Alabama Cave Shrimp
(Palaemonias alabamae)

5-Year Review:
Summary and Evaluation

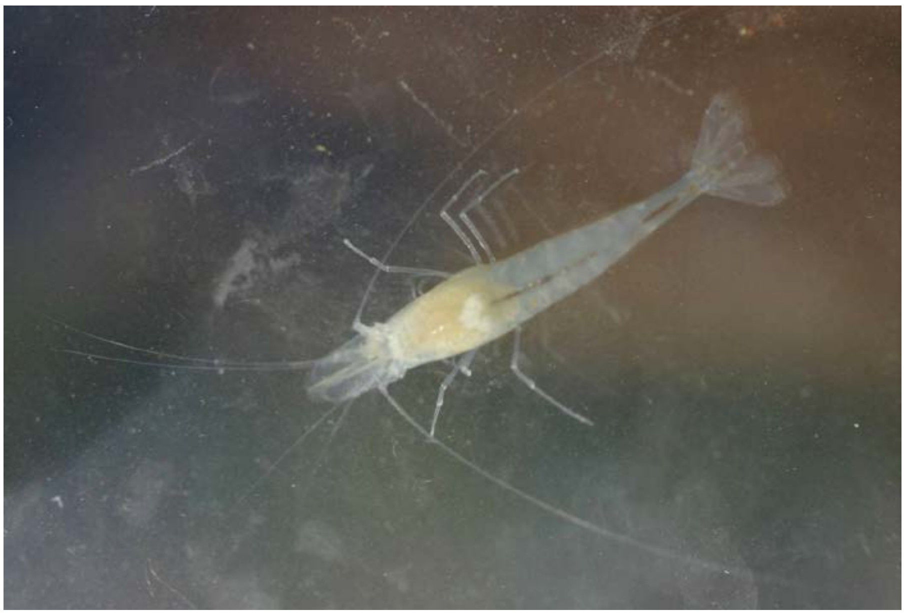

Photo by: Dr. Bernard Kuhajda

U.S. Fish and Wildlife Service
Southeast Region
Alabama Ecological Services Field Office
Daphne, Alabama

January 2016

5-YEAR REVIEW
Alabama cave shrimp/Palaemonias alabamae

I. GENERAL INFORMATION

A. Methodology used to complete the review

This 5-year review was conducted by the Alabama Field Office's Aquatics Team (Jennifer Grunewald, Jeff Powell, and Anthony Ford). The specific sources of information used in this analysis were found in the 1988 final listing rule under the Endangered Species Act (53 FR 34696); the final recovery plan (FWS 1997); peer-reviewed scientific publications; unpublished survey data and reports, and personal communication with recognized experts. We announced initiation of this review and requested information on the species in a published *Federal Register* notice with a 60-day comment period (79 FR 16366). Data and additional information were received from Stuart McGregor, Shannon Allen, Dr. Bernard Kuhajda, Randall Blackwood, and Dr. Kevin Roe. Experts who peer reviewed this document include Stuart McGregor, Randall Blackwood, and Shannon Allen. Comments were evaluated and incorporated as appropriate into this 5-year review (see Appendix A).

B. Reviewers

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

Lead Field Office – Alabama Ecological Services Field Office, Daphne, AL: Jennifer Grunewald, (251) 441-6633; Jeff Powell, (251) 441-5858; and Anthony Ford, (251) 441-5838.

C. Background

1. **Federal Register Notice citation announcing initiation of this review:** (79 FR 16366), March 25, 2014

2. **Species status:** Stable
   The Alabama cave shrimp is considered stable due to persisting populations in the known locations of Bobcat, Hering, Glover, and Brazelton caves; the shrimp has not been documented in the type locality, Shelta Cave, since 1973. In Bobcat Cave, which has received the most monitoring, oocytes or ova have been observed most years though there is a rise and fall in the number of individuals observed. The range has been extended with the confirmation of Alabama cave shrimp in Muddy Cave, Madison County, Alabama.

3. **Recovery achieved:** 1= 0 -25 % species recovery objectives achieved

4. **Listing history**
Original Listing
FR notice: 53 FR 34696
Date listed: September 7, 1988
Entity listed: species
Classification: endangered

5. **Review History**
Recovery Data Call: Annually from 1998 – 2014, 1997 (Final Recovery Plan published)
A species' review was conducted for this cave shrimp 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 this species' listing classification was found to be appropriate.

6. **Species' Recovery Priority Number at start of review (48 FR 43098)**: 5 (degree of threat is high, potential for recovery is low, and the taxonomy is the species level)

7. **Recovery Plan**
Name of plan: Alabama Cave Shrimp (Palaemonias alabamae) Recovery Plan
Date issued: September 4, 1997

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy: Not applicable. The Alabama cave shrimp is an invertebrate, and therefore, not covered by the DPS policy, and will not be addressed further in the other DPS questions in this review.

B. Recovery Criteria

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

2. **Adequacy of recovery criteria**.

   a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** Yes

b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)?** Yes

3. **Recovery Criteria**: The 1997 Final Recovery Plan only identifies downlisting (reclassification to threatened) criteria.

   1. **Identification and protection of reproductively viable populations of Alabama cave shrimp in five groundwater basins (or aquifers).**

<u>Has not been met</u>: At the time of listing, the Alabama cave shrimp (ACS) was historically, only known from five caves in Madison County, Alabama: Shelta (the type locality), Bobcat, Hering, Glover, and Brazelton caves (FWS 1988). Currently, viable populations of ACS are only confirmed in two groundwater basins: Bobcat Cave, in southwest Madison County (McGregor and O'Neil 2004) and the Hering/Glover/Brazelton (HGB) cave system (Rheams et al. 1994), which is a series of hydrologically connected caves in southeast Madison County. The ACS has not been found in Shelta Cave since the 1970s (FWS 1997). Bobcat Cave is owned by the U.S. Army, Redstone Arsenal (RSA) and is therefore subject to protection under Section 7 of the Endangered Species Act (ESA). The HGB caves are located on private lands, and are not currently protected.

On December 12, 1993, McGregor et al. (1994) reported three unidentified shrimp from a cave in western Jackson County about 24 km (15 miles) northeast of Hering Cave; however, specimens were not vouchered and the species was never confirmed (Limrock Blowing Cave). On November 17, 2005, an unidentified cave shrimp was reported from Muddy Cave, in southern Madison County (specimen was vouchered) (Kuhajda 2005b). Preliminary observations indicated that the specimen was likely an ACS (Kuhajda 2006, 2006a, 2005a). Although the cave had been surveyed on several previous occasions, no shrimp were ever reported (Rheams et. al 1992; Kuhajda 2004). Following genetic analyses by Kevin Roe using the DNA sequences of the first subunit of the mitochondrial Cytochrome Oxidase C gene, a comparison was made between the Bobcat and Muddy cave specimens (Roe, pers. comm. 2015). Results indicated that the Muddy Cave specimen was identical to the specimens found in Bobcat Cave and according to Kuhajda (2006), the specimens also closely resembled one another, but no morphological studies have been conducted to confirm this hypothesis (Kuhajda, pers. comm. 2015). The confirmation of ACS in Muddy Cave is a slightly southern range extension for the species and if this cave is in a separate groundwater basin, this could represent a third population. A follow-up site visit to Muddy Cave was made on July 27, 2006, and resulted in one cave shrimp sighting but no individuals were collected (Kuhajda, pers. comm. 2014).

Several known locations of the ACS are protected by landowners, aiding in the recovery of the species. The entrances to Shelta Cave are owned by the National Speleological Society (NSS) and protected by a large perimeter fence which controls public access (J. Buhay, pers. comm. 2006). Bobcat Cave is located on RSA, a U.S. Army installation, and access is restricted and urban development is reduced. Muddy Cave is owned by the North Alabama Land Trust and is operated by the Southeastern Cave Conservation, Inc., and access is restricted.

2. Reproductive viability, defined as reproducing populations which are stable or increasing in size, should be demonstrated for all five populations for a 20-year period.

<u>Has not been met</u>: Reproductively viable populations of ACS have been confirmed in two cave systems: in Bobcat Cave and in the HGB complex. The population in Bobcat Cave appeared to be stable in 2006, but in recent years both the frequency of individual counts and numbers of cave shrimp observations have declined (McGregor and O'Neil 2013); however, the number of observations increased in the 2013-2014 sampling year (McGregor and O'Neil 2014). According to McGregor and O'Neil (2014), ACS females with oocytes or attached ova were observed annually 1990 – 2007 and in 2010, 2011, and 2014. The status of the population in the HGB system is unknown; however, the most recent surveys were conducted in the early 1990s, at which time it was presumed to be viable (Rheams et al. 1994; McGregor et al. 1994). Visits were made to the HGB system by Randall Blackwood in 2013, and 2014, but conditions were not favorable to allow sampling (Blackwood, pers. comm. 2014). The status of the population in Muddy Cave is unknown.

C. Updated Information and Current Species Status

1. Biology and Habitat.

a. **<u>Abundance/population trends</u>**: Available information indicates that range-wide, the ACS may be declining. The population of ACS in Shelta Cave has not been observed since the early 1970's. The population in Bobcat Cave appeared to be stable prior to 2006, but in recent years both the frequency of individual counts and observations of cave shrimp have both declined (McGregor and O'Neil 2004, 2013); however, the number of observations did slightly increase between 2013-2014 (McGregor and O'Neil 2014). Since 1990, Bobcat Cave has been surveyed monthly, when water levels allowed access (268 times), and ACS have been reported 113 times, for a total of 1,088 sightings. Sightings have been documented every month of the year at least once, except in February, March, and April. The lack of reported sightings in these months is likely due to high water levels and inaccessibility to the cave's pools. ACS have been reported in all other months ranging from a low of 6 in May to a maximum of 349 in August. The most productive months, in terms of total number of sightings, are August (349), July (219), and October (169). The same is generally true for numbers of gravid

ACS females sighted and include, August (63 gravid females), October (26 gravid females), and July (at least 11 gravid females) (McGregor and O'Neil 2014).

The ACS population in the HGB system has not been well documented. Between 1991 and 1994, there were approximately 19 individual sightings including at least two gravid females (Rheams et al. 1992; McGregor et al. 1994). R. Blackwood reported as many as 39 individual ACS sightings in his 1998 surveys (R. Blackwood, unpublished data). Visits were made to the HGB system by R. Blackwood in 2013 and 2014 but unfavorable weather conditions prevented sampling (Blackwood, pers. comm. 2014). The status of the population in Muddy Cave has not been determined.

<u>Demographic trends</u>: Demographic trends are relatively unknown. Cooper (1975) observed gravid ACS females in Shelta Cave from July to January, where the number of eggs carried by each female ranged from 8 to 12. In Bobcat Cave, females have been noted to carry 20 to 24 (Rheams et al. 1994). Cooper and Cooper hypothesized that eggs matured in the fall and hatched in the winter and has observed late-stage oocytes from late August through December (2010). McGregor et al. (1994) believed that the ACS needs at least one growing season to reach sexual maturity; however, larval development for the species has not been fully determined. Cooper (1975) estimated that sex ratios for the ACS are approximately 1:1, and that sexual dimorphism does exist (females average 1.2 mm longer than males in total length, and the male rostrum averages 4.2 percent longer than the females). Although the life span has not been documented for the ACS, the closely related Kentucky cave shrimp (*P. ganteri*) is reported to live between 10 and 15 years (Leithauser 1988).

b. **<u>Genetic variation</u>**: Recent genetic analyses of cave shrimps in Alabama have identified two distinct monophyletic groups in the state; one from Bobcat Cave, HGB Cave system, and Muddy Cave in northeast Alabama (Madison County) (*P. alabamae*) and one from McKinney Pit Cave and Elbow Cave, which are in northwest Alabama (Colbert and Lauderdale counties) near Tuscumbia, Alabama (undescribed Tuscumbia cave shrimp) (Roe, pers. comm. 2015). Shrimp found in Key Cave are more similar to the McKinney Pit Cave and Elbow Cave specimens when compared to the Bobcat-HGB-Muddy cave specimens (Kuhajda, pers. comm. 2015) however, attempts are being made to compare the genetics between ACS and its closest relative, the Kentucky cave shrimp, found in Mammoth Cave in Kentucky. The Kentucky cave shrimp differs morphologically from the ACS by its larger size, longer rostrum (flattened frontal projection of head), more numerous ventral rostral spines, and more dorsal rostral spines (Smalley 1961). A third species, the Tuscumbia cave shrimp (undescribed), has been reported from McKinney Pit Cave and Elbow Cave, and differs both morphologically and genetically from both the Kentucky and Alabama cave shrimp (Kuhajda, pers. comm. 2006; Rintelen et al., 2012; Roe, pers. comm. 2015). Genetic sequencing suggests that the undescribed Tuscumbia cave shrimp is found in McKinney Pit Cave and Elbow Cave. The shrimp that has been collected in Key Cave is more genetically similar to the undescribed Tuscumbia cave shrimp (Kuhajda, pers. comm. 2015). Genetic analysis on the recently discovered shrimp from Muddy Cave suggests that it is an ACS because of its similarities to specimens collected in Bobcat Cave (Roe, pers. comm. 2015).

c. Taxonomic classification or changes in nomenclature: None

d. <u>Spatial distribution</u>: The ACS was first collected in Shelta Cave in 1958 (Cooper 1975), yet it has not been seen there since the early 1970's. The population in Bobcat Cave has been monitored monthly from 1990 to the present and remains viable. Oocytes or attached ova have been observed on shrimp most years during the monitoring period. With the discovery of populations in Hering/Glover (1991) and in Brazelton Cave (1994) (Rheams et al. 1994), and ACS found in Muddy Cave (2005) (Kuhajda, pers. comm. 2006a) the total range of the species extends approximately 20 km (12 miles) east-southeast across the Flint River and the Huntsville, Green, and Monte Sano mountains and southward to near the Tennessee River (McGregor et al. 1994). In December 1993, McGregor et al. (1994) mentioned three individual shrimp from a cave in western Jackson County about 24 km (15 miles) northeast of Hering Cave (reported by a recreational caver in Limrock Blowing Cave); however, this siting has never been confirmed.

e. <u>Habitat</u>: Little is known about the habitat requirements of the ACS, other than it occurs in silt-bottomed pools in a cave environment (FWS 1997). Current knowledge is primarily based upon observations in Shelta and Bobcat caves. Only a few observations have been made in the HGB system; this system is different from Bobcat and Shelta caves in that the HGB system experiences substantial flows during spring and winter months (Rheams et al. 1992). Rheams and others (1992) reported that the cave bottom in this system had more sand and gravel compared to the other caves. Habitat in Muddy Cave is described as being similar to that found in Bobcat and the HGB cave system (McGregor, pers. comm. 2006).

Habitat is extremely difficult to quantify due to the dynamic nature of cave systems. Basic chemical and physical conditions in the caves are highly influenced by land use in the recharge area and can be impacted by surface runoff from developments (e.g., residential) and manipulation of landscapes (e.g., clearing of forestland) in the recharge area.

Efforts to determine potential threats are ongoing at Bobcat Cave by the Department of the Army RSA and Geological Survey of Alabama. As part of the Army Operational Range Assessment Program the Environmental Management Division at RSA is performing an assessment on the Army Installation to monitor munition constituents and has included water and sediment samples in Bobcat Cave in the analysis (Department of Defense, pers. comm. 2015)

2. Five Factor Analysis

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

Actions that can severely modify or destroy ACS habitat include physical alterations to a cave, such as dumping trash into a cave or sinkhole, or closing off cave entrances or sinkholes; alteration of drainage and hydrologic patterns; lowered groundwater levels; and groundwater degradation or contamination by toxins, nutrients, and/or sewage. Surface pollutants can easily and rapidly enter the subsurface aquifer, particularly during storm events. The Mississippian carbonate aquifer, where caves that support the ACS are found, is susceptible to contamination due to the shallow groundwater depth, moderately well to well-drained soils, soils with low organic content, and rapid contaminant transport through the karst groundwater flow system (U.S. Geological Survey 2002).

Urbanization of areas surrounding Shelta and Bobcat caves, and development in the recharge area of the HGB system, may cause contamination of the aquifers containing ACS. Groundwater contamination may result from sewage leakage, industrial discharges, road and highway runoff, toxic spills, pesticides, and siltation. A study conducted by U.S. Geological Survey (2002) in the Mississippian carbonate aquifer in parts of Middle Tennessee and northern Alabama found that nitrate was detected at high concentrations and more frequently than other nutrients, as well as frequent detections of pesticides and volatile organic compounds (VOC). Pesticide detections appeared to be associated with the amount of cropland in the vicinity of a sampling site. Chlorinated solvents were the most persistent VOC found in this study and the highest concentrations and highest number of compounds were found in the more urbanized settings. The Redstone Environmental Office has detected trichloroethylene (TCE) in several of the shallow groundwater monitoring wells coming onto the RSA installation northeast of Bobcat Cave; however, the TCE detections appear to be isolated and are bound by contaminants that were not detected above the method detection limit (Shaw Environmental & Infrastructure, Inc. 2013).

Groundwater contamination is likely the greatest threat to ACS populations. Groundwater quality has been monitored monthly in Bobcat Cave since 1996 (McGregor and O'Neil 2014). Heavy metals such as lead, cadmium, and chromium detected in water samples may indicate a source of pollution or proximity to an ore deposit. Lead was detected in 11 of 12 samples in Bobcat Cave in 2013-14 ranging from <0.9 to 19.2 µg/L with a median of 5.4 µg/L and since 1996 the average detection rate (percent of samples collected) of lead for Bobcat Cave is 59.8. Cadmium was detected in 6 of 12 samples from Bobcat Cave in 2013-2014; there is a declining trend of cadmium levels from 1996-2014, but the number of detections has been on the rise since 2010. The average of cadmium detections is 54.9 percent. Chromium was detected in 11 of 12 samples in 2013-2014 ranging from <0.8 to 3.0 µg/L with a median of 1.4 µg/L and since 1996 detection rates of chromium have varied but have averaged 62.4 percent. It has not been determined what affect these levels might have on the ACS populations in Bobcat Cave. Devi and Fingerman

(1995) found inhibition of AChE (acetylcholinesterase) activity in the central nervous system of red swamp crayfish (*Progambarus clarkii*) after exposure to sublethal levels of cadmium (5 ppm) and lead (100 ppm) for 24 and 48 hours. In Bobcat Cave, dissolved solids and pH have remained steady in recent years and nitrate levels have shown a long-term decline since 1996. Other potential threats facing the Bobcat Cave ACS population include: development of lands outside RSA, but lying within the recharge area; pumping of large municipal wells and lowering of water levels; and accidental disruption of aquatic habitat by investigators (Campbell 1997).

Over the past 25 years, considerable progress has been made in monitoring ACS populations in Bobcat Cave, as well as understanding the relationships between surface runoff and groundwater quality and precipitation amounts and cave water levels (Rheams et al. 1992, 1994; McGregor and O'Neil 1996, 2000, 2001, 2002, 2003, 2004, 2008a, 2008b, 2012, 2013, 2014; McGregor et al. 1994, 1997; McGregor et al. 1997, 1999; Campbell et al. 1995). Dye-tracer studies have shown that the recharge area is a relatively small area of shallow ground water sources and a deeper ground water source which sustains the cave during drier periods (McGregor et al. 1997; McGregor and O'Neil 1996). Also, the immediate surface drainage into Bobcat Cave has recently been protected by removing cattle and other agricultural practices, and returning the landscape to an unmanaged state (McGregor and O'Neil 2004). These multi-agency supported studies have significantly contributed to our awareness about ACS life history and population trends. The studies have provided habitat and life history information and have shown that population sizes of ACS increase and decrease over time.

Habitat degradation has occurred in Shelta Cave from unknown causes. Water samples taken in Shelta Cave in 1990 indicated that the aquifer had become contaminated by cadmium, heptachlor epoxide, and dieldrin (FWS 1993). The traces of dieldrin, chlordane, and heptachlor epoxide found in water and sediment samples may be the result of pesticides used for termite control that have leached into the soil. Anomalous levels of cadmium, almost five times the drinking water standard have been reported, and insecticides like chlordane and dichloro-diphenyl-trichloroethane (DDT), dichloro-diphenyl-dichloroethylene (DDE), and dichloro-diphenyl-dichloroethane (DDD) were detected in sediment samples in Shelta Cave at levels that are cause for concern for potential biological effects (FWS 1993). Since aquatic troglobites, such as the ACS, tend to be long-lived and may store, rather than depurate, pollutants such as these, even low levels of pollutants can be of concern (Dickson et al. 1979; Bosnak and Morgan 1981; Hobbs 1992).

Aquatic surveys of Shelta Cave conducted during 1968-1975, 1985-1987, and 1988, reveal a decline in all aquatic organisms monitored (Hobbs and Bagley 1989). Whether this decline is due to water quality degradation, nutrient loss due to abandonment of the cave by bats in the past, or a combination of these and/or unknown factors, remains to be determined. The perimeter fence that was installed at the entrance to Shelta Cave in 2003, allows bats to have a natural path into the cave. Bats have been observed at the entrance of Shelta Cave by cavers (Blackwood, pers. comm. 2015). Initial hypotheses are that the chlorinated water may be eliminating the bacteria and other food sources of the cave crayfish and cave fish. Fecal coliform has been detected in samples performed after the repairs were made and may indicate leakage from sewer lines.

Areas around the HGB caves are continually being developed. Forests are being cleared for new homes on and around Keel Mountain, therefore, the ACS found in the HGB caves may soon be in danger of surface water and groundwater contamination from sewage leakage, lawn fertilizers, pesticides, and increased surface runoff from residential development in the near future. Additionally, large chicken farms are present in the Hering Cave recharge area and could impact water quality in all three caves in the cave complex by discarding excess grains and manure into sink holes. The recharge area around Hering Cave has been delineated and dye tracer studies have documented a direct hydrologic connection among the HGB caves (Campbell 1998). The greatest threats to the ACS at the HGB caves are potential pollutants originating from residential development and delivered to the caves during periods of runoff.

Water quality data were collected in Muddy Cave by GSA from October 2006, through September 2007, after the discovery of ACS in the cave (McGregor and O'Neil 2008a). Results suggest that Muddy Cave is influenced by contaminated runoff based on elevated levels of nitrate, chloride, chloroform, and lower dissolved oxygen compared to Bobcat Cave. Chloroform was detected in Muddy Cave but not in Bobcat Cave during the sampling time period; chloroform ranged from 0.5 to 9.56 μg/L with a median value of 0.97 μg/L (McGregor and O'Neil 2008a). Muddy Cave runoff is locally influenced by agricultural fields, pasture, and a small horse ranch.

Urbanization and population growth has undoubtedly increased water demands in Madison County, Alabama. The city of Huntsville has experienced water shortages in previous years due to increased demand and drought (Doyle 2005). In response to this demand, the city drilled and brought on line the Drake Well. Capable of pumping up to 7,570 liters (2,000 gallons) per minute, this well is located less than 1 km (0.5 mile) from Bobcat Cave. Also, Huntsville Utilities has begun construction on a new water treatment plant along the Tennessee River which is expected to be completed in 2017, to help meet the increasing water demands of Madison County (Gary Bailey, pers. comm., 2015). Increased water consumption has the potential to affect the Bobcat and Shelta cave aquifers by lowering groundwater levels and reducing the amount of available habitat for the ACS.

Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

Since the ACS population in each of these caves is so low that they are rarely seen, the removal of any ACS by collectors may affect the ability of the species to reproduce. Other cave species are known to have extremely low reproductive rates when compared to closely related surface species (Cooper 1975). If the same is true for the ACS, declining population numbers, compounded by low reproductive rates, will significantly affect the species' ability to recover. However, unauthorized collecting of ACS from Shelta, Bobcat, and Muddy caves is not likely to occur due to the protection afforded by the landowners. The entrances to Shelta Cave are owned by the National Speleological Society (NSS) and protected by a large perimeter fence which controls public access (J. Buhay, pers. comm. 2006). Bobcat Cave is located on RSA, a U.S. Army installation, and access is restricted. Muddy Cave is owned by the North Alabama Land Trust and is operated by the Southeastern Cave Conservation, Inc., and access is restricted. We do not have evidence that removal of ACS is occurring at this time; however due to the rarity of the ACS, it is a threat that we have to closely monitor for.

Factor C. Disease or predation:
ACS population numbers apparently remain low and continue to be subject to natural predation from other cave-dwelling species. Cooper and Cooper (1974) observed a Southern Cavefish, *Typhlichthys subterraneus*, regurgitating an ACS in Shelta Cave. Other potential predators in this cave include the Tennessee cave salamander, *Gyrinophilus palleucus,* and two troglobitic crayfishes. Potential predators observed in Bobcat, Brazelton, Glover, and Hering caves are the southern cavefish, troglobitic crayfish, unidentified salamanders, Tennessee cave salamander, bullfrogs, and raccoons (Rheams et al. 1992, McGregor et al. 1994). Predation by naturally occurring predators is a normal aspect of the population dynamics of a species. However, the effect of predation on a declining troglobitic species with an apparently low reproductive potential would be more significant than if the population were stable. Since this animal is rarely seen and difficult to study, we do not have existing evidence of disease in this cave shrimp. We do believe that natural predation is occurring in the cave systems where ACS is occurring; however, we do not know the specifics of the food webs.

Factor D. Inadequacy of existing regulatory mechanisms:
The ACS is afforded protection under the ESA and by the state of Alabama. The ACS is afforded a Global Rank of G1 by NatureServe (critically imperiled), a State Rank of S1 (critically imperiled), and a State Status of SP under the Invertebrate Species Regulation (state protected, Alabama Administrative Code 220-2-.98) (Alabama Natural Heritage Program 2014). The Invertebrate Species Regulation (220-2-.98) states that it shall be unlawful to take, capture, kill, or attempt to take, capture, or kill; possess, sell, trade for anything of monetary value, or offer to sell or trade anything of monetary value the ACS without a scientific collection permit or written permit from the Commissioner, Department of Conservation and Natural Resources, which shall specifically state what the permittee may do with the species. Since there is no new information on the species' sensitivity to common pollutants, Federal water quality laws (e.g., Clean Water Act) such as those administered by the State, may or may not be protective of the ACS, especially since limitations and monitoring of groundwater are not common regulatory practices.

Conservation measures include: property owners at Shelta (NSS) and Bobcat (RSA) caves have gated entrances and limited access, and the Environmental Protection Agency (EPA) has restricted the use of heptachlor epoxide and banned the use of dieldrin, both of which are presumably lethal to the ACS. EPA County bulletins prescribe buffers for certain current-use pesticides, which may also be helpful.

Shelta Cave is owned by the NSS and a perimeter fence has been installed to exclude unauthorized visitors. Bobcat Cave is owned by RSA and admittance is controlled. The entrances to the HGB caves are located on private lands and are currently unprotected. The entrance to Muddy Cave is owned by the North Alabama Land Trust and is operated by the Southeastern Cave Conservation, Inc.

Factor E. Other natural or manmade factors affecting its continued existence: Droughts as well as water withdrawn for human use, especially during times of drought, can impact cave water levels. Changes in land use in the recharge area can accelerate pollutant's delivery to caves during surface runoff. Other factors include: human-induced random events such as toxic spills in the recharge area; construction of new facilities/buildings in the recharge area; and potential road construction projects in the recharge area. Construction has begun on widening of Zierdt Road from two to four lanes, from I-565 south to Martin Road, to handle increased traffic expected from new housing development to the west of RSA. The Zierdt Road runs along the western boundary of RSA and passes within 365.8 meters (1,200 feet) of Bobcat Cave. The Service has been coordinating with Alabama Department of Transportation on this project since 2006 and is expected to be completed by the end of 2017 (Les Hopson, pers. comm. 2015). Also, a "visionary" road project in Huntsville is projected to pass near the entrance to Muddy Cave (Huntsville Planning Division 2015).

D. Synthesis -

The Alabama cave shrimp is a rare, troglobitic cave shrimp that survives in only three of its four known locations. The population in its type locality, Shelta Cave, has not been seen since the early 1970s. Population levels in Bobcat Cave and the HGB cave system appear to be low. The status of the newly identified population in Muddy Cave is unknown. The sighting in western Jackson County (Limrock Blowing Cave), reported by McGregor et al. (1994), should be further investigated. Results from survey data throughout the range indicate that population levels remain low where the species exists.

Specific life history and habitat needs have not been well documented. Water quality and suitable cave habitat continue to be chronically plagued by polluted surface runoff. Water quality data from Bobcat Cave indicate that polluted deep groundwater may also pose a potential impact (McGregor and O'Neil 2002, 2003, 2004, 2008a, 2008b, 2012, 2013, 2014)

Many of the studies conducted over the past 25 years have advanced our understanding of surface/groundwater interactions, as well as how precipitation relates to the timing and magnitude of waters being delivered to caves. However, the cave environment is extremely dynamic and more research is needed to better understand the quality of water in caves and how and when it is delivered. This is a critical concept, not only for the cave shrimp, but for all karst dependent species.

The Alabama cave shrimp, despite numerous surveys over the past 25 years, remains extremely rare throughout its range and is in danger of extinction. According to recovery criteria (FWS 1997), a total of five viable populations in five distinct groundwater systems needs to be identified, protected, and documented as viable prior to downlisting the species. At the time of this review, there are only two confirmed populations in two distinct groundwater basins.

III. RESULTS

A. Recommended Classification: No change is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

(a) Continue monitoring Alabama cave shrimp populations in Bobcat Cave to develop long-term trends.
(b) Continue monitoring ground-water quality and water levels in Bobcat Cave. Special attention should be placed on the levels and trends of potential toxins, such as lead and cadmium, persistent current-generation pesticides, and other parameters associated with urban runoff, as well as potential temperature change.
(c) Determine the origin (age, source, and recharge area) of deep groundwater in the Bobcat Cave aquifer.
(d) Determine if Muddy Cave is in a distinct groundwater system from Bobcat Cave.
(e) Investigate possible populations of Alabama cave shrimp in Limrock Blowing Cave in western Jackson County, Alabama.
(f) Work with private landowners to confirm shrimp populations and develop water quality monitoring plans for the HGB system, Muddy Cave, and in Limrock Blowing Cave in western Jackson County, Alabama.
(g) Work with EPA to determine the source of, and remediate, TCE and other contaminant plumes that will affect the Bobcat Cave population.
(h) Implement all other recovery actions (listed below).
(i) Continue looking for research opportunities to refine DNA sampling techniques with cave shrimp.
(j) Develop a morphological and genetics database that will allow accurate comparisons among all cave shrimp.

<u>Recovery Actions (FWS 1997):</u>

1. Protect Alabama cave shrimp populations and their groundwater habitat.
2. Develop technical information and educational material essential for cave and recharge area stewardship.
3. Monitor Alabama cave shrimp populations.

4. Conduct life history and other needed research.
5. Continue searching for additional populations.
6. Modify or replace the gated entrance to Shelta Cave.
7. Assess suitability of re-introduction of Alabama cave shrimp into Shelta Cave.

V. REFERENCES

Alabama Natural Heritage Program. 2014. Alabama Inventory List: the rare, threatened, and endangered plants and animals of Alabama. Privately printed by the Alabama Natural Heritage Program, 1090 South Donahue Drive, Auburn University, AL 36849.

Blackwood, R. 2014. Re: Alabama Cave Shrimp. 12/10/2014 @ 18:04, email provided site visit information and comments on development near the Hering cave system.

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Peer-Reviewers –

Mr. Stuart McGregor
Geological Survey of Alabama, Tuscaloosa, AL, (205) 247-3629

Mr. Randall Blackwood
National Speleological Society, Huntsville, AL, (256) 859-3246

Ms. Shannon Allen
Environmental Management Division, United States Army, Redstone Arsenal, Huntsville, AL, (256) 876-3977

Provided new/updated information –

Mr. Stuart McGregor
Geological Survey of Alabama, Tuscaloosa, AL

Ms. Shannon Allen
United States Army, Redstone Arsenal, Huntsville, AL

Dr. Bernard Kuhajda
University of Alabama, Tuscaloosa, AL

Dr. Kevin Roe
Iowa State University, Ames, IA

Mr. Randall Blackwood
National Speleological Society, Huntsville, AL

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW ***of the Alabama cave shrimp***

Current Classification:

Recommendation resulting from the 5-Year Review:

_____ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist
__X_ No change is needed

Review Conducted By: Jennifer Grunewald, USFWS Alabama Ecological Services Field Office

FIELD OFFICE APPROVAL:

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

Approve ______________________ Date 1/11/2016

APPENDIX A: Summary of peer review for the 5-year review of the Alabama cave shrimp (Palaemonias alabamae)

A. Peer Review Method: see below

B. Peer Review Charge: see below

A follow up request sent (email – dated November 19, 2014) to potential reviewers requesting comments on the 5-year review (see below for copy of actual request). Request was sent to Bernie Kuhajda (Tennessee Aquarium), Stuart McGregor (Geological Survey of Alabama), Jim Godwin (Alabama Natural Heritage Program), Alexander Huryn (University of Alabama), Paul Johnson (Alabama Department of Conservation and Natural Resources), Nathan Whelan, Pat O'Neil (Geological Survey of Alabama), and Randall Blackwood(National Speleological Society).

Hi folks, just following-up on the 5-year Review Notice that was published earlier this spring. If you have any new information, please forward it to either Jennifer, Andy, or myself.
Thanks!
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On March 25, 2014, the U.S. Fish and Wildlife Service published a notice in the *Federal Register* announcing a 5-year review of 33 federally listed southeastern species, including the Alabama cave shrimp, plicate rocksnail, flat pebblesnail, cylindrical lioplax, lacy elimia, round rocksnail, and painted rocksnail. The purpose of the 5-year review is to summarize new information for the species, ensure that the classification of species as threatened or endangered is accurate and reflects the best available information, and to identify actions required to conserve the species.

The purpose of 5-year reviews is to ensure that the classification of species as threatened or endangered on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12) is accurate. These reviews will consider the best scientific and commercial data that have become available since the current listing determination or most recent status review of each species. Anyone with new data or information on the Alabama cave shrimp is asked to submit it to either Jeff Powell (jeff_powell@fws.gov), Jennifer Pritchett (jennifer_pritchett@fws.gov), or Anthony Ford (anthony_ford@fws.gov) at the U.S. Fish and Wildlife Service.

As always, thank you for your assistance.
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Jeff Powell
Aquatic Biologist
U.S. Fish and Wildlife Service
Alabama Ecological Services Field Office

C. Summary of Peer Review Comments/Report

Mr. Stuart McGregor, Geological Survey of Alabama, Tuscaloosa, AL: Majority of comments were editorial corrections/suggestions, as well as a clarification of information cited from a paper by himself and others (refer to DFO files for reviewed document).

Mr. Randall Blackwood, National Speleological Society, Huntsville, AL: Mr. Blackwood provided information on Huntsville area road construction, the perimeter fence at the entrance of Shelta Cave, and on pipeline maintenance near Shelta Cave.

Ms. Shannon Allen, United States Army, Redstone Arsenal, Huntsville, AL: Ms. Allen provided information on published citations that could be used in the document, including a contaminants report by the Department of the Army's Installation Restoration Branch. Other information she provided was to address munitions constituents from the Army Operational Range Assessment Program. Ms. Allen also commented that a report to examine the current information available on the origin of the Bobcat Cave aquifer has been completed but Christine Easterwood, Wildlife Biologist at Redstone Arsenal, stated that the report is not finalized.

D. Response to Peer Review

We appreciated the new information provided by all 3 peer reviewers. We evaluated this information and incorporated appropriates changes as appropriate into the document.