Kentucky Cave Shrimp
(Palaemonias ganteri)

5-Year Review:
Summary and Evaluation

(photo courtesy of KY Dept of Fish and Wildlife Resources)

U.S. Fish and Wildlife Service
Southeast Region
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

Public notice of this five-year review was provided in the *Federal Register* on September 21, 2007 (72 FR 54057), and a 60-day comment period was opened. During this comment period, we obtained information on the status of this species from several experts. Additional data was obtained to complete this review from the recovery plan, peer-reviewed scientific publications, and unpublished field observations and data by Service, State, and other experienced biologists and personal communications. Once all known literature and information was collected for this species, Dr. Michael A. Floyd, lead Recovery Biologist with the Kentucky Ecological Services Field Office, completed the review. The draft document was peer-reviewed by Dr. Julian Lewis, Lewis and Associates, Borden, Indiana; Mr. Ryan Evans, Kentucky State Nature Preserves Commission (KSNPC), Frankfort, Kentucky; and Mr. Rick Olson, Mammoth Cave National Park, Mammoth Cave, Kentucky; and comments received were incorporated as appropriate (see Appendix A).

B. Reviewers

Lead Field Office: Dr. Michael A. Floyd, Kentucky Ecological Services Field Office, (502) 695-0468, ext 102

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

Peer Reviewers: Dr. Julian Lewis, Lewis and Associates, LLC
Mr. Rick Olson, Mammoth Cave National Park
Mr. Ryan Evans, Kentucky State Nature Preserves Commission

C. Background

1. FR Notice citation announcing initiation of this review:
72 FR 54057 (September 21, 2007)

2. Species Status: Uncertain (2009 Recovery Data Call). Virtually no information on population trends is available for the past year (or the past several years). We are unable to make any conclusion with regard to species status because we do not know if population numbers are stable or how the populations have responded to current threats.

3. Recovery Achieved: 1 (0-25% recovery objectives achieved)

4. Listing history:

FR notice: 48 FR 46337
Date listed: October 12, 1983
Entity listed: Species
Classification: Endangered

5. Review History:

A previous 5-year review for this species was noticed on November 6, l991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors, threats, etc. as they pertained to the individual species. The notices summarily listed these species and stated that no changes in the designation of these species were warranted at that time. In particular, no changes were proposed for the status of the species in this review.

Recovery Plan for Kentucky Cave Shrimp (*Palaemonias ganteri*). 1988.

Recovery Data Call, 2000-2009

6. Species' Recovery Priority Number at start of 5-year review (48 FR 43098):

5, the Kentucky cave shrimp is taxonomically categorized as a species, has a high degree of threat, and has a low recovery potential.

7. 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

Is the species under review listed as a DPS? No. This species is an invertebrate, therefore the DPS policy is not applicable to this species.

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 done 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? Yes, but the criteria are vague in that several terms (*e.g*., protection, viability, reproducing population) are not defined.

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

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.

   This criterion has been partially met: Permanent protection has been achieved for three of the nine groundwater basins known to support populations of *P. ganteri* - Echo River Spring, Ganter Spring and Running Branch Spring. The latter two basins lie entirely within Mammoth Cave National Park (MCNP) in Kentucky, and except for a small area along its southeastern border, the majority of the Echo River Spring groundwater basin also occurs within MCNP (USFWS 1988). Portions of three other basins, Mile 205.7 Spring, Pike Spring, and Turnhole Spring, are afforded some protection because they occur within MCNP. No current information (within the last 10 years) exists on population size or viability, so it is not known if any of the Kentucky cave shrimp populations are viable and/or reproducing.

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.

   This criterion has been partially met: See discussion above.

   In addition to not being met, these recovery criteria are vague, in that: population viability, population protection, and habitat protection are not well defined. Several recovery tasks are intended to address habitat and population protection, but the needs of this species, including its environmental tolerances, are not well understood.

C. 1. Updated Information and Current Species Status

A brief synopsis of the Kentucky cave shrimp's appearance, biology, and habitat was provided by USFWS (1994). The species is a small, blind, freshwater crustacean (Order Decapoda) reaching a maximum total length of 30 mm (1.2 inches). It has a translucent body (the body lacks pigment) that makes it very difficult to see during survey efforts. Aquarium studies have resulted in life span estimates of 10 to 15 years. The Kentucky cave shrimp feeds by grazing the surface of sediments in caves, consuming protozoans, algal cells, fungi, and other organic materials. The species has very specific habitat requirements - large, base level passages of caves characterized by slow flow, abundant organic matter, and coarse to fine grain sand and coarse silt sediments. Female shrimp have been found with eggs at all times of the year; consequently, reproduction appears to be continual and not seasonal. Some evidence suggests, however, that seasonal reproduction does occur subsequent to flooding events and the subsequent additional food supply. Females carry their clutch of eggs (up to 33) tucked under their abdomen. It is not known whether females reproduce more than once in their lifetime.

Detailed information on taxonomic classification, current distribution, ecology and life history, population biology, and habitat requirements for the Kentucky cave shrimp was provided by Holsinger and Leitheuser (1982a, pp. 1-34; 1982b, pp. 1-64; 1983, pp. 1-31), Leitheuser and Holsinger (1983, pp. 1-44), Lisowski (1983, pp. 88-92), Leitheuser and Holsinger (1985, pp. 1-102), and Leitheuser *et al*. (1986, pp. 1-35) in the early to mid-1980s. This information was summarized in the species' recovery plan (USFWS 1988). As noted in the recovery plan, the species' known distribution is limited to nine groundwater basins in the Mammoth Cave National Park region of central Kentucky (USFWS 1988). These groundwater basins include Echo River Spring, Ganter Spring, Running Branch Spring, Mile 205.7 Spring, Pike Spring, Double Sink (Sandhouse Cave), Turnhole Spring, McCoy Blue Spring, and Suds Spring (Figure 1, FWS 2007).

The only new or recent information on the species' biology and habitat was provided by Pearson and Jones (1998), who conducted faunal inventories and habitat analyses at 10 sites within the Mammoth Cave System over a three-year period from 1993 to 1995. They observed individuals of *P. ganteri* at 6 of 10 historic sites, with the greatest abundances observed in 1995. Individuals of *P. ganteri* were observed at Colossal River in 1994 (1 shrimp); Mystic River in 1993 (8), 1994 (33), and 1995 (233); Golden Triangle Area in 1994 (25) and 1995 (45); Roaring River in 1994 (32) and 1995 (34); Shrimp Pools at Roaring River in 1995 (4); and Echo/Styx River in 1994 (6) and 1995 (2). For sites where Kentucky cave shrimp was present, estimates of shrimp density ranged from 0.0006 shrimp/m^2 (0.00005/ft^2) to 0.262 shrimp/m^2 (0.24/ft^2). Earlier density estimates provided by Holsinger and Leitheuser (1982b; 1983) were based on one dimension – the length of passage – resulting in numbers of shrimp per linear meter (or foot) of passage. These estimates ranged from 0.006

shrimp/m (0.002 shrimp/ft) to 0.66 shrimp/m (0.2 shrimp/ft). Tentative population estimates for each groundwater basin were provided in the recovery plan (USFWS 1988). These included Echo River Spring (750 individuals), Ganter Spring (150), Running Branch Spring (300), Mile 205.7 Spring (50), Pike Spring (5,000 to 10,000), Double Sink (unknown), Turnhole Spring (unknown), McCoy Blue Spring (unknown), and Suds Spring (500). More recent population estimates are unavailable.

As part of an environmental analysis to assess potential impacts of a 4.2-km (2.6-mile) connector highway between US 31W and I-65 in Warren County, Lewis and Lewis (2005) surveyed 12 sites within the Graham Springs Groundwater Basin using visual searches and baited jar traps. The Graham Springs Basin is located adjacent to and just west of known shrimp habitat in the Turnhole Springs Basin (Figure 1). No Kentucky cave shrimp individuals were located during the survey. However, time constraints and the fact that the headwater area of the Graham Springs Basin was far removed from the highway project area led to less examination of the area than might be prudent (Dr. Julian Lewis, Lewis and Associates, personal communication, 2008). At least one area of potentially good habitat for the Kentucky cave shrimp was identified by Lewis & Lewis (2005) and this site should be re-examined for the presence of the shrimp. Other potential habitat in the upstream Graham Springs Basin might well exist, as well as adjacent areas along the escarpment area. Although there were no historic records of the species from the Graham Springs Basin, Lewis and Lewis (2005) hypothesized that the species could have occurred historically in the basin but was now extirpated due to the extensive habitat degradation (e.g., sedimentation, illegal dumps) observed during their survey.

Another possibility that might be explored is the Hidden River Cave groundwater system (Dr. Julian Lewis, Lewis and Associates, personal communication, 2008). Although this system is still having periodic episodes of groundwater degradation, the overall water quality has improved dramatically as compared to 20 years ago. It would be of interest to carefully examine this cave for the presence of the Kentucky Cave shrimp.

2. Five-factor analysis:

a. Present or threatened destruction, modification or curtailment of its habitat or range: Groundwater contamination represents the greatest threat to the Kentucky cave shrimp (USFWS 1988). Sources of this contamination include random traffic accidents (*e.g.*, trucks carrying toxic chemicals) along Interstate 65 (I-65) and other local highways; oil and gas activities; agriculture; permitted discharges from industry, wastewater treatment plants, and other sources; and general nonpoint-source pollution (USFWS 1988). 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.

The recovery plan provided details on three separate traffic accidents in the mid-

1980s that had the potential to adversely affect the species (USFWS 1988). A tanker truck overturned on I-65 in May 1985 near the Cumberland Parkway interchange (mile 43), spilling cresol (an organic compound commonly used as a disinfectant or deodorizer). A spill of hazardous synthetic solvents occurred on I-65 (mile 59) near its crossing of the Green River in November 1985. A train derailment in November 1985 threatened to send approximately 3,400 liters (900 gallons) each of an unidentified pesticide and methyl alcohol into the cave systems important to the shrimp. Fortunately, in each of these cases, state and federal authorities were able to successfully contain the spill prior to leakage into groundwater systems. Traffic accidents continue to represent a threat to the species as truck traffic along I-65 and other local highways has actually increased over time (Dave Harmon, KYTC, personal communication, 2008). Traffic data obtained from the KYTC revealed that between August 2004 and August 2008, 248 traffic accidents occurred on I-65 between mile points 43 and 53 in Edmonson and Barren counties, adjacent to MCNP (Dave Harmon, KYTC, personal communication, 2008). Eighty-one of these accidents involved vehicles that potentially carried substances (*e.g.,* chemicals) that, if spilled, could represent a threat to groundwater basins. Pursuant to Design Memorandum No. 12-05 announced in July 2005, the Kentucky Transportation Cabinet adopted a policy on best management practices (e.g., runoff and spill retention/filtration structures) to be used during construction and maintenance/operations of all roads on the National Highway System located in Karst and Significant Resource Areas (Dave Harmon, KYTC, personal communication, 2008). Areas along the I-65 corridor in Barren, Edmonson, Hart, and Warren counties fall under this policy.

Portions of the Double Sink, Turnhole, McCoy Blue Spring, Suds Spring, Pike Spring, and Mile 205.7 Spring groundwater basins are located in oil fields where oil and natural gas wells are drilled (USFWS 1988; KGS 2008). According to well data retrieved from the KGS (2008), hundreds of oil and gas wells occupy these areas. If not contained properly, brine from these wells can enter sinkholes or be washed into surface streams during storm flows. Drillers also sometimes pull out well casings, leading to intrusion into caves of oil, gas, and brine. Numerous, abandoned oil and gas wells in the region have been left open and have the potential to adversely affect groundwater basins. At present, the Kentucky Division of Oil and Gas Conservation, the state authority who grants permits in Kentucky, is not required under section 7 of the ESA to consult with the Service on potential impacts to listed species. Consequently, the Kentucky Ecological Services Field Office (KFO) does not review permits for areas surrounding MCNP that could impact cave shrimp basins.

Agricultural activities have the potential to contribute significant quantities of sediment, as well as introduce organic waste, fertilizers, herbicides, and pesticides, into groundwater systems (Crawford 1989; KDOW 1991). Sediment (siltation) has been listed repeatedly by the Kentucky Natural Resources and Environmental Protection Cabinet (Division of Water) as one of the most common stressors of aquatic communities in the Green River watershed (KDOW 2004; KDOW 2008); agriculture was listed as the primary source of the siltation. These KDOW reports focus mainly on surface systems, but these same

pollutants undoubtedly affect groundwater systems that underlie this karst region. Increased siltation may cause a decline in the available food supply for Kentucky cave shrimp by limiting the available habitat for stream interstitial fauna (USFWS 1988). This fauna is a large and significant portion of the food web base in cave streams and is very habitat specific (USFWS 1988). According to KDOW (2006), nonpoint-source impacts on groundwater in Kentucky are caused primarily by agriculturally related nutrients and pesticides. Pollutants of concern include nitrates (from fertilizer application, manure storage and application, and animal feeding operations), pesticides (*e.g*., atrazine), and herbicides.

Permitted dischargers within Barren, Edmonson, Hart, and Warren counties include wastewater treatment plants, various industrial sites, limestone quarries, public schools, and other miscellaneous entities (Vicki Prather, KDOW, personal communication 2008). All of these permitted discharges have the potential to adversely affect the Kentucky cave shrimp, but each is routinely monitored to ensure that they are not exceeding effluent limits; consequently, they generally do not represent a significant threat. Of special interest, however, are limestone quarries that have the potential to interrupt karst drainage patterns and introduce sediment into karst systems. A recent permit (KPDES #KY0106747) for a proposed limestone quarry in Edmonson County has the potential to negatively impact the Kentucky cave shrimp because it occurs within an area that discharges directly into the Turnhole Springs groundwater basin. Quarry operations could negatively affect water quality and habitat conditions within the Turnhole Springs basin by introducing sediment or altering air and water flows within the system. The permit has been issued and adjudicated, but the permittee has not yet opened the quarry, possibly due to economic conditions (L. Sowder, KDOW, pers. comm., 2009). A signed agreed order requires that KDOW call an interested party meeting when the permittee is ready to open.

Urban areas impact groundwater systems through stormwater runoff that introduces contaminants such as metals, oil and grease, road salt and deicers, bacteria (*e.g*., *Escherichia coli*), nutrients and pesticides (Crawford 1989; KDOW 2006; Rick Olson, MCNP, personal communication, 2008). Septic tank effluent has been shown to travel through the thin soils of karst areas into groundwater systems in only a few hours (Crawford 1989). Due primarily to the presence of pathogens (*e.g*., *Escherichia coli*), 10 springs within the Green River basin have been identified as impaired by the KDOW and included on their 303d list of impaired waters (KDOW 2008). One of these basins, McCoy-Blue Hole Spring, is known to support a population of the Kentucky cave shrimp. The source of these pathogens was listed as unknown. Contamination of groundwater systems is also caused by the practice of disposing of solid and liquid wastes in sinkholes (e.g., sinkhole dumps), where these contaminants can be washed directly and quickly into the groundwater system (Crawford 1989). These dumps can contain a variety of harmful chemicals, including petroleum products, solvents, metals, pesticides, and herbicides.

According to Poulson (1992), Lock and Dam No. 6 on the Green River, which impounds 25.7 km (16 mi) of the Green River's mainstem within Mammoth Cave National Park, has had an adverse effect on the Kentucky cave shrimp. The loss of free flow conditions caused by the impoundment has resulted in siltation of shrimp habitat. This siltation has buried sand and gravel substrates where shrimp feed and also has hindered downstream transport of organic matter. A somewhat bizarre flow pattern has also been observed within the Mammoth Cave system, probably as a by-product of the dam, in which water from the Green River (under some flow conditions) actually enters Mammoth Cave rather than emerges from it (Dr. Julian Lewis, Lewis and Associates, personal communication, 2008). During this scenario, water from the Green River apparently enters Mammoth Cave via the Styx Spring, flows across the Styx River, enters Echo River, and then discharges from Echo River Spring. This introduces surface water that differs physically and chemically, not to mention biologically, from that naturally present in the cave. According to assessments and reviews completed by three federal agencies, the removal of Lock and Dam No. 6 would benefit the Kentucky cave shrimp by restoring the free-flowing nature of the Green River and preventing future sedimentation of cave shrimp habitats (Widlak 1999; USACE 2004; Olson 2005).

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:

A potential predator to the Kentucky cave shrimp, the rainbow trout (*Salmo gairdneri*), was introduced into streams of the Green River basin (*e.g*., tailwaters of Nolin Lake and Lynn Camp Creek) during the early 1970s (Clay 1975) by the Kentucky Department of Fish and Wildlife Resources. The species was later observed in some spring and cave habitats that support populations of Kentucky cave shrimp. Leitheuser and Holsinger (1983) reported an observation of two rainbow trout (30.5-38.1 cm [12-15 in]) eating a Kentucky cave shrimp in Pike Spring in September 1983. A total of seven trout were reported by Leitheuser and Holsinger in Pike Spring. Since that time, rainbow trout have not been observed in Pike Spring, and the species appears to have been extirpated (Rick Olson, MCNP, personal communication, 2008). Consequently, predation from trout is not considered a threat to the species. Likewise, disease is not known to represent 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 also afforded protection by the Endangered

Species Act (Act) of 1973, as amended (87 Stat. 884, as amended: 16 U.S.C. 1531 *et seq*), which requires federal agencies to consult with the Service when activities they fund, authorize, or carry out may affect a listed species. The Act requires federal permits for any activity that may result in "take" of a listed species. The species is afforded some protection from groundwater pollution and habitat disturbance because six of the nine groundwater basins in which it occurs lie wholly or partially on federal land (MCNP). Further protection is afforded by Sections 7(a)(1) and 7(a)(2) of the Act, which requires MCNP to carry out programs for the conservation of the Kentucky cave shrimp and to consult with the Service on any actions authorized, funded, or carried out by them to insure that these actions do not jeopardize the continued existence of the species.

The Kentucky cave shrimp has been designated as an endangered species by 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 resulting from poor land use practices (siltation), and other nonpoint-source pollutants (inadequate sewage treatment, traffic accidents, oil and gas well releases). 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 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 reduced 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 (Soule 1980; Hunter 2002). 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).

D. Synthesis

Since completion of the recovery plan in 1988, little new information is available on the species' status or threats; however, the general threats to the species remain the same. Groundwater contamination (via numerous sources) continues to be the primary threat to the species. 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. Contaminant sources include traffic accidents (involving toxic chemicals), agricultural activities, resource extraction (limestone quarries), a variety of permitted discharges, and nonpoint-source pollutants. 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 six of the nine groundwater basins in which it occurs lie wholly or partially on federal land (MCNP). The Service's Kentucky Field Office and MCNP continue to work cooperatively on the conservation of the species.

The perceived low abundance of Kentucky cave shrimp in each of its groundwater basins suggests that these populations contribute little to recruitment and rarely interbreed. This prohibits 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. 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.

The species continues to be restricted to nine groundwater basins in the Mammoth Cave National Park region of central Kentucky (USFWS 1988). These groundwater basins include Echo River Spring, Ganter Spring, Running Branch Spring, Mile 205.7 Spring, Pike Spring, Double Sink (Sandhouse Cave), Turnhole Spring, McCoy Blue Spring, and Suds Spring (Figure 1). According to estimates provided in the recovery plan, these populations range in size from a low of 50 at Mile 205.7 Spring to 10,000 in Pike Spring.

Based on the best available information regarding the species' current status and threats, the species continues to be impacted by poor water quality and habitat deterioration resulting from groundwater contamination, siltation caused by poor land use practices, and by other nonpoint-source pollutants. Their limited distribution also makes them vulnerable to toxic chemical spills and limits the natural genetic exchange between and within populations. Because of their restricted distribution and continued vulnerability to these threats, we believe that the species continues to meet the definition of endangered (in danger of extinction throughout all or a significant portion of its range) and should remain classified as such.

III. RESULTS

A. Recommended Classification: Endangered; no change is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The following recovery actions should be made a priority over the next five years:

1) Determine the current status and distribution of the Kentucky cave shrimp by completing a new, comprehensive inventory of groundwater basins surrounding Mammoth Cave National Park. All historic basins should be searched along with adjacent basins (e.g., Graham Springs) that could potentially support the species.

2) Conduct research to determine the factors that are adversely impacting the species and the means to eliminate or reduce such impacts. Determine the effects of sediment, pesticides, herbicides, and other contaminants.

3) Maintain adequate water quality within basins known to support cave shrimp. Develop region-wide habitat protection methods or best management practices that would prevent groundwater contamination and habitat disturbance of cave shrimp habitats. Conduct routine monitoring of water quality to determine if pollutants are present.

4) 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.

5) Continue to protect, restore, and enhance habitat quality throughout the drainage. Federal, state, and private parties should continue to work cooperatively to restore and protect habitats, especially those areas with karst features.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of the Kentucky cave shrimp (*Palaemonias ganteri*)

Current classification: Endangered

Recommendation resulting from the 5-Year review: No change is needed.

Review conducted by: Dr. Michael A. Floyd, Kentucky Field Office, Frankfort, Kentucky

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 4/21/10

REGIONAL OFFICE APPROVAL

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 4-30-10

APPENDIX A: Summary of peer review for the 5-year review of the Kentucky cave shrimp (*Palaemonias ganteri*)

A. Peer Review Method: The draft document was peer-reviewed by Dr. Julian Lewis, Lewis and Associates, Borden, Indiana; Mr. Ryan Evans, KSNPC, Frankfort, Kentucky; and Mr. Rick Olson, MCNP; and comments received were incorporated as appropriate.

B. Peer Review Charge: Peer reviewers were asked to read the 5-year review and provide any comments, both editorial and content. Peer reviewers were not asked to provide recommendations on the classification of the species.

C. Summary of Peer Review Comments/Report:
Peer reviews were mainly editorial in nature with very minor substantive comments to the content. The only substantive comments regarding content dealt with previous surveys of the Graham Springs Basin, the use of the word "pathogen" in the Five-factor analysis, and potential impacts caused by Lock and Dam 6 and impoundment of the Green River.

D. Response to Peer Review:
We agreed with substantive comments of the authors and modified the text to reflect the new information. Text was added regarding survey efforts in the Graham Springs Basin and the potential for the Kentucky cave shrimp to exist there. The term "pathogen" was replaced with "bacteria" in the Factor A discussion (Five-factor analysis) to provide a more accurate description of potential threats from organisms such as *Escherichia coli*. Details were added to the last paragraph in the Factor A discussion regarding impacts caused by Lock and Dam 6 and impoundment of the Green River (Five-factor analysis).