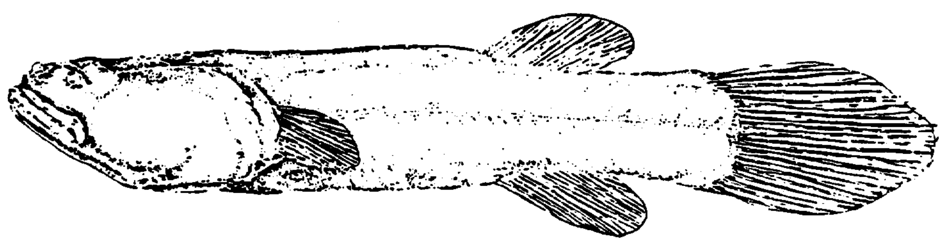
84-11-01-001

Ozark Cavefish



Ozark Cavefish by Kent Bonar

Recovery Plan

A RECOVERY PLAN FOR THE

OZARK CAVEFISH

(*Amblyopsis rosae*)

Prepared By

L.D. Willis, Jr.

For

U.S. Fish and Wildlife Service

Southeast Region

Atlanta, Georgia

Approved: ______________________
Director, U.S. Fish and Wildlife Service

Dated: ______________________

Disclaimer

This is the completed Ozark Cavefish Recovery Plan. It has been approved by the U.S. Fish and Wildlife Service. It does not necessarily represent official positions or approvals of cooperating agencies, and it does not necessarily represent the views of all individuals who played a role in preparing this plan. This plan is subject to modification as dictated by new findings, changes in species status, and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities, and other constraints.

ADDITIONAL COPIES ARE FOR SALE FROM:

Fish and Wildlife Reference Service
Informatics General Corporation
6011 Executive Blvd.
Rockville, Maryland 20852
301/770-3000
1-800-582-3421

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

PART IV: APPENDICES

LIST OF FIGURES

Page

PART I: INTRODUCTION

Background

The Ozark cavefish, *Amblyopsis rosae* (Eigenmann), is a member of the family Amblyopsidae, a group of fishes distributed through the eastern half of the United States between 32° and 39° latitude (Fig. 1). Although the family is widespread within this area, the troglobitic members appear to have limited distributions. The family, commonly known as cavefishes, contains six species (see Putnam, 1872; Packard 1886; Eigenmann 1898, 1909; Cox 1905; Woods and Inger 1957; Cooper and Kuehne 1974) which show varying degrees of cave adaptation. The following list is in order of the most cave adapted species to the least according to Poulson (1961, 1963). *Amblyopsis rosae*, *Amblyopsis spelaea*, and *Typhlichthys subterraneus* are all obligate cave forms (troglobites). *Chologaster agassizi* is a facultative cave form (troglophile), and *Chologaster cornuta* is a non-cave form (epigean). The sixth member of the family *Speoplatyrhinus poulsoni* was discovered after Poulson's work (Cooper and Kuehne 1974). This species has also been listed as threatened by the Fish and Wildlife Service.

The Ozark cavefish (*A. rosae*) was first reported from specimens collected from caves near Sarcoxie, Missouri by Garman (1889) as *Typhlichthys subterraneus*. Eigenmann (1898) set it apart as a new genus and species, *Troglichthys rosae*, and Woods and Inger (1957) moved it to the genus *Amblyopsis*.

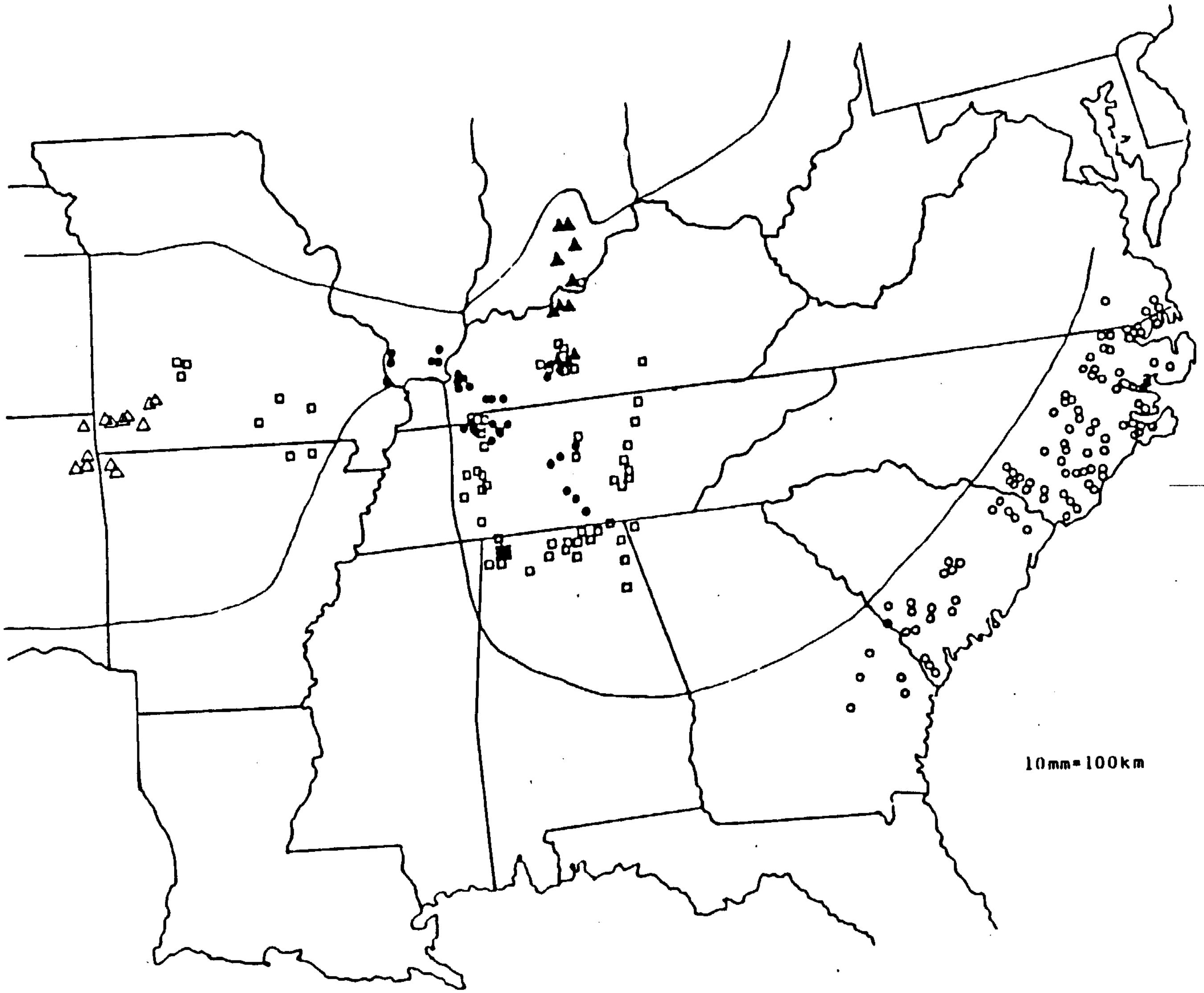


Figure 1. Published distribution records of the Amblyopsidae: Amblyopsis rosae (△), Amblyopsis spelaea (▲), Typhlichthys subterraneus (□), Speoplatyrhinus poulsoni (■), Chologaster cornuta (○), Chologaster agassizi (•). Modified from Lee et al, 1980-et seq.

Amblyopsis rosae is one of the most cave adapted members of the family, and one of the most cave adapted vertebrates known. This specialization to the cave environment may limit its ability to recover from even minor perturbations. This, combined with the shrinking of its known range, was the basis of the Ozark cavefish being officially recognized as a threatened species by the U.S. Department of the Interior, effective December 3, 1984 (49 FR:43965-43969).

Description

The Ozark cavefish attains a maximum total length of about 50 mm. The head is dorsoventrally flattened with a slightly protruding lower jaw. The fish have no pelvic fins and the dorsal and anal fins are located more posterior than usual. The caudal fin is rounded and has two to three rows of sensory papillae on the upper and lower halves. The fish lack melanophores and appear pinkish-white. They have vestigial eyes with no remnant of the optic nerve in adults. The Ozark cavefish is not readily distinguished from the southern cavefish in the field. These species and the northern cavefish differ mainly in details of their osteology and the arrangement of cutaneous sense organs. The species are greatly different in their degree of cave adaptation and this is the basis for their separation as species.

Distribution

The distribution of *A. rosae* is entirely within the Springfield Plateau of the Ozark Highlands (Fig. 2). The Springfield Plateau embraces approximately 21,000 km^2 and is drained by the White River on the south and east, the Neosho River (Arkansas River Basin) on the west, and Osage River (Missouri River Basin) to the north. The Boone and Burlington Limestones are the principal cave bearing formations in the area. Historically, the Ozark cavefish occurred in 24 caves in nine counties with unconfirmed reports in 52 caves in 14 counties. Willis and Brown (1985) searched 180 sites for the Ozark cavefish in 14 counties and found cavefish in 14 caves in six counties of the Springfield Plateau of southwest Missouri, northwest Arkansas, and northeast Oklahoma. An additional population was discovered in 1986. This represents all of the known populations of *A. rosae* existing at the present. The Ozark cavefish has apparently disappeared from a large portion of its historic range. Because many parts of these caves are unexplorable and many more caves exist than have been discovered, there is a possibility that more populations do exist.

Status

Population trends have not been documented for *Amblyopsis rosae*. However, from repeated museum collections in which every fish seen was collected and from field notes of Tom Poulson, some idea of past populations can be obtained by comparing these numbers with those seen by Willis and Brown (1985). Appendix A summarizes the known population data.

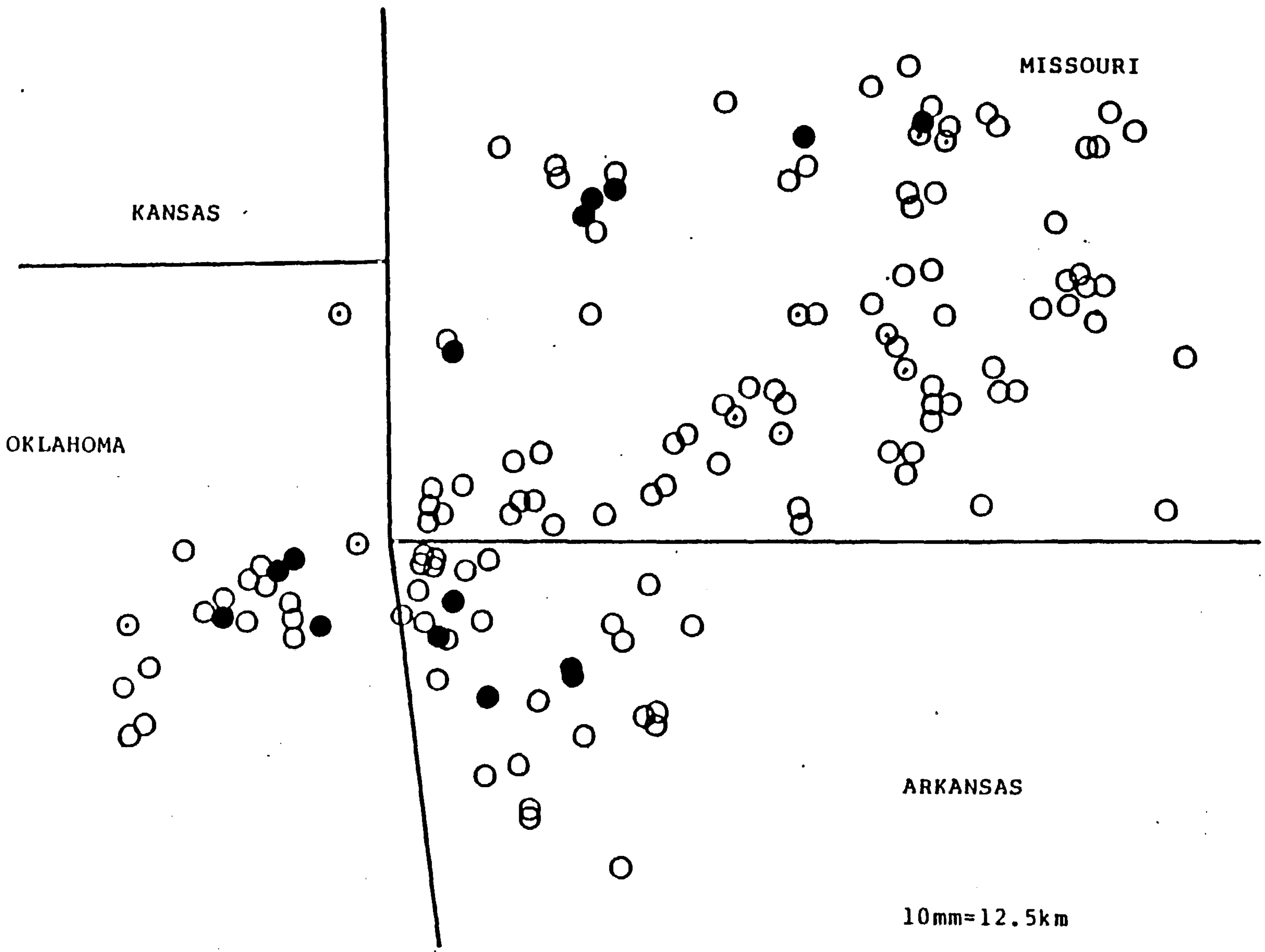


Figure 2. Distribution of the Ozark cavefish Amblyopsis rosae in the southwestern Ozark Mountains. Caves which have been reported to contain fish are indicated (○) and those with current populations (●), from Willis, 1984.

It appears that the population at Cave Springs, Arkansas, has been able to recover from extensive exploitation in the form of collections made over a long period of time. Based on field surveys and museum records, Cave Springs represents by far the largest population, making up approximately 68 percent of the world population. This location is atypical of most. Because the populations of *A. rosae* have been separated for such a long time (Willis & Brown 1985), there is little reason to assume the different populations respond in the same way to perturbations. The Cave Springs population is seemingly adapted to a high carrying capacity situation while the populations in other locations are probably adapted to lower population sizes. These populations may not be able to withstand proportionately as great a perturbation as the Cave Springs population.

Habitat Requirements

Caves are unique ecosystems, often characterized by stable environmental conditions that must rely upon the outside world for energy. All of the caves with fish contain some comparatively large source of allochthonous energy, usually bat guano or washed or blown leaf litter. Plankton is the primary food of *A. rosae* (Poulson 1963); however, isopods, amphipods, crayfish, and salamander larvae are also eaten. There is also some evidence they feed directly on bat guano. Analysis of the relative abundance of food in select *A. rosae* habitats is summarized in Appendix B. Physical-chemical analyses indicate that most of the caves tested contained relatively high water quality. This data is summarized in Appendix C.

Noteworthy is the low dissolved oxygen in some caves which contain fish. The ability of A. rosae to withstand the low dissolved oxygen may be an adaptation to ground water conditions which often tend to be anoxic and is also related to its low metabolic rate, an adaptation to the low food supply of the cave environment. The highest concentration of food in caves is on the bat guano piles. In order to exploit this food source, the fish must be capable of withstanding the conditions immediately below the bat roosts. The bat guano increases nutrient concentrations and the biological oxygen demand in the water.

Limiting Factors and Potential Causes of Decline

Factors which are most likely to limit or cause the decline of cavefish populations include 1) destruction of the habitat; 2) collecting; 3) disturbance by amateur spelunkers; and 4) lack of reproduction.

Destruction of the habitat poses a serious threat to A. rosae. Some caves have been intentionally sealed shut by landowners, inundated by reservoirs, or dried up by lowered water tables. Sealing cave entrances shuts off the food supply of the cave ecosystem. One cave with historical records of cavefish is now under a parking lot. Results of water table fluctuations are not known, but even rising water levels result in drastic habitat alterations.

Collection by scientists and curiosity seekers presents a very real cause of concern for this species. Due to its uniqueness, and a lack of a fear response which makes it easy to capture, the fish may be easily exploited. Because the fish is now listed as threatened and therefore protected by Federal law, much of this problem will hopefully be controlled.

Water quality is threatened in the western portion of the Springfield Plateau by the toxic metals in the area of old lead and zinc mines of the tri-state mining district, and in the east by the City of Springfield, Missouri. However, any cave within the known range is potentially susceptible to intentional land application or accidental spills of toxic chemicals. The agricultural practice of land application of organic wastes resulting from poultry and swine production apparently poses little, if any, threat to cavefish as long as wastes do not contain significant amounts of pesticides.

Commercial exploitation of caves has destroyed or damaged a considerable amount of habitat in the past, but further threats of this nature do not seem imminent at the present time because most of the caves with extant populations of cavefish would not be good commercial caves. Vandalism often results in superficial damage to caves that primarily lessens their aesthetic value (writing on walls, littering, etc.) rather than their ecological productivity or stability. Of more concern is the disturbance caused by large numbers of recreational cavers using many of these caves. Caves are very stable systems and the organisms have specialized to make the best use of this stability. The activities of even a single experienced caver can cause tremendous disturbance in these caves. It is not unusual to see 3-10 groups of 3-20 cavers exploring a single cave in any given weekend. Only a few of these cave explorers are vandals; however, they may unknowingly be doing great damage to the cave ecosystem. This disturbance may interrupt breeding of cavefish and the gray bat, *Myotis grisescens*, and increased activity may increase the cavefish's need for food in a food scarce environment.

For long-term protection of the cavefish, it is important that disturbance be controlled so that it does not disrupt the commensalistic association between *A. rosae* and the gray bat. Commensalism is defined as the association of two species in which one is benefitted (the cavefish) and the other is neither benefitted nor harmed (the gray bat). Gray bats are listed as endangered by the Department of the Interior, and are the primary colonial bat in *A. rosae* caves. *A. rosae* is dependent on a species which is itself endangered. Of the 14 caves which Willis and Brown (1985) found to contain fish, five still contain bat colonies, while six contain evidence of past use by bats. The success of the Ozark cavefish as a species may be directly related to the success of the gray bat. Bats cannot tolerate disturbance during the daylight hours or during the entire winter hibernation period, and disturbance of maternity colonies can result in unsuccessful rearing of young. This type of disturbance may result in bat mortality, abandonment of the cave, and in the loss of an energy source for the cavefish.

Little is known about what is required for successful reproduction of these fish. It is suspected that spawning is triggered by spring floods and the return of bats, whicn increase the food supply. Gravid females have been observed in Logan Cave during the month of January when the bats are gone and the lowest flows of the year are recorded. In many caves, the greatest obstacle may be finding potential mates at the right time. Poulson (1961) estimated only 20 percent of the mature females spawn in a given year.

Recovery Actions Already Accomplished

The best aid to the recovery of the Ozark cavefish is to protect its habitat. This has been attempted in two instances by the purchasing of caves by state agencies. The State of Arkansas has obtained Cave Springs Cave which contains the largest cavefish population, and Missouri has purchased Turnback Creek Cave which contains a small population, but has considerable habitat. With appropriate management, these caves will significantly add to the protection of this species.

A. Recovery Objective

Objective: To remove the Ozark cavefish from threatened status by assuring that populations are restored and protected throughout a significant portion of the historic range. Recovery will be achieved when: (1) the following caves and their recharge areas are protected: Cave Springs and Logan, Arkansas; Twin and Engelbrecht (Inglebrook), Oklahoma; Ben Lassiter, Kellhofers, Sarcoxie, and Turnback Creek, Missouri; (2) the cavefish population in each cave remains stable or increasing as evidenced by observation of no less than 100 per survey visit in Cave Springs and no less than 20 per survey visit in each of the other caves over at least a ten year period; and (3) at least three additional cavefish populations are confirmed and protected (as above) in Greene County, Missouri (to restore historic distribution), with a minimum sighting threshold of five cavefish each per survey visit.

B. Step-down Outline

1) Study local and regional hydrological patterns.

1.1 Determine recharge area for recovery caves (i.e. Logan, Twin, Engelbrecht, Ben Lassiter, Kellhofers, Sarcoxie, and Turnback Creek caves).

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

2) Provide protection and management for recovery caves.

2.1 Obtain conservation agreements with private landowners.

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.

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

2.4 Investigate the feasibility of introducing bats into the uncolonized recovery caves.

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

3) Develop and implement a monitoring program.

3.1 Annually monitor water quality in recovery caves.

3.2 Monitor cavefish populations in known locations and survey possible locations.

3.3 Monitor other possible cavefish sites.

C. Recovery Outline Narrative

1) Study local and regional hydrological patterns. The protection of the aquifers and the recharge zones of cavefish habitats is crucial to the protection and recovery of the cavefish. Most caves have few safe sites where a fish could avoid even a short period of pollution. In limestone sinkhole areas characteristic of the Ozark cavefish's range, the introduction of pollutants into the aquifer is very easy. Lowering the water table from water utilization or changes in surface drainage may also impact cavefish by significantly reducing the amount of available habitat.

1.1 Determine recharge area for recovery caves (i.e. Logan, Twin, Engelbrecht, Ben Lassiter, Kellhofers, Sarcoxie, and Turnback Creek caves). Protection of the cave aquifer requires the delineation of the recharge area or the area that supplies water to the aquifer. Once the recharge area is known, the specific actions necessary to protect the aquifer can be developed.

1.2 Determine the extent of continuous habitat in all recovery caves. Interconnecting caves are known to occur. Any caves which may connect with the recovery caves must be identified and protected so the recovery cave will be protected. Dye trace studies used to delineate recharge areas may also identify connecting caves. Any such cave systems should be protected as a recovery cave.

2) Provide protection and management for recovery caves. Cavers may impact cavefish by direct disturbance as well as indirectly by affecting the food supply. Food is scarce in caves and cavefish have infrequent opportunities to feed. Disturbance by cavers causes them to use energy and stirs up silt which may compromise their food finding abilities. If the cave houses a bat colony, disturbance may cause the bats to abandon the cave or not reproduce. The larger cavefish populations seem to occur in caves where bat guano is the main energy source.

2.1 Obtain conservation agreements with private landowners. Private landowners are often very protective of caves on their property. An agreement to protect the cave and its inhabitants is frequently in the best interest of the cavefish and the landowner. If necessary, conservation agreements should be purchased on the recovery caves. This should include not only the cave opening but also the entire cave recharge zone. In most cases, such agreements would consist of not using sinkholes and disappearing streams for landfills and disposal of farm chemicals. In addition, the landowner should be encouraged to contact appropriate officials in case of chemical spills or other potential hazards to the cavefish. The most important aspect of these agreements is the education of the local landowners. Most of the people in these areas do not realize the problems associated with dumping garbage into sinkholes. Conservation agreements may be particularly useful at Engelbrecht, Ben Lassiter, Kellhofers, and Sarcoxie Caves.

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. The purchase of a cave may result in the private owner leaving the area or not providing further protection. Having a caretaker on the public payroll is prohibitive. To protect these caves, a gate or fence to exclude cavers but allow bats to use the cave should be developed and installed.

The exclusion of cavers while gray bats are in these caves is critical. The method of exclusion must not interfere with bats using the cave. Twin Cave should be fenced or regated and signs posted to inform cavers of the reason for exclusion. Logan and Cave Springs Caves should be fenced until a suitable gate is developed.

2.3 Develop and implement habitat protection strategies for all recovery caves. An assessment of protection needs should be prepared by the Fish and Wildlife Service and reviewed by biologists working in the field. The assessment should provide recommendations for protecting caves needed for recovery. Methods and alternatives such as easements, acquisitions, use of existing regulations, land exchange, etc., would be evaluated and an appropriate method determined. This should be done after recharge areas are defined and important sinkholes and drainage fields are identified. Special protection plans should be drawn up for each site suggesting the type of gate or fence which should be installed and identifying site specific problems which may be important.

Public ownership can be the best and provides the most permanent protection for a cave system if the cave is well managed. Cave Springs in Arkansas and Turnback Creek in Missouri are already publicly owned. No cave should be purchased without the money also being available to manage it appropriately.

2.4 Investigate the feasibility of introducing bats into uncolonized recovery caves. Select one of the recovery caves and develop a technique to establish a resident bat population. The gray bat (*Myotis grisescens*) will have to be utilized because it is the only colonial bat which is common enough in the area to be used. Evaluate the feasibility of this effort and expand it to other caves as appropriate.

2.5 Coordinate with State and private agencies to make spelunkers aware of the harm caving can inflict upon cavefish. Unintentional harm to cavefish may be prevented by educating cavers. State and private groups can assist in this education by posting signs and printing articles in their publications. Coordinate with the respective groups to develop an educational program for their constituents.

3) Develop and implement a monitoring program. The cavefish population and its habitat should be monitored to document changes or trends as they occur.

3.1 Annually monitor water quality in recovery caves. Water quality in Cave Springs and possibly other caves in Arkansas is monitored periodically by a State agency. A program to annually monitor water quality should be developed for all recovery caves with the respective states. Water quality parameters to be monitored include temperature, dissolved oxygen, pH, turbidity, conductivity, nitrites, nitrates, phosphates, and ammonia, and a scan for pesticides and heavy metals.

3.2 Monitor cavefish populations in known locations and survey possible locations. Cave Springs Cave contains the majority of the estimated Ozark cavefish population. This population should be censused at two year intervals to monitor population trends. Previous census efforts counted approximately 100 individual cavefish in the accessible areas of the cave. The other recovery caves should have such a census to establish a population base and then be censused at three year intervals. Historic sites and potential sites should be surveyed at 5-10 year intervals to determine if the Ozark cavefish has repopulated the cave. Station markers should be established in recovery caves and fish counted from these stations at appropriate intervals.

3.3 Monitor other possible cavefish sites. At three year intervals other possible cavefish sites should be searched for cavefish. This effort should be in the Greene County, Missouri area because this area is where most cavefish extirpations have occurred. The repopulation of this historic range is considered critical to recovery of the Ozark cavefish.

Literature Cited

Cooper, J.E. and R.A. Kuehne. 1974. Speoplatyrhinus poulsoni, a new genus and species of subterranean fish from Alabama. Copeia 2:486-493.

Cox, U.O. 1905. A revision of the cave fishes of North America. Appen. Rept. Comm. Fish. (1904):377-393.

Eigenmann, C.H. 1898. A new blind fish (Typhlichthys rosae). Proc. Indiana Acad. Sci. (1897):231.

Eigenmann, C.H. 1909. Cave vertebrates of America. A study in degenerative evolution. Carnegie Instit. of Wash. Publ. 104:1-241.

Garman, S. 1889. Cave animals from southwestern Missouri. Bull. Mus. Comp. Zool. 17:232.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister and J.R. Stauffer, Jr. 1980 et seq. Atlas of North American Freshwater Fishes. N.C. State Mus. Nat. Hist., Raleigh. i-x +854 pp.

Packard, A.S. 1886. The cave fauna of North America with remarks on the anatomy of the brain and origin of the blind species. Mem. Nat. Acad. Sci. 4:1-156.

Poulson, Thomas L. 1961. Cave adaptation in amblyopsid fishes. Unpub. PhD dissert., Univ. Mich., Ann Arbor. vi + 185 pp.

Poulson, Thomas L. 1963. Cave adaptation in amblyopsid fishes. American Midland Naturalist. 70(2):257-290.

Putnam, F.W. 1872. The blind fishes of Mammoth Cave and their allies. American Naturalist. 6:6-30.

Willis, L.D. 1984. Distribution and habitat requirements of the Ozark cavefish, Amblyopsis rosae. MS Thesis, University of Arkansas.

Willis, L.D. and A.V. Brown. 1985. Distribution and habitat requirements of the Ozark cavefish, Amblyopsis rosae. American Midland Naturalist. 114(2):311-317.

Woods, L.P. and R.F. Inger. 1957. The cave, spring, and swamp fishes of the family Amblyopsidae of central and eastern United States. American Midland Naturalist. 58:232-256.

PART III

IMPLEMENTATION

Priorities in column four of the following implementation schedule are assigned as follows:

Priority one (1) - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority two (2) - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority three (3) - All other actions necessary to provide for full recovery of the species.

LIST OF ABBREVIATIONS

SE	Federal Endangered Species Program
AGFC	Arkansas Game and Fish Commission
ANHP	Arkansas Natural Heritage Program
MDC	Missouri Department of Conservation
ODWC	Oklahoma Department of Wildlife Conservation

Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	Responsible Agency: FWS Division	Responsible Agency: Other	Estimated Fiscal Year Costs: FY 1	Estimated Fiscal Year Costs: FY 2	Estimated Fiscal Year Costs: FY 3	Comments/Notes
I-2	Determine recharge area for recovery caves	1.1	2	7 yrs.	2,3,4	SE	AGFC ANHP MDC ODWC	10,000	10,000	10,000	One cave per year.
I-2	Determine the extent of continuous habitat in all recovery caves	1.2	2	7 yrs.	2,3,4	SE		-	-	-	Secure assistance of local caving groups in mapping these caves.
A-2	Obtain conservation agreements with private landowners	2.1	2	ongoing	2,3,4	SE	AGFC ANHP MDC ODWC	1,000	1,000	1,000	One agreement per year.
M-5	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	2.2	1	continuous	2,3,4	SE	landowner AGFC ANHP MDC ODWC	2,500	2,500	2,500	One cave per year.
M-3	Develop and implement habitat protection methods for all recovery caves	2.3	2	continuous	2,3,4	SE	AGFC ANHP MDC ODWC				Cost cannot be determined until habitat protection needs are known.
M-2	Investigate the feasibility of introducing bats into uncolonized recovery caves	2.4	3	continuous	2,3,4	SE					A method to accomplish this task is not available at this time.
O-1	Coordinate with State and private agencies to make spelunkers aware of the harm caving can inflict upon cavefish	2.5	2	continuous	2,3,4	SE	AGFC ANHP MDC ODWC	2,500	2,500	2,500	

Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency FWS Region	Responsible Agency FWS Division	Responsible Agency Other	Estimated Fiscal Year Costs FY 1	FY 2	FY 3	Comments/Notes
M-3	Annually monitor water quality in recovery caves	3.1	2	continu-ous	2,3,4	SE	AGFC ANHP MDC ODWC	4,000	4,000	4,000	
I-1	Monitor cavefish populations in known locations and survey possible locations	3.2	2	continu-ous	2,3,4	SE	AGFC ANHP MDC ODWC	2,500	2,500	2,500	
I-1	Monitor other possible cave-fish sites	3.3	3	continu-ous	2,3,4	SE	AGFC ANHP MDC ODWC	-	-	-	Enlist aid of local cavers to report cavefish sightings.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES*

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

* (Column 1) - Primarily for use by the U.S. Fish and Wildlife Service.

PART IV

APPENDICES

Appendix A: Longterm population data from Cave Springs Cave, Arkansas, and Ben Lassiter Cave, Missouri. TU - Tulane University Museum, New Orleans, LA. UMMZ - University of Michigan Museum, Ann Arbor, MI.

? - Questionable Locality Data

* - Unknown Area Surveyed

** - Incomplete Survey

*** - Complete Survey of Transversible Cave

Cave	Date	#Observed	#Collected	Source
Cave Spring, Arkansas	*9/55		30	TU#10719
	*11/55		27	TU#11602
	*10/57		55	TU#16561
	*10/57		16	TU#16723
	**7/58	50	0	Poulson
	**8/59		6	Poulson
	*10/59		16	TU#TU22675
	*8/60	93	10	Poulson
	**10/67		6	Poulson
	*8/68		3	Poulson
	***8/69	78	5	Poulson
	***3/83	97	0	Willis
	***3/84	100	0	Willis
Ben Lassiter Cave	?*8/24		8	UMMZ#64947
	?*9/40		4	UMMZ#151466
	**7/58	6	3	Poulson
	***8/59	11	5	Poulson
	***8/60	7	5	Poulson
	***10/67	14	7	Poulson
	***8/68	5	3	Poulson
	***8/69	15	5	Poulson
	**3/83	3	0	Willis
	***9/83	6	0	Willis
	**1/84	0	0	Willis
	**2/84	0	0	Willis

Appendix B: Food Availability in Selected Caves from Willis, 1984.

Macroinvertebrate colonization of ca. 2g leaf pack traps after 24-60 days in select caves (number/leaf pack).

Cave Name	Taxa			
	Caecidotea	Chironomidae	Amphipoda	Miscellaneous
Bear Hollow Cave	0.0	0.0	0.0	0.0
Wilson's Cave	0.5	0.0	0.5	0.5 salamander
Jail Cave	0.0	0.0	0.0	0.0
Cave Springs Cave	6.5	0.0	0.0	0.0
Ben Lassiter Cave	15.5	0.5	0.0	0.0
Bella Vista Trout Cave	0.0	0.0	0.0	0.0
Civil War Cave	1.5	0.0	0.0	0.0
January-Stansberry Cave	0.0	1.0	0.0	0.0
Fantastic Caverns	0.5	0.0	0.0	0.5 snail
Turnback Creek Cave	8.5	0.0	0.0	0.0
Twin Cave	0.0	0.0	0.0	0.0
Logan Cave	4.5	1.5	0.5	0.0

Relative abundance of plankton from select caves (number/l).

Cave Name	Taxa				
	Cladocera	Harpacticoida	Cyclopoida	Miscellaneous	Total
Bear Hollow Cave	0.11	0.16	0.04	0.28	0.59
Wilson's Cave	0.05	0.00	0.00	0.13	0.18
Jail Cave	0.10	0.00	0.00	0.00	0.10
Cave Springs Cave	0.42	0.00	0.00	0.05	0.47
Ben Lassiter Cave	0.20	0.00	0.00	0.00	0.20
Bella Vista Trout Cave	0.04	0.00	0.00	0.00	0.04
Civil War Cave	0.24	0.00	0.11	0.05	0.40
January-Stansberry Cave	0.00	0.00	0.00	0.00	0.00
Fantastic Caverns	0.00	0.23	0.03	0.00	0.06
Turnback Creek Cave	0.00	0.00	0.00	0.00	0.00

Appendix C: General water chemistry of select caves of the Springfield Plateau. Units are as follows: Turbidity = NTU, Temp. = C, FPOM, DO, TOC, Alkyl, Ammonia, Nitrite + Nitrate-N, T-Phosphorus, O-Phosphorus = MG/L, and T-Arsenic, T-Cadmium, T-Chromium, T-Lead, T-Zinc = UG/L, CPOM present =+, CPOM absent =-, from Willis, 1984.

Cave Name	Turbidity	pH	DO	Cond	FPOM	CPOM	TOC	Alkalinity	Temp	Ammonia	NO_2-NO_3	T-Phos	O-Phos	T-Arsen	Cadmium	Chromium	Cooper	Lead	Zinc
Jail Cave	3.0	6.7	3.4	472	15.6	-	25.53	230	12.0	3.8	5.8	0.16	0.10	<5	<0.5	<1	10	2	9
Twin Cave	4.7	6.0	7.2	225	1.2	-	4.56	100	16.0	0.02	1.2	0.02	0.01	<5	<0.5	1	<10	1	< 3
January-Stansberry	3.7	6.0	7.6	50	1.2	-	30.09	90	16.0	0.01	0.8	0.01	0.01	<5	<0.5	<1	<10	<1	3
Cave Sprgs. Ranch	2.7	6.0	6.8	235	1.5	-	13.72	110		0.03	2.3	0.04	0.02	<5	0.9	3	<10	1	62
Logan Cave	-2.6	6.0	7.9	229	2.6	+	8.00	110	15.0	0.01	2.7	0.03	0.01	<5	<0.5	2	<10	<1	< 3
Cave Sprgs, AR	5.9	6.0	6.8	130	0.4	-	57.60	120	14.0	0.01	4.3	0.02	0.02	<5	<0.5	2	<10	<1	< 3
Fish Pond Cave	17.5	6.0	7.8	155	2.8	-	9.61	40	14.0	0.25	8.6	0.16	0.12	<5	<0.5	1	<10	2	5
Bear Hollow Cave	17.0	6.0	8.1	95	2.2	+	24.27	100	14.0	0.01	0.4	0.03	0.02	<5	<0.5	2	<10	1	< 3
Bella Vista Trout	80.0	6.0	7.4	99	2.8	-	37.18	100	14.0	0.06	1.6	0.04	0.01	<5	<0.5	1	<10	<1	3
Civil War Cave	-	6.0	10.6	226	6.6	-	-	70		0.01	6.4	0.03	0.01	<5	<0.5	4	<10	1	5
Rootcave Cave	-	6.0	11.9	232	6.4	-	-	30	17.0	0.01	0.2	0.03	0.01	<5	<0.5	1	<10	3	< 3
Ben Lassiter Cave	12.5	6.5	11.3	310	4.9	+	2.78	50	15.0	0.04	3.4	0.10	0.07	<5	1.8	2	11	2	8
Wilson Cave	-	6.0	11.8	238	3.8	+	-	40	12.0	0.01	4.8	0.02	0.01	<5	<0.5	<1	<10	1	9
Sarcoxie Cave	-	6.0	11.7	188	3.8	+	-	30	13.0	0.02	5.3	0.01	0.01	<5	<0.5	<1	<10	<1	< 3
Killhofer's Cave	-	6.0	10.3	200	11.8	+	-	70	12.5	0.02	3.2	0.01	0.01	<5	<0.5	<1	<10	1	3
Coolbrook Cave	-	6.0	9.2	282	3.8	-	-	75	13.0	0.05	3.2	0.03	0.01	<5	<0.5	2	<10	1	9
Turnback Creek Cave	-	6.0	10.7	129	2.8	-	-	80	15.0	0.03	2.2	0.02	0.01	<5	<0.5	<1	<10	2	< 3
Fantastic Caverns	15.5	6.0	11.0	485	4.6	+	11.28	115	13.0	0.02	2.6	0.04	0.01	<5	<0.5	<1	<10	2	< 3
Smallin's Cave	-	6.0	9.6	220	6.2	-	-	170	13.0	0.03	2.2	0.03	0.01	<5	<0.5	<1	<10	1	8
Minnick's Cave	-	6.0	9.5	302	3.0	-	-	110	13.0	0.02	3.4	0.03	0.01	<5	<0.5	2	<10	1	< 3
Mud Cave	-	6.0	10.5	205	4.0	-	-	50	14.0	0.02	3.9	0.03	0.01	<5	<0.5	1	<10	<1	< 3

Appendix D: List of Caves visited by Willis, 1984 with data including number of times visited, number of cavefish seen, records of fish reported (0 = no report, 1 = rumor, 2 = literature or museum record), number of cave crayfish seen, bat colonies present, water supply (0 = dry or drip pools, 1 = seasonal flow, 2 = constant flow), relative use (-1 = high use, 0 = moderate use, 1 = protection enforced), habitat ranking (equal sum of relative use + water supply + bats + 1 (if crayfish were present) * 1 (if fish were present) and remarks.

Cave Name	Number Visits	Fish Observed	Records of Fish	Crayfish Observed	Bat Colony	Water Supply	Relative Use	Habitat Ranking	Remarks
ARKANSAS									
Logan Cave	10	12	1	2	1	2	-1	4	Very diverse bio.
Cave Springs Cave	4	100	2	0	1	2	1	5	2/3 of cavefish known
Mule Hole Sink Cave	2	4	0	0	0	1	1	3	Probably connected to Cave Springs
Fish Pond Cave	2	0	0	0	0	2	1	3	Large spring
Bear Hollow Cave	4	0	0	0	0	2	-1	1	Large cave/massive disturbance
Bella Vista Trout Cave	2	0	0	0	0	2	1	3	No life seen
Civil War Cave	4	4	1	0	0	2	-1	2	Commercial cave
Rootville Cave	1	0	1	0	0	2	0	1	Large cave
Little Mouth Cave	1	0	0	0	0	1	0	1	
Big Mouth Cave	1	0	0	0	0	0	0	0	Dry
Pregnant Nun Cave	1	0	0	0	0	0	0	0	Good formations
Covington's Cave	1	0	0	0	0	2	1	3	Small spring
Popcorn Cave	1	0	0	0	0	0	0	0	Dry
Lessley Cave	1	0	0	0	0				Small
Dickerson Cave	1	0	0	0	0	2	0	2	Small
No Name Cave	1	0	0	0	0				
Spanish Treasure Cave							-1		Commercial
Crystal Cave	1					0	0		Dry

Cave Name										Remarks
Wonderland Cave	1		0	0	0	0	0	-1		Dry
No Name in Bella Vista	1		0	0	0	0	1	0	1	Many salamanders
Big Ditch Cave		x					2	0	2	Flooded
Hickory Creek Cave	1		0	0	0	0	2	0	0	Normally flooded by beaver
Prairie Creek Cave	1		0	0	0	0	2	0	2	Flooded
Eden's Bluff	1		0	0	0	0	0	0	0	Dry
No Name Cave	1		0	0	0	0	0	0	0	Dry
Fitton Cave	1		0	1	0	0-1	2	0	2-3	Large cave
Cob Cave	1		0	0	0	0	2	-1	1	Small
Eden's Cave	1		0	0	0	0	2	-1	1	Small
Fancher Cave	1		0	1	0	-	2	0	2	
Hogscale Cave	1		0	0	0	-	0	0	0	
Omega Cave	1		0	0	0	-	2	0	2	
T-Cave	1		0	0	0	-	0	0	0	
Cosmic Caverns		x		1	0	-	2	-1	0	Commercial
Crumley Cave	1		0	0	0	-	0	0	0	
Oscar Johnson Cave	1		0	0	0	-	0	0	0	
Pine Creek: upper & lower	1		0	0	0	-	2	-1	0	Tri-level
No Name Cave	1		0	0	0	-	1	-1	0	
Brey Cave	3		0	0	0	0	1	0	1	Small
Cave near Sonora	1		0	0	0	1	0	0	0	Small, nice formations

Cave Name										Remarks
Savoy Cave	4		0	1	0	0	2	1	3	Very tight squeeze with breakdown
Johnson Fish Farm Cave		x	0	1	0	0	2	0	2	Aley reported fish
Parson's Cave	1		0	0	0	0	0	0	0	
No Name Cave	1		0	0	0	0	0	0	0	
No Name Cave	1		0	0	0	0	0	0	0	
No Name Cave	1		0	0	0	0	0	0	0	Fracture
MISSOURI										
No Name Cave	1		0	1	0	0	2	0	2	Flooded
Barnett Cave	1		0	0	0	0	0	0	0	Dry
Hooker's Cave	1		0	0	0	0	1	0	1	Small stream
Burn's Cave	1		0	0	0	0	2	0	1	
No Name Cave	1		0	0	0	0	0	0	0	Dry
Johnson's Well	1	x	-	1	-	-	1	-	-	
Cold Storage Cave	1	x	-	-	-	-	-	-	-	Water supply for owner
Flat Creek Cave	1		0	0	0	0	0	-1	0	Dry
McMurty Spring	1	x	-	0	-	-	2	1	-	Space too small
Hankin's Well	1	x	-	2	-	-	-	-	-	Owner uncooperative
Town Branch Spring Cave	1		0	0	0	0	2	0	2	Small cave
Seasonal Spring	1		0	1	0	0	1	0	1	Dry, owner has seen fish

Cave Name										Remarks
Rockhouse Caverns Cave	1		0	0	0	0	2	-1	1	Historical bat colony, type locality for <u>Typhlotriton</u>
Ash Cave	1		0	0	0	0	0	-1	0	Dry
Crystal Caverns Cave	1	x	-	0	-	-	-	-	-	Commercial cave
Dry Springs	1		0	0	0	0	0	0	0	Dry
Crane Spring	1		0	1	0	0	0	0	0	
Unidentified cave				1						Aley reported fish
Ed Smith Cave	1	x	-	1	-	-	-	-	-	Could not find
Swan Cave	1		0	1	0	0	0-1	-1	0	Dry
Wilson Cave	1	x	-	1	-	-	-	-	-	Owner uncooperative; has seen fish in spring
Atkinson Spring Cave #1	1		0	1	0	0	2	0	2	Aley reported fish
Atkinson Spring Cave #2	1		0	0	0	0	1	0	1	Small cave
Minnick Cave	1		0	1	1	0	2	0	3	Newly opened
Baker Spring Cave				1						
Civil War Cave	1		0	1	29	0	2		3	Water source is a sinking stream
Dutton's Cave	1	x	-	0	-	-	2	-	-	Water supply for owner
Blue Hole Springs	1		0	1	0	0			-	Phreatic
Saunders Valley Cave	1		0	0	0	0	1	0	1	
Sink Hole in Christian Co.	1	x	-	0	-	-	-	-	-	Filled
Brown Spring Cave	1		0	1	0	0	2	0	2	
Merritt Spring	1		0	1	0	0	0	0	0	
Aton's Well	1		0	0	0	0	2	0	2	Hand dug well

Cave Name										Remarks
Minch Cave	3		0	1	0	0	2	0	2	Well entrance
Fantastic Caverns	7		2	1	12	0	2	1	4	Commercial cave
Taylor's Spring Cave	1	x	-	1	2	-	2	1	4	Owner uncooperative; saw crayfish at entrance
Road Cave Pit	1	x	-	0	-	-	-	-	-	Could not find
Moore's Spring Cave	1	x	-	2	-	-	-	-	-	Sealed shut
Sammon's Well	1		0	1	0	0	2	0	2	Capped well
Dillard's Mine Shaft	1		0	0	0	0	0	0	0	Vertical shaft
Sink Hole Near Minch Cave	1	x	0	0	-	-	-	-	-	No entrance
No Name Cave	1		0	0	0	0	2	0	2	
Pfaff's Cave	1		0	2	5	0	2	0	3	Fish collected by Pflieger
Dillard's Cave	1		0	0	0	0	0	0	0	Dry
Sam Williams Spring	0	x	-	2	-	-	-	-	-	
Raney Creek Cave	0	x	-	2	-	-	-	-	-	
Sarcoxie Cave (Downer's Cave, Day's Cave)	2		3	2	5	0	2	1	5	Type locality
Wilson's Cave	10		4	2	3	0	2	0	4	Very small cave
Kellhaufer's Cave	1		4	1	3	0	2	1	5	Well & Spring entrances
Cave Spring Cave	1		0	1	0	0	2	1	3	Probable connection with Kellhaufer's
Cool Brook Spring Cave	1		0	1	0	1	2	-1	1	Gray Bat colony
Carter's Cave	1		0	0	0	0	2	-1	1	Very dangerous cave

Cave Name										Remarks
Spout Springs	1		0	0	0	0	2	0	2	No cave entrance
Turnback Creek Cave	1		1	1	8	1	2	-1	4	Large cave with good formations
Ruark Cave #4	1		0	0	0	0	0	0	0	Several deer carcasses
Mill's Cave	1	x	-	0	-	-	-	-	-	Filled
Golding's Cave	4		0	0	0	0	1	1	2	Many _Typhlotriton_
Longwell Cave	3		0	0	0	0	2	1	2	Many _Typhlotriton_
Death Cave	1		0	0	0	0	2	0	2	Small cave
Jesse James Cave	2		0	0	0	0	1	-1	0	Historical bat cave
Granny Down Cave	1		0	0	0	1	2	-1	2	Gray bats
Henson Cave	1		0	0	0	0	2	-1	1	Two level cave
Wind Cave	1		0	0	0	0	2	-1	1	Extensive public use
No Name Cave	1		0	0	0	0	0	0	0	
No Name Cave	1		0	0	0	0	0	0	0	
No Name Cave	1	x	-	0	-	-	2	-	-	Flooded
Kettle Cave	1		0	0	0	0	0	0	0	Dry
Daylight Cave	1		0	0	0	0	0	0	0	
Flutestone Cave	1		0	0	0	0	0	0	0	
Hobo Cave	1		0	0	0	0	0	0	0	
Rootstone Cave	1		0	0	0	0	0	0	0	Dry
No Name Cave	1		0	0	0	0	0	0	0	
Bluff Dweller's Cave	1	x	-	0	-	-	-	0	0	Commercial
Ben Lassiter Cave	6		4	2	3	0	2	1	5	Good cavefish habitat

Cave Name										Remarks
Blinzer's Well Cave	1		0	1	0	0	2	1	3	Well which intersects cave system
No Name Cave	1		0	0	0	0	0	0	0	Dry
Whispering Springs	1		0	0	0	0	1	0	1	Seasonal flow
Jolly Mill	1	x	-	-	-	-	-	-	-	Sealed shut
Elm Springs	2		0	0	5	0	2	0	3	Small
Back Rub Cave	1		0	0	0	0	1	0	0	Small
No Name Cave	1	x	-	1	-	-	-	-	-	
Reed's Spring	1		0	1	0	0	2	-	-	Spring in city of same name
Gentry Cave	1		0	1	0	0	0	0	0	Dry
Galena Spring	1		0	1	0	0	-	-	-	
Indian Creek Caverns	1		0	1	0	0	2	0	2	Danger of flooding
No Name Cave	1		0	0	0	0	1	0	1	
Elm Springs Cave	1		0	0	0	0	1	0	1	
Insane Cave	1		0	0	0	0	1-2	0	1-2	Many Thyplotriton
Mud Cave	1		0	1	0	1	2	1	4	Owner's water supply
Booker Cave	1		0	0	0	0	0	0	0	Small
Old Spanish Treasure	?		0	0	0	0	2	-1	1	Old commercial cave
Last Creek Cave	1		0	1	0	0	2	0	2	Sinking stream entrance
Belle Star Cave	1		0	0	0	0	2	0	2	

Cave Name										Remarks
Belle Star Spring Cave	1		0	0	0	0	2	0	2	
Gold Cave	1	x	-	-	-	-	-	-	-	
Cave Springs Cave	1		0	2	0	0	2	1	3	Due to fill in the channel, the cave could not be totally surveyed.
Bluehole Spring		x	-	1	-	-	2	-	-	Could not find
Jackson Cave		x	-		-	-	-	-	-	Could not find
Bald Knobber's Cave	1		0	0	0	0	0	-	0	
Lost Linda Cave	1		0	0	0	0	0	0	0	
Jones Cave #1	1		0	0	0	0	0	0	0	
Jones Cave #2	1		0	0	0	0	0	0	0	
Devil's Den/Devil's Hole	1		0	0	0	0	2	0	2	Flooded
Dry Fork Cave	1		0	0	0	0	0	0	0	Small
Henderson Cave	1		0	0	0	0	2	0	2	Small
Chert Bridge Cave	1		0	0	0	0	1	0	1	Small
Atkinson's Cave	1		0	0	0	0	0	0	0	Sink
OKLAHOMA										
Jail Cave	7		3	2	2	hist. col.	2	-1	4	Small pool containing fish
Twin Cave	5		5	2	6	rec. col.	2	1	6	Large cave
Inglebrook Cave	2		1	0	0	0	2	-1	2	Old commercial cave
Mitchell's Cave #1	2		0	1	1	0	1	0	3	Small pool

Cave Name										Remarks
Mitchell's Cave #2	2		0	0	0	0	0	0	0	Dry, linked with Mitchell's #3
January-Stansberry Cave	2		0	0	6	1	2	0	0	Type local for *Cambarus tartarus*
Spavinaw Bat Cave	1		0	0	0	1	2	1	4	Gray bats
T-Cave	1		0	0	0	0	1	0	0	Near Jail
Dry Creek Cave Systems	3		0	1	0	0	0	0	0	Several caves, most linked
Beaver Dam Cave	1		0	0	0	1	2	1	4	Gray bats
White Water Creek Flood Control Dam	1	x	-	2	-	0	-	-	-	No longer exists
No Name Cave (Near Jail)	1		0	0	0	0	0	0	0	
No Name Cave on Dry Creek	1		0	0	0	0	1	0	0	Seasonal flow
No Name Creek	1		0	1	0	0	2	0	2	Good potential habitat for Troglobites
Hole in the Wall	1		0	0	0	0	0	0	0	Flooded by Fort Gibson Reservoirs
No Name Cave	1		0	0	0	0	1	-1	0	Dry; Seasonal flow
Cave Springs Ranch	3		0	2	2	0	2	1	4	Fish reported in SWAN

Appendix E

List of Reviewers for the
Ozark Cavefish Recovery Plan

Dr. Royal Suttkus
Tulane Museum of Natural History
Belle Chasse, LA 70037

Dr. Frank B. Cross
Museum of Natural History
University of Kansas
Lawrence, KS 66045

Dr. Jeff Black
Department of Biology
Oklahoma Baptist University
Shawnee, OK 74801

Dr. John Cooper
Museum of Natural History
North Carolina State University
Raleigh, NC 27695

Dr. Neil Douglas
NE Louisiana University
Monroe, LA 71209

Mr. Steve Wilson, Director
Arkansas Game and Fish Commission
2 Natural Resources Drive
Little Rock, AR 72205

Mr. Steven Alan Lewis, Director
Oklahoma Department of
Wildlife Conservation
Post Office Box 53465
Oklahoma City, OK 73105

Mr. Larry R. Gale, Director
Missouri Department of Conservation
Post Office Box 180
Jefferson City, MO 65102

Mr. Harold K. Grimmett,
Executive Director
Natural Heritage Commission
Suite 500, Continental Building
Main and Markham
Little Rock, AR 72201

Mr. Fred Lafser, Director
Department of Natural Resources
Post Office Box 176
Jefferson City, MO 65102

Mr. Tom Aley, Director
Ozark Underground Laboratory
Route 1, Box 62
Protem, MO 65733

Dr. Steve Jones
Department of Biology
Drury College
Springfield, MO 65802

Dr. Ken Thomson
Southwest Missouri State University
Springfield, MO 65804

Dr. William L. Pflieger
Fish and Wildlife Research Center
Missouri Department of Conservation
1110 College Avenue
Columbia, MO 65201

Dr. Thomas Poulson
University of Illinois at Chicago
Department of Biological Sciences
Post Office Box 4348
Chicago, IL 60680

Dr. A. V. Brown
University of Arkansas
Department of Zoology
632 Science-Engineering
Fayetteville, AR 72701

Mr. Larry Willis
Department of Biology
Virginia Tech.
Blacksburg, VA 24061