of cave species, including microbiological communities, the caving community is encouraged to clean equipment between caves in order to reduce potential

cave to cave transfer of unknown species. Once introduced into other cave systems, the effect although initially unapparent could pose a significant threat to cave species including cavefish. A recent threat to bats called "white nose syndrome" is considered transmittable by cavers and decontamination procedures have been developed and distributed.

As knowledge of cavefish life history is negligible, the scientific community and our partners need to consider methods to study cavefish without harming individuals, populations, or habitat. An understanding of how and when cavefish spawn, whether they mouth brood or not, general population ecology can aid in conservation and recovery efforts. Developing methods for propagation and establishing a conservation population should occur while population numbers are generally stable.

Ozark cavefish is still threatened by potential risks to water quality and quantity associated with urbanization and other land use development activities, a lack of knowledge regarding the species life history and ecology, potential indirect effects to the species life history and ecology posed by "white nose syndrome" effects to bat populations, trespass and vandalism, and trampling either by inadvertent researchers or spelunkers; therefore we believe Ozark cavefish still meets the definition of threatened as defined by the ESA.

III. RESULTS

A. Recommended Classification:

The status of the Ozark cavefish should remain unchanged. However if results of a subsequent five year review continue to demonstrate rapid urbanization and agricultural development within the recharge zones, groundwater quality and quantity data show further impairment, no additional cavefish sites are found and there is a loss of current sites, the cavefish should be considered for elevation to endangered status.

B. New Recovery Priority Number 5c

The degree of threat to Ozark cavefish caves and recharge zones is high as urbanization and development increase, lands are converted for agricultural purposes, and caving as a recreational activity increases. Recovery potential is low because of the increase in and limited ability to reduce existing threats from urbanization, the difficulty with which conservation actions are implemented, and the predicted increase in the Ozark human population. Furthermore, as the biology of Ozark cavefish and its groundwater habitat are poorly understood, recovery of this species will remain problematic. "C" was added to the new recovery priority number as this species is in conflict with construction, development, and other forms or economic activity.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

1. As the majority of community and agricultural development activities have no federal nexus, it is imperative that the Service and its partners establish cooperative relationships with city councils, planning boards, quorum courts, county commissioners, tribes, and others involved in the economic development of communities and their growth.

2. Establish trust and relationships with private landowners as the likelihood of future discovery exists mostly on private lands.

3. The recovery plan should be revised to reflect current knowledge, refine reclassification criteria, re-define delisting criteria, and accurately address the five factors.

4. Determine life history characteristics of Ozark cavefish.

5. Determine importance of gene flow between individual populations.

6. Research use of mucous samples for genetic analysis.

7. Establish methodology for the propagation of Ozark cavefish.

8. Conduct tissue analysis of non-sensitive species, and sediments in caves for contaminants and metals.

9. Continue and expand water quality monitoring, including pharmaceuticals and other contaminants.

10. Determine occurrence and accurate status of sites where cavefish have not been found within at least the last 5 years.

11. Continue monitoring of the groundwater basin within the Springfield plateau for potentiometric surface and water quality.

12. Evaluate alternatives whereby incentives are offered to cooperating private landowners, developers, and communities.

13. Investigate and install security measures at caves. These may include pressure plates, cameras, sensors, data loggers, and cave stewards.

14. Ascertain methods for Ozark cavefish population enumeration throughout

the Springfield Plateau by sampling groundwater portals (i.e.: wells, springs, etc.) for cavefish. Development of a model may prove beneficial in this effort.

15. Investigate alternatives to land application of litter within recharge zones and educate landowners on appropriate setbacks from sensitive karst features and appropriate timing of land application when applying nutrients to soil.

V. REFERENCES

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Ozark cavefish (*Amblyopsis rosae*)

Current Classification Threatened

Recommendation resulting from the 5-Year Review

_x__ No change is needed

Review Conducted By: David Kampwerth and Chris Davidson, Conway, Arkansas Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 12-13-2010

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, Fish and Wildlife Service, Southeast Region

Approve_____ Date_____

Cooperating Regional Director, Fish and Wildlife Service, Southwest Region

_____Concur _____ Do Not Concur

Signature_____ Date_____

Cooperating Regional Director, Fish and Wildlife Service, Midwest Region

_____Concur _____ Do Not Concur

Signature_____ Date_____

APPENDIX A: Summary of peer review for the 5-year review of **Ozark cavefish (*Amblyopsis rosae*)**

Reviewers:
Internal
Richard Stark, Fish and Wildlife Biologist
U.S. Fish and Wildlife Service

Steve Hensley, Ozark Plateau National Wildlife Refuge Manager
U.S. Fish and Wildlife Service

Heidi Kuska, Fish and Wildlife Biologist
U.S. Fish and Wildlife Service

Carla Mitchell, Acting Holla Bend National Wildlife Refuge Manager
U.S. Fish and Wildlife Service

External
Mark Howery, Wildlife Diversity Biologist
Oklahoma Department of Wildlife Conservation

Rick Horton, Ozark Cavefish Recovery Team Leader
Missouri Department of Conservation

Blake Stephens, Fisheries Management Biologist (Ozark cavefish)
Missouri Department of Conservation

Chris Vitello, Ozark Unit Fisheries Field Chief
Missouri Department of Conservation

Dr. Doug Novinger, Resource Scientist-Aquatic Systems
Missouri Department of Conservation

Brain Wagner, Nongame Aquatics Biologist
Arkansas Game and Fish Commission

Douglas Fletcher, Chief of Stewardship
Arkansas Natural Heritage Commission

A. Peer Review Method: A draft copy of this 5 year review was sent to the above knowledgeable individuals for their review and comment. These biologists were selected based on their current active involvement with Ozark cavefish conservation efforts and/or knowledge with this fish.

B. Peer Review Charge: Reviewers were charged with providing a review of the document including any other comments and/or additions appropriate to include. We did not ask peer reviewers to evaluate our status recommendation.

C. Summary of Peer Review Comments/Report: Reviewers responded verbally and/or by email. All reviewers thought the information in the draft 5-year review of Ozark cavefish provided to them was accurate. They did provide some additional references and recommendations that were incorporated into the 5-year review as appropriate.

D. Response to Peer Review: Recommendations from the reviewers were included in the document. These consisted primarily of references to new surveys and/or additions to the species status and/or recommendations for future actions.