Kentucky Cave Shrimp
(*Palaemonias ganteri*)

5-Year Review:
Summary and Evaluation

Kentucky Cave Shrimp
Photo Credit: Kentucky Department of Fish and Wildlife Resources

April 2022

U.S. Fish and Wildlife Service
Atlanta Regional Office
Kentucky Ecological Services Field Office
Frankfort, Kentucky

5-YEAR REVIEW
Kentucky Cave Shrimp (*Palaemonias ganteri*)

I. GENERAL INFORMATION

A. Methodology used to complete the review:

In conducting this 5-year review, we relied on the best available information pertaining to historical and contemporary distributions, life history, genetics, habitats, disturbances, and potential threats to this species. We announced initiation of this review and requested information in a Federal Register (FR) notice published on July 14, 2021 (86 FR 37178). We did not receive public comments during the comment period. To acquire the most current information available, various sources were solicited, including data housed at the state conservation agencies and heritage programs, and individuals with knowledge of the species that are associated with federal and state agencies, academia, and non-governmental conservation organizations. Specific sources included the 2016 5-year review; 1988 recovery plan; 1983 final rule listing this species under the Endangered Species Act (Act); consultation documents written pursuant to section 7(a)(2) of the Act; peer reviewed scientific publications; unpublished field observations by federal, state, and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals. Because no significant new information was identified for inclusion in this 5-year review, this document did not receive a full peer review; however, portions of the document were reviewed for accuracy by Rick Toomey, Ph.D., Mammoth Cave National Park (groundwater basin delineation) and David Hayes, Ph.D., Eastern Kentucky University (genetics).

B. Reviewers

Lead Regional or Headquarters Office

Atlanta Regional Office, Carrie Straight, (404) 679–7226

Lead Field Office

Kentucky Ecological Services Field Office, Carrie Allison, (502) 695-0468

C. Background

1. Federal Register Notice citation announcing initiation of this review

July 14, 2021 (86 FR 37178)

2. Listing history

Original Listing
Federal Register Notice: 48 FR 46337
Date Listed: October 12, 1983
Entity Listed: Species
Classification: Endangered

3. Review history

August 29, 2016 5-Year Status Review recommending no change in status (Service 2016)
April 30, 2010 5-Year Status Review recommending no change in status (Service 2010)

4. Species' Recovery Priority Number at start of review: 5

Degree of Threat: High
Recovery Potential: Low
Taxonomy: Species

5. Recovery Plan

Name of Plan: Kentucky Cave Shrimp Recovery Plan
Date Issued: October 7, 1988

II. REVIEW ANALYSIS

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

The Endangered Species Act (ESA) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable.

B. Recovery Criteria

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

No. Significant research on the species' biology and habitat has been completed since the recovery plan was published in 1988.

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

Yes, but several terms in the recovery criteria are not specifically defined (e.g., protection, viability, reproducing population).

3. List the recovery criteria as they appear in the recovery plan and discuss how each criterion has or has not been achieved.

Recovery Criteria:

In order to reclassify the Kentucky cave shrimp, this criterion must be met:

1. Protection of viable, reproducing populations in five groundwater basins currently known to support the species or found to support it in the future.

In order to delist the Kentucky cave shrimp, this criterion must be met:

1. Protection of viable, reproducing populations in nine groundwater basins currently known to support the species or found to support it in the future.

Neither criterion has been fully met. See 2016 5-year review for additional details (Service 2016).

C. Updated Information and Current Species Status

1. Biology and habitat

The 2010 5-year review (Service 2010) presents the most comprehensive overviews of the species' biology and habitat. Limited new information is presented herein.

a. Summary of new information of species biology and life history:

A brief synopsis of the Kentucky cave shrimp's appearance, biology, and habitat was provided by the Service (1994). We have no new information on biology or life history that affects the status of the species.

b. Abundance, population trends, demography:

The Kentucky cave shrimp recovery plan (Service 1988) and subsequent 5-year reviews (Service 2010, 2016) reference 9 groundwater basins within the Mammoth Cave National Park region of central Kentucky that are occupied by the Kentucky cave shrimp. However, the Kentucky cave shrimp is currently considered to occupy 11 groundwater basins (Table 1). These revisions/clarifications were initially determined during the development of the Biological Assessment for the Green River Lock and Dam Removal Project (USACE 2021) and further clarified in coordination with Mammoth Cave National Park Service staff in 2022, as summarized below:

1. Echo River Spring and River Styx Spring were previously considered one basin; however, a better understanding of the basins indicates that, under normal conditions, these basins have separate flow. Therefore, River Styx Spring should be treated as separate basin (Rick Toomey, personal communication, March 2022).
2. In 2019, a National Park Service survey team identified a Kentucky cave shrimp in Blindfish River. Dye tracing confirmed that Blindfish River drains to Great Onyx Spring, which adds Great Onyx Spring to the list of occupied basins (Rick Toomey, personal communication, August 2020).

Table 1. Occupied groundwater basins.

1988 Recovery Plan	Current
Echo River Spring	Echo River Spring
Double Sink	Double Sink
Ganter Cave	Ganter Bluehole (= Ganter Cave, Ganter Spring)*
McCoy Blue Hole	McCoy Blue Hole
Mile 205.7 Spring	Mile 205.7 Spring
Pike Spring	Pike Spring
Running Branch	Running Branch
Suds Spring	Suds Spring
Turnhole Spring	Turnhole Spring
	River Styx Spring
	Great Onyx Spring

*The Recovery Plan refers to Ganter Cave and the 2010 5-year Review refers to Ganter Spring. These are the same basin and now recognized as Ganter Bluehole.

In addition, the recovery plan (Service 1988) and subsequent 5-year reviews (Service 2010, 2016) also state that 6 of the previously recognized basins occur wholly or partially within Mammoth Cave National Park. Based on watershed revisions and the inclusion of River Styx Spring and Great Onyx Spring, there are now 9 occupied basins that occur wholly or partially within the park (Figure 1).

While the amount of available Kentucky cave shrimp habitat within each groundwater basin is unknown, the 11 groundwater basins total approximately 103,955 acres. The River Styx Spring, Great Onyx Spring, Ganter Cave, and Running Branch groundwater basins occur entirely within park boundary, as does the majority of Echo River Spring. Mile 207.5, Pike Spring, and Turnhole Spring groundwater basins have substantial portions both within and outside of the park boundary. McCoy Blue Hole and Suds groundwater basins are entirely outside the park boundary, as is the majority of Double Sink. In total, approximately 19,148 acres (18%) of the 11 groundwater basins occur within Mammoth Cave National Park and approximately 84,807 acres (82%) occur outside of the park boundary (Table 2).

Because this species' primary habitat includes large, base level passages of caves, assessing species abundance, populations, and distribution is difficult, time consuming, and in some cases involves risk to surveyors. Therefore, population estimates have not been updated since the 1988 (Service 1988).

c. Genetics:

Stump (2019) collected environmental DNA (eDNA) samples at 11 sites from the Mammoth Cave National Park area between September 2012 and September 2013. The primary intent of the study was to determine if eDNA would be useful in detecting the presence of Kentucky cave shrimp in karst drainages (see section C.1.e); however, the study also sequenced eDNA amplicons for the mitochondrial gene cytochrome C oxidase subunit 1 (COI) and identified seven haplotypes

presumed to belong to the Kentucky cave shrimp. The study found no clear pattern between haplotype distribution and the current sub-basin drainages. Stump (2019) hypothesized that this could be due to female shrimp being carried out of upriver sub-basins during high flow events and deposited further downstream where they migrate into cave systems and reproduce. No additional genetic information is available.

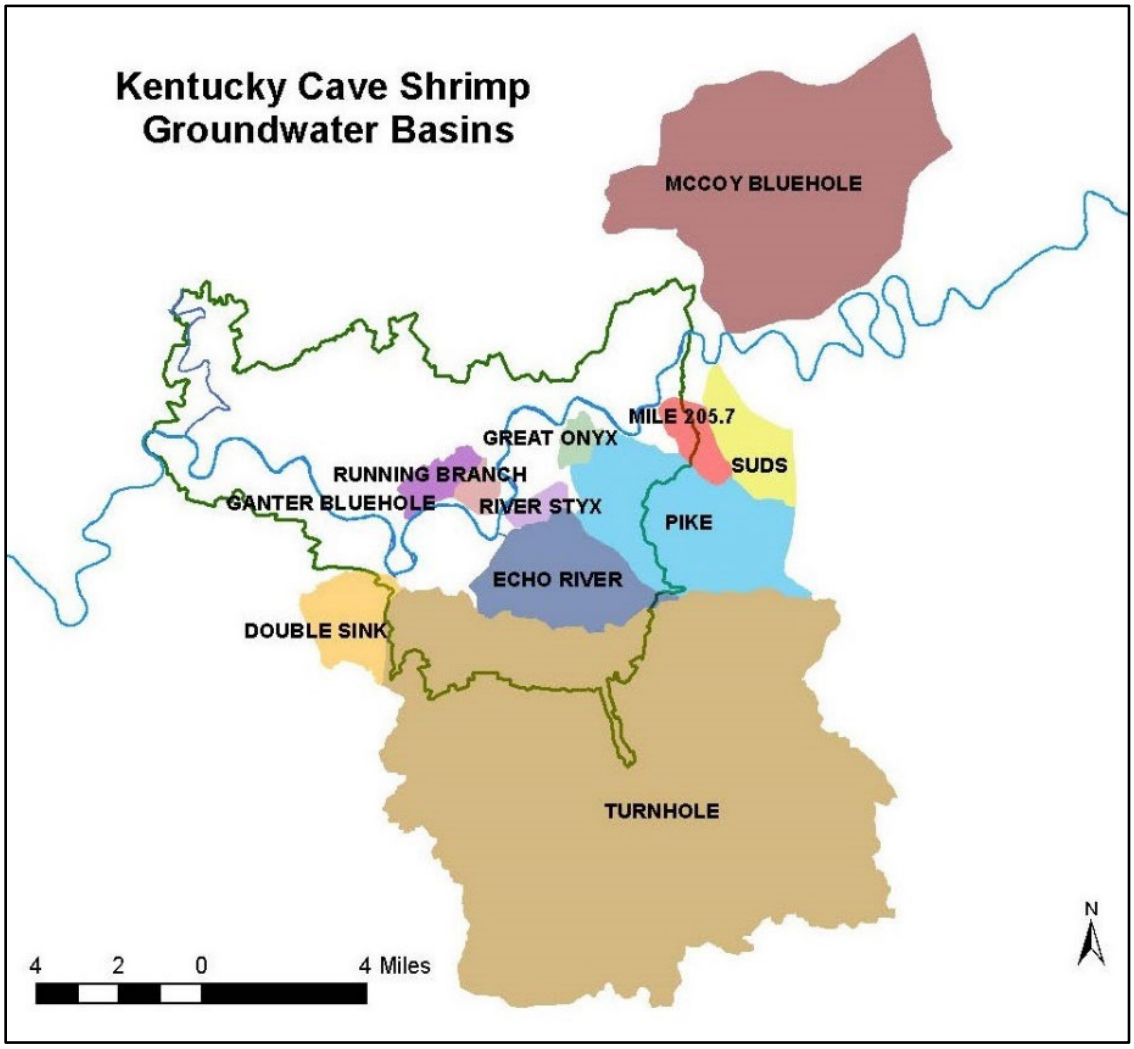

Figure 1. Kentucky cave shrimp groundwater basins. Mammoth Cave National Park is indicated by the green polygon and the Green River is indicated by the blue line shown traversing through the middle of the figure.

Table 2. Kentucky cave shrimp groundwater basins and approximate acreages in and out of Mammoth Cave National Park (MCNP).

Groundwater Basin	Total Approximate Acreage	Approximate Acreage within MCNP	Approximate Acreage outside MCNP
Echo River Spring	5,362	5,286	77
Double Sink	2,743	111	2,632
Ganter Bluehole	1,025	1,025	0
McCoy Blue Hole	22,032	0	22,032
Mile 205.7 Spring	1,226	499	726
Pike Spring	9,079	3,524	5,555
Running Branch	526	526	0
Suds Spring	2,597	0	2,597
Turnhole Spring	58,102	6,914	51,188
River Styx Spring	556	556	0
Great Onyx Spring	707	707	0
Total	**103,955**	**19,148**	**84,807**

d. Taxonomic classification or changes in nomenclature:

We are not aware of any changes to the Kentucky cave shrimp's taxonomic classification or nomenclature; therefore, the listed entity's taxonomy remains valid.

e. Distribution and trends in spatial distribution:

As referenced above, the species is now considered to occupy 11 groundwater basins (Figure 1). River Styx Spring was historically considered part of Echo River Springs and is now recognized as a separate basin. In 2019, a survey team with the National Park Service observed the Kentucky cave shrimp in Blindfish River. Dye tracing indicated that Blindfish River drains into the Great Onyx Spring groundwater basin, thereby expanding the distribution to include the Great Onyx Spring groundwater basin (Rick Toomey, personal communication, January 2022).

Stump (2019) collected eDNA samples at 11 sites within 9 groundwater basins known to be occupied by the Kentucky cave shrimp within the Mammoth Cave Park area. The 11 sites included two locations within the Echo River Spring groundwater basin, two locations within the Turnhole Spring groundwater basin, and one site each in the Ganter Bluehole, McCoy Bluehole, Mile 205.7 Spring, Pike Spring, River Styx Spring, Running Branch, and Suds Spring groundwater basins. The sample from the Mile 205.7 Spring groundwater basin site and one site within the Turnhole Spring groundwater basin were eliminated from evaluation due to contamination. Kentucky cave shrimp were detected at 7 of the 9 sites evaluated; however, no Kentucky cave shrimp were detected at either site within the Echo River Spring groundwater basin. The Echo River Spring groundwater basin is known to support high numbers of Kentucky cave shrimp

(Rick Toomey, personal communication, August 2018); therefore, the negative detection is thought to be attributed to either (1) high flows in the basin (Rick Toomey, personal communication, August 2018) or (2) because the discarded extracellular DNA may be highly sought after as a nutrient source by scavenger species (Stump 2019) and is not, therefore, indicative of species absence in that groundwater basin.

The 11 groundwater basins currently considered extant encompass approximately 103,955 acres; however, the amount of available habitat within each basin or the extent to which each groundwater basin is occupied are unknown.

f. Habitat or ecosystem conditions:

The Kentucky cave shrimp has very specific habitat requirements – water in large, base level passages of caves characterized by slow flow, abundant organic matter, and coarse to fine grain sand and coarse silt sediments (Service 2010). All of the occupied groundwater basins are connected to the Green River; therefore, the hydrology of the groundwater basins is influenced by the water level of the river. When the river exhibits low or normal flow, groundwater flows from the springs into the river. During high flow, water from the river may backflow into the basins through the springs, depending on the force of the river and the amount of groundwater flowing from the basin. When water backflows into the groundwater basins, sediment, detritus, and other organic material from the river are deposited in the basins (USACE 2021).

The construction of Green River Lock and Dam 6, which became operational in 1906, impounded 25.7 kilometers (16 miles) of the Green River mainstem within Mammoth Cave National Park (Service 2010). The loss of free-flowing conditions negatively impacted the Kentucky cave shrimp by causing siltation that buried sand and gravel substrates where the species feeds and hindered downstream transport of organic matter (Poulson 1992). According to assessments and reviews completed by three federal agencies, the removal of Green River Lock and Dam 6 would benefit the Kentucky cave shrimp by restoring the free-flowing nature of the Green River and preventing future sedimentation (Widlak 1999; USACE 2014; Olson 2005).

A partial, uncontrolled breach of Green River Lock and Dam 6 occurred in November 2016, causing a partial loss of the pool, movement of a portion of the riverward lock wall, and other structural failures to the facility (Service 2018). Water levels at the dam site dropped by 11 feet and impacts extended approximately 12 miles upstream into Mammoth Cave National Park. In response to the breach, the Service's Aquatic Habitat Restoration Team began removal of Green River Lock and Dam 6 in March 2017 and completed removal by September 2017. Monitoring of portions of this upstream habitat by Mammoth Cave National Park staff indicated that there were no major changes in hydrology that would negatively affect the Kentucky cave shrimp (USACE 2021). Specifically, the habitat maintained sufficient water and water depth to support the Kentucky cave shrimp.

The Service expects that removal of Green River Lock and Dam 6 and restoration of this portion of the Green River to free-flowing conditions has directly benefited the species by returning the groundwater basins to conditions that more closely approximates the natural environment where the species evolved.

2. Five-factor analysis (threats, conservation measures, and regulatory mechanisms)

The purpose of a 5-year review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of Act protections may shed light on some future activities that constitute threats to the species; however, the analysis under Factor D (Inadequacy of Existing Regulatory Mechanisms) focuses on the adequacy of existing alternative (i.e., non-Endangered Species Act) mechanisms to address the continuing and foreseeable threats. Given this framework and the limited amount of new information available on the species, the 5-factor analysis presented in the Service's 2010 5-year review remains applicable to Kentucky cave shrimp and is summarized below.

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

Groundwater contamination via human-related activities continues to represent the greatest threat to the Kentucky cave shrimp (detailed information is provided in the listing rule (Service 1983), the recovery plan (Service 1988), and the 2016 5-year review (Service 2016)). Based on a qualitative review of U.S. Geological Survey National Landcover Database using the Multi-Resolution Land Characteristics Consortium viewer, there have been no major landcover changes in the area from 2011 to 2019. Because of the extensive karst systems in the Mammoth Cave region, pollutants associated with these contaminant sources can quickly enter groundwater basins through sinkholes, sinking streams, and other karst features and travel rapidly downstream to where they can adversely affect cave shrimp populations through direct impacts to individuals, degradation of habitat, and reduction of food resources for the species. In addition, the sinkholes, springs, and underground streams that occur throughout karst systems likely provide very little filtering of pollutants when surface water enters the subterranean system (Butscher and Huggenberger 2009). Contamination events are difficult to monitor in underground habitats; however, past occurrences of contamination events were detailed in the 2010 5-year review (Service 2010). Although some protections are in place, there is no expectation that this threat will ever be eliminated and will continue to threaten the species in the future, especially because 85.6% of the occupied groundwater basin acreages occur outside of Mammoth Cave National Park and some sources of contamination, like those from traffic accidents, can occur even within the park.

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

The Kentucky cave shrimp is not overutilized for commercial, recreational, scientific, or educational purposes. Consequently, this listing factor is not considered a threat to the species.

c. Disease or predation:

The 2010 5-year review mentions that rainbow trout (*Oncorhynchus mykiss*) occur in the same systems as the Kentucky cave shrimp; however, according to the Kentucky Department of Fish and Wildlife Resources, trout stocking no longer occurs in the proximity of any of the occupied groundwater basins. The nearest trout stocking location is in the Nolin River Lake Tailwater in Edmonson County, Kentucky (Eric Cummins, personal communication, March 2022), which is over 7 miles upstream of the confluence with the Green River and more than 15 miles from the nearest occupied groundwater basins (Double Sink and Ganter Blue Hole). In addition, there no evidence that predation from trout is considered a threat to the species; therefore, potential predation by trout is not likely to be a threat to the species. Likewise, there is no information that would indicate that disease is a threat to the species.

d. Inadequacy of existing regulatory mechanisms:

The Kentucky cave shrimp and its habitats are afforded some protection from water quality and habitat degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.), Kentucky's Agriculture Water Quality Act of 1994 (KRS 224. 71-140), Kentucky's Groundwater Protection Plan (KRS 224; 401 KAR 5:037), and additional Kentucky laws and regulations regarding natural resources and environmental protection (KRS 146.200-360; KRS 224; 401 KAR 5:026, 5:031). The species is afforded some protection from groundwater pollution and habitat disturbance because 4 of the 11 occupied groundwater basins occur entirely within Mammoth Cave National Park and an additional 5 basins occur partially within the park. While these basins, or portions of basins, are managed in a way to protect underground resources, they only comprise approximately 18% of the total acreage of occupied groundwater basins.

The Kentucky cave shrimp has been designated as an endangered species by the Commonwealth of Kentucky (KSNPC 2005), but this designation conveys limited protection under state law. Kentucky law prohibits the collection of the species for scientific purposes without a valid state-issued collecting permit (KRS 150.183), but this regulation provides no protection to the species' habitat.

Despite the limited protection afforded by the laws and corresponding regulations cited above, the Kentucky cave shrimp continues to be threatened by groundwater contamination. Existing regulatory mechanisms have not been adequate in protecting the species and its habitat from these impacts.

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

The species' low relative abundance and restricted distribution continue to make it vulnerable to extirpation from toxic chemical spills, habitat modification, nonpoint-source pollutions, and natural catastrophic changes to their habitat (e.g., flood scour, drought). The low density and abundance of Kentucky cave shrimp populations may limit the natural interchange of genetic material between these populations, and the small population size reduces the reservoir of genetic diversity within populations. This can lead to inbreeding depression and reduced fitness of individuals, and it is possible that some of the populations are below the effective population size required to maintain long-term genetic and population viability (Soule 1980; Hunter 2002).

While we are unaware of any species-specific climate change studies, climate change is predicted to have significant impacts on the levels, quality, and sustainability of groundwater through direct influence on groundwater organisms, environmental conditions, and ecosystem processes (Taylor et al. 2013). Changes in water temperature, dissolved oxygen, recharge rates, altered hydrological regime, groundwater levels, and groundwater quality are expected (Taylor et al. 2013). Many groundwater species may be particularly vulnerable to impacts of climate change because of their unique habitat requirements, endemicity, adaptations, and often limited dispersal abilities (Taylor and Niemiller 2016). Other impacts from the changing climate, e.g., increases in extreme storm events and resultant flooding in eastern North America (Intergovernmental Panel on Climate Change 2021), could increase contamination of ground water resources through transportation in flood waters putting these basins at further risk.

D. Synthesis

The Kentucky cave shrimp is a small, blind, freshwater crustacean (Order Decapoda), which feeds by grazing the surface of sediments in the waters of large, base level passages of caves. The species is restricted to 11 groundwater basins in the Mammoth Cave National Park region of central Kentucky. The region's sinkholes, sinking streams, and other karst features allow pollutants to quickly enter groundwater systems and travel downstream to where they can adversely affect cave shrimp populations. Population estimates have not been revised since 1988; however, the perceived low abundance of Kentucky cave shrimp in each of its groundwater basins makes these populations vulnerable to catastrophic contamination events that could lead to extirpation. Due to the varied sources and unpredictable nature of these contaminants, current regulatory mechanisms have been ineffective in preventing these impacts. The species is afforded some protection from groundwater pollution and habitat disturbance because 4 of the 11 occupied groundwater basins occur entirely within federal land that is managed in a way to protect underground resources. In addition, the species is likely vulnerable to the effects of climate change including changes in water temperature, dissolved oxygen, recharge rates, altered hydrological regime, groundwater levels, and groundwater quality. While the removal of the Green River Lock and Dam 6 has likely contributed to restoring Kentucky cave shrimp habitat to a more natural condition, populations may still have limited natural

interchange of genetic material that could lead to inbreeding depression and reduced fitness of individuals. It is possible that some of the cave shrimp populations are below the effective population size required to maintain long-term genetic and population viability. Because of their restricted distribution and continued vulnerability to threats, we believe that the species continues to meet the definition of endangered.

III. RESULTS

A. Recommended Classification:

_____ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist (Indicate reasons for delisting per 50 CFR 424.11):
  _____ Extinction
  _____ Recovery
_____ Original data for classification in error
__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIVITIES

A list of recovery actions is provided in the recovery plan (Service 1988) and additional items were included in the 2016 5-year review (Service 2016). The following activities are added to support and promote recovery of Kentucky cave shrimp.

- Determine the level of genetic exchange between populations. Information on cave shrimp movements within the basin would provide important information on the long-term viability of the species.
- As indicated in Stump (2019), eDNA has shown to be a useful method for determining presence of the species in areas that are difficult to sample; therefore, continue eDNA sampling to determine if the the species could be present in Mammoth Cave National Park staff have identified the Buffalo Creek, Floating Mill, Sand Cave, Grinstead Mill, Big Spring, Ugly Creek, Lawler Bluehole, Gorin Mill, and Graham Spring groundwater basins.
- Continue to refine the delineation of known groundwater basins and assess the potential threats associated with each basin.
- Obtain a revised population estimate.

V. REFERENCES

Butscher, C., and P. Huggenberger. 2009. Modeling the temporal variability of karst groundwater vulnerability, with implication for climate change. Environmental Science and Technology 43:1665–1669.

Hunter, M.L., Jr. 2002. Fundamentals of conservation biology, second edition. Blackwell Science, Inc. Malden, Massachusetts. 547 pp.

Intergovernmental Panel on Climate Change. In press. 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-

Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. 39 pp.

Kentucky State Nature Preserves Commission (KSNPC[1]). 2005. Rare and extirpated biota of Kentucky. 19 pp.

Olson, R. 2005. The ecological effects of Lock and Dam 6 in Mammoth Cave National Park *In* D. Harmon, ed., People, Places, and Parks: Proceedings of the 2005 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites 294-299. Hancock, Michigan.

Poulson, T. 1992. The Mammoth Cave ecosystem *In* The Natural History of Biospeology. A. I. Camacho, ed. Monographs of the National Museum of Natural Sciences. Madrid: National Museum of Natural Sciences p. 564-611.

Soule, M.E. 1980. Threshold for survival: maintaining fitness and evolutionary potential. Pages 151-169 *In* M.E. Soule and B.A. Wilcox, eds. Conservation Biology. Sinauer Assocaites, Inc., Sunderland, Massachusetts.

Stump, A.J. 2019. The use of environmental DNA for the detection of *Palaemonias ganteri* (Hay 1901), a federally endangered cave species. Online Theses and Dissertations. 651. https://encompass.eku.edu/etd/651

Taylor, S.J., and M.L. Niemiller. 2016. Biogeography and conservation assessment of Bactrurus groundwater amphipods (Crangonyctidae) in the central and eastern United States. Subterranean Biology 17: 1–29.

Taylor, R., B. Scanlon, and P. Döll. 2013. Ground water and climate change. Nature Climate Change 3:322–329.

U.S. Army Corps of Engineers (USACE). 2014. Environmental assessment of Green River Lock and Dam Nos. 3, 4, 5, 6 and Barren River No. 1. Louisville, Kentucky. 78 pp.

U.S. Army Corps of Engineers (USACE). 2021. Final biological assessment on the Green River Lock and Dam 5 Removal project prepared by Redwing Ecological Services, Inc. 136 pp.

U.S. Fish and Wildlife Service (Service). 1983. Determination of Endangered Status and Designation of Critical Habitat for the Kentucky Cave Shrimp. 48 FR 46337-46342.

U.S. Fish and Wildlife Service (Service). 1988. Kentucky Cave Shrimp Recovery Plan. Atlanta, Georgia. 47 pp.

U.S. Fish and Wildlife Service (Service). 1994. The Kentucky Cave Shrimp. Unpublished endangered species information sheet. Asheville, North Carolina. 2 pp.

U.S. Fish and Wildlife Service (Service). 2010. Kentucky Cave Shrimp 5-year Review. Atlanta, Georgia. 14 pp.

U.S. Fish and Wildlife Service (Service). 2016. Kentucky Cave Shrimp 5-year Review. Atlanta, Georgia. 2 pp.

[1] The Kentucky State Nature Preserves is now the Office of State Nature Preserves

U.S. Fish and Wildlife Service (Service). 2018. Conclusion of emergency consultation on removal of Green River Lock and Dam 6. Frankfort, Kentucky. 4 pp.

Widlak, J. 1999. Fish and Wildlife Coordination Act report for the Green and Barren Rivers disposition study. Cookeville, Tennessee.

U.S. FISH AND WILDLIFE SERVICE
5-Year Review of Kentucky Cave Shrimp (*Palaemonias ganteri*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

_____ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist
__X__ No change needed

Review Conducted By: Carrie Allison, Kentucky Ecological Services Field Office

APPROVALS / SIGNATURES

FIELD OFFICE APPROVAL:

Field Supervisor Kentucky Ecological Services Field Office, Fish and Wildlife Service*

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2022.04.27 11:33:26 -04'00' Date 04/27/2022

*Since 2014, Field Supervisors in the Region have been delegated authority to approve 5-year reviews that do not recommend a status change.