Pahrump Poolfish (*Empetrichthys latos*)

5-Year Review: Summary and Evaluation

Figure 1: Pahrump poolfish, photo by U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service

Southern Nevada Fish and Wildlife Office

Las Vegas, Nevada

December 20, 2018

5-YEAR REVIEW
Pahrump Poolfish (*Empetrichthys latos*)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since listing (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species listing or last review. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

Classified as a subspecies named *Empetrichthys latos latos* by Miller (1948), the Pahrump poolfish (*Empetrichthys latos*) became a full species when *E. l. Pahrump* and *E. l. concavus* went extinct. Following the extinction of the Ash Meadows poolfish (*E. merriami*) in the late 1940s or early 1950s, they became the only extant species within the *Empetrichthys* genus (Soltz and Naiman 1978; Miller et al. 1989). Currently, two refugia locations contain Pahrump poolfish (i.e., Corn Creek, Shoshone Ponds). A third location at Lake Harriet, Spring Mountain Ranch State Park is being renovated due to the presence of aquatic nonnative species while efforts to establish a fourth site at the Springs Preserve are ongoing.

Information about the ecology, behavior, life history, population dynamics, and habitat requirements of the Pahrump poolfish is limited and based largely on historical information derived from its ancestral location at Manse Spring. The species occupies entirely different habitats today. This knowledge is supplemented with limited information on life history and habitat characteristics at refuge sites and from laboratory (aquaria) settings.

Methodology Used to Complete This Review:

The Southern Nevada Fish and Wildlife Office (SNFWO), following the Region 8 guidance, prepared this review. We used information from the 1980 Recovery Plan for the Pahrump killifish, survey information from experts who have been monitoring this species, and the database maintained by the Nevada Natural Heritage Program. We received no substantial information from the public in response to our Federal Notice initiating this 5-year review.

This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed, maintained, or initiated within the next 5 years.

Contact Information:

Lead Regional Office:

Angela Picco, Deputy Division Chief for Listing, Recovery, and Habitat Conservation Planning, Region 8, California and Nevada; (916) 414-6490.

Lead Field Office:

James Harter; Southern Nevada Fish and Wildlife Office, Las Vegas; (702) 515-5230.

Federal Register (FR) Notice Citation Announcing Initiation of This Review:

On June 18, 2018, the Service announced initiation of the 5-year review for the Pahrump poolfish and requested information from the public regarding the species' status (83 FR 28251). We did not receive any substantial comments from that announcement.

Listing History:

__**Original Listing**__

FR notice: 32 FR 4001

Date listed: March 11, 1967[1]

Entity listed: Subspecies[2]

Classification: Endangered

---

[1] Originally listed as endangered under the Endangered Species Preservation Act of 1966 (Udall 1967). Its endangered status was retained with the passage of the Endangered Species Act of 1973.

[2] The Pahrump killifish (*Empetrichthys latos latos*) has been changed to a species, Pahrump poolfish (*E. latos*), based on extirpation of all closely related subspecies (69 FR 17383).

Revised Listing

Proposed Rule to Reclassify from Endangered to Threatened Status

FR notice: 58 FR 49279

Date of FR notice: September 22, 1993

Withdrawal of Proposed Rule to Reclassify From Endangered to Threatened Status

FR notice: 69 FR 17383

Date of FR notice: April 2, 2004

State Listing

The State of Nevada classifies the Pahrump poolfish as endangered under Nevada Administrative Code §§ 503.065.

Associated Rulemakings:

No associated rulemakings have been made.

Review History:

The status of the Pahrump poolfish has not been reviewed since the species listing in 1967. More current distribution, threats, and associated information have been documented in the Withdrawal of Proposed Rule to Reclassify From Endangered to Threatened Status published in the Federal Register on April 2, 2004 (69 FR 17383).

Species' Recovery Priority Number at Start of 5-Year Review:

The recovery priority number is 11 for *E. latos* according to the Service's 2013 Recovery Data Call for the Southern Nevada Fish and Wildlife Office, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (48 FR 43098). This number indicates that the taxon is a full species with a moderate degree of threat and a low recovery potential.

Recovery Plan or Outline:

Name of plan: Pahrump Killifish Recovery Plan

Date issued: March 17, 1980

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species act (61 FR 4722, February 7, 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act. The Pahrump poolfish occur in a limited area, and no DPS designation exists.

Information on the Species and its Status

Information about the ecology, behavior, life history, population dynamics, and habitat requirements of the Pahrump poolfish is based largely on historical information derived from Manse Spring. This knowledge is supplemented with limited information on life history and habitat characteristics at refuge sites and from laboratory (aquaria) settings. Caution should be exercised in interpreting this information since habitat differences at these various sites, and even within the same site over time, can lead to divergence of life history traits.

The Pahrump poolfish is a small, short-lived fish, which exhibits sexual dimorphic differences in size as well as variances in size due to population density and temperature. They obtain a maximum length of approximately 3 inches (in) (77 millimeters [mm]) and exhibit sexual dimorphism in size, with females generally larger than males, although substantial divergences in body size have been observed among disparate populations (Service 1980; Baugh et al. 1988; Heckmann 1988; Goodchild and Stockwell 2016). Pahrump poolfish also exhibit temporal variance in body size, which likely correlates to variations in population density and water temperature over time (Goodchild 2016). Given its small size, the Pahrump poolfish is probably short-lived (e.g., two to four years; Sigler and Sigler 1987).

Other characteristics of the Pahrump poolfish include a slender, elongate body with dorsal and anal fins placed far back on the body, pectoral fins typically with 16 to 18 rays, and no pelvic fins (Sigler and Sigler 1987; La Rivers 1994). These fish have a broad upturned mouth, a dark longitudinal streak that tends to disappear in older, larger individuals, and an orange ring around the eye. Coloration is generally greenish-brown with black mottling, but males may be silver-blue without mottling during the spawning season (Soltz and Naiman 1978; Service 1980). The dorsal, anal, and caudal fins are bright orange-yellow when the fish are in an environment of optimal temperature and dissolved oxygen (Selby 1977; Soltz and Naiman 1978).

The spawning period for poolfish generally occurs in the spring, but may occur in any season and for much of the year if proper conditions are present (Service 1980; Sigler and Sigler 1987; Williams 1996). At Manse Spring (1961-1965), Pahrump poolfish had a protracted reproductive period that extended from January through July with a peak in April based on the number of mature eggs in the ovaries of Pahrump poolfish specimens collected during those years (Deacon and Williams 2010). Pahrump poolfish transplanted to new locations appear to adjust their spawning season to temperature conditions at the new sites, with delays in spawning observed at sites with cooler and more variable temperatures (Selby 1977; Deacon and Williams 2010; Goodchild 2016).

Sexual maturity of Pahrump poolfish is reached once females are a certain size, and reproduction potential increases with size. Pahrump poolfish at Manse Spring apparently did not reach sexual maturity until they were greater than 1.2 in (30 mm) Standard Length (SL) based on the absence of mature eggs in the ovaries of smaller fish (less than 1.2 in [30 mm] SL) that were collected from 1961-1965 (Deacon and Williams 2010). Reproductive potential (measured as the mean number of mature eggs produced by each size class) increased substantially with size for fish greater than or equal to 1.2 in (30 mm) SL during the month of April, which was the peak period of reproduction. Deacon and Williams (2010) thus surmised that the number and proportion of larger female Pahrump poolfish in the population during April was an important determinant of reproductive potential at Manse Spring.

Annual fecundity (total number of eggs spawned by a female during a single spawning season) of Pahrump poolfish is unknown. This species likely produces few eggs per spawning season, but may spawn multiple times per season at sites with appropriate environmental conditions (Sigler and Sigler 1987). In the laboratory, Baugh et al. (1988) found that the number of eggs produced per female ranged from 0 to 28 over a three-day trial period, and Deacon et al. (1964) reported that adult females produced 10 to 30 eggs per week for over two months. In the laboratory, eggs hatched in 7 to 10 days (average of 8 days) in water temperatures of 75 degrees Fahrenheit (ºF) (24 degrees Celsius [ºC]) (Baugh et al. 1988), which was the approximate temperature of Manse Spring. Selby (1976) reported that Pahrump poolfish eggs developed over a period of two to three weeks. Both egg and larval Pahrump poolfish development will likely differ by site due to water temperature differences; e.g., slower development would be expected in cooler waters (Baugh et al. 1988).

Pahrump poolfish are opportunistic omnivores, eating a wide variety of animal (e.g., aquatic insects, snails) and plant material, while also ingesting large amounts of debris and inorganic material (Deacon 1984; Hobbs et al. 2003; Deacon and Williams 2010). Debris, such as sand or sticks, is generally coated with epiphytic bacteria or diatoms, providing nutrients to fish. These fish appear able to adapt their diet to food item availability as determined by environmental conditions (Hobbs et al. 2003; Deacon and Williams 2010). For example, prior to the establishment of goldfish at Manse Spring, the relative volume of aquatic insects in the Pahrump poolfish diet was high (Deacon and Williams 2010). Following goldfish establishment, a higher proportion of Pahrump poolfish consumed plant material and the average volume of aquatic insects in the guts of samples declined. Deacon and Williams (2010) attributed this dietary shift to habitat changes caused by goldfish (e.g., higher turbidity, disturbance of aquatic macrophytes), which may have affected insect density and detectability. In a dietary study of transplanted Pahrump poolfish populations, Hobbs et al. (2003) demonstrated that debris, plant and algal material comprised the largest part of their diet at Shoshone Ponds and Spring Mountain Ranch State Park, whereas insects and other animal items comprised a larger part of the diet at Corn Creek. Based on their known diet at Manse Ranch and available food sources at

Shoshone Ponds North, Deacon et al. (1980) suggested that larger zooplankton was likely an important food source for Pahrump poolfish at Shoshone Ponds.

Spatial Distribution

Historically, Pahrump poolfish occurred in a single isolated spring, Manse Spring, on private property in the Pahrump Valley of southern Nye County, Nevada (Figure 2). Currently, Pahrump poolfish are located at Shoshone Ponds Natural Area on lands managed by the Bureau of Land Management (BLM) southeast of Ely, White Pine County, Nevada; and at the Corn Creek Spring system on the Desert National Wildlife Refuge northwest of Las Vegas, Clark County, Nevada (Figure 3). In addition, there is a refugium site under renovation on lands managed by Nevada State Parks at Lake Harriett, Spring Mountain Ranch State Park, west of Las Vegas in Clark County, Nevada.

Abundance

Historical Distribution and Abundance

The three subspecies of Pahrump poolfish historically occupied three distinct spring systems in Pahrump Valley (Miller 1948; La Rivers 1994). By the late 1950s, the distribution of this species was restricted to Manse Spring, which was then the second largest spring in Pahrump Valley and the type locality for *E. l. latos*, now *E. latos* (Soltz and Naiman 1978; La Rivers 1994; Deacon and Williams 2010). Early estimates of abundance are not available, but Pahrump poolfish were described as being more common in its environment than its congener, the Ash Meadows poolfish, perhaps due to a lack of competition with other native fishes (Miller 1948; La Rivers 1994). The Pahrump poolfish population at Manse Spring was reported to be over 1,000 individuals for several years during the 1960s and early 1970s (Deacon and Williams 2010).

Disturbances from human activities led to the extirpation of Pahrump poolfish from Manse Spring. By the late 1960s, Minckley and Deacon (1968) projected that Manse Spring would go dry within a decade based on declining spring discharge from groundwater pumping to support local agriculture. In the early 1970s, Manse Spring stopped flowing due to excessive groundwater pumping for agricultural development; in 1975, the spring pool dried, thus eliminating the only native habitat for Pahrump poolfish (Minckley et al. 1991). Prior to this, flow reductions from groundwater pumping, aquatic vegetation removal, introduction of nonnative goldfish (*Carassius auratus*), and other human activities had adversely affected the Pahrump poolfish population at Manse Spring (Minckley and Deacon 1991; Deacon and Williams 2010). Human alterations (removal of aquatic vegetation) to Pahrump poolfish habitat at Manse Spring caused the Pahrump poolfish population to experience two dramatic population crashes in the 1960s (to fewer than 50 adults each time), from which the species was able to rebound prior to its extirpation from the site in 1975 (Deacon and Williams 2010).

Pahrump poolfish were transplanted from Manse Spring to three previously fishless locations, during the early 1970s, in an attempt to prevent extinction of the only remaining member of the genus *Empetrichthys* (69 FR 17383; Minckley et al. 1991; Deacon and Williams 2010). These locations were Latos Pools on the Lake Mead National Recreation Area, Clark County, southern

Nevada; Corn Creek Springs at the Desert National Wildlife Refuge, Clark County, southern Nevada; and Shoshone Ponds on BLM land southeast of Ely in White Pine County, east-central Nevada. The Latos Pools population was initially successful, but failed within a decade of establishment due to flooding (69 FR 17383). In order to replace the Latos Pools population, a third population of Pahrump poolfish was established in 1983 at the Nevada State Park's Spring Mountain Ranch State Park in western Clark County.

History and Status of Refuge Populations

The status of refuge populations of Pahrump poolfish varies by location (69 FR 17383; Selby 1977; USFWS 1980; Minckley and Deacon 1991; Deacon and Williams 2010), and is summarized below:

- **Latos Pools**: This population was initially successful but failed within a decade of establishment due to flooding. Pahrump poolfish were not reintroduced to this location.
- **Corn Creek**: Pahrump poolfish were introduced into the Corn Creek refuge site in 1971 and initially flourished until the population dwindled in the mid-1970s following invasion of the nonnative mosquitofish (*Gambusia affinis*). Following the draining of the ponds and elimination of mosquitofish, Pahrump poolfish were reintroduced in 1976. Again, this population flourished until red swamp crayfish (*Procambarus clarkii*) invaded Corn Creek in the early 1990s and the last free-living Pahrump poolfish at Corn Creek were observed in 1998. In 2002, a viewing facility for Pahrump poolfish was built at Corn Creek to provide an area free of crayfish and other exotic species. Pahrump poolfish were reintroduced at this site in 2003, but into an aquaria-like setting distinctly different from the spring pools in which Pahrump poolfish were originally introduced. The primary conservation value of this facility is to educate the public about Pahrump poolfish.

  More recently, in 2011, the main pond fed by the Corn Creek Springs was reconstructed with smaller pools to maintain warmer water temperatures, a hardened (cement) bottom to prevent burrowing by crayfish, and a perimeter step-up to prevent and slow colonization of the pond by crayfish. Habitat restoration upstream and downstream of the pond to facilitate spring flow and reduce conditions advantageous to crayfish was largely completed in 2011 and 2012. Rotenone treatments were conducted in 2014 to remove nonnative mosquitofish and guppies from the main pond and associated spring flows. Following removals, Pahrump poolfish were reintroduced to the system in 2014. Although the main pond has remained free of nonnative fish since renovation, crayfish continue to persist throughout the system.

  Population estimates for the most recent surveys (June 2016) are as follows (NDOW 2016a):

  - North Tank: 66 Pahrump poolfish with a 95% confidence interval of 44 to 98 fish.
  - South Tank: 75 Pahrump poolfish with a 95% confidence interval of 55 to 102 fish.

    - Concrete Pond: 2,501 Pahrump poolfish with a 95% confidence interval of 2,175 to 2,875 fish.

- **Shoshone Ponds**: Pahrump poolfish were introduced into the Shoshone Ponds in 1972 but were soon extirpated due to vandalism. A reintroduction to the ponds in 1976 ultimately led to the establishment of the site. The site consists of three manmade ponds fed by artesian well flow (North, Middle, and South Pond) as well as a stream formed from artesian well (Well #2 Outflow) and a nearby earthen stock pond (Stock Pond). Although the environment at Shoshone Ponds differs and is geographically distant from the Pahrump poolfish's ancestral home (Manse Spring), the species has survived at Shoshone Ponds for over 40 years. From 1989 to 2017, the estimated number of Pahrump poolfish has varied from 922 to over 8,100 fish. A recent failure to the Stock Pond well in 2013 led to the installation of a solar-powered groundwater pump to maintain acceptable water levels. Habitat work to improve conditions at the site is currently in the planning phases.

  Population estimates for the most recent surveys (August 2016) are as follows (NDOW 2016):

    - North Pond: 136 Pahrump poolfish with a 95% confidence interval of 58 to 426 fish.
    - Middle Pond: 574 Pahrump poolfish with a 95% confidence interval of 441 to 748 fish.
    - Stock Pond: 2,151 Pahrump poolfish with a 95% confidence interval of 1,907 to 2,426 fish.
    - Well #2 Outflow: 12 Pahrump poolfish with a 95% confidence interval of 5 to 30 fish.

- **Spring Mountain Ranch State Park**: Pahrump poolfish were introduced to an irrigation reservoir known as Lake Harriett at Spring Mountain Ranch State Park in 1983. This population has historically been the largest with estimated numbers of Pahrump poolfish from 1998 to 2015 varying from 3,594 to 58,041 fish (NDOW 2015). The availability of extensive areas of both shallow and deep water, along with the relative absence of other aquatic species that might prey upon or compete with the Pahrump poolfish (such as other fish or crayfish) had allowed this population to exhibit robust growth and maintain a large population size.

  Due to Lake Harriett's close geographic proximity to Las Vegas, the risk of aquatic invasive species introduction is high. In 2012, carapace pieces from crayfish were found adjacent to the inflow of Lake Harriet (NDOW 2012). Sampling conducted on July 2013, confirmed the establishment of crayfish throughout Lake Harriet (NDOW 2013). The presence of mosquitofish was first documented in Lake Harriett in autumn of 2015, and by summer of 2016, mosquitofish were prevalent throughout the lake.

  Following the introduction of crayfish and mosquitofish, the population of Pahrump poolfish substantially decreased. Population estimates of Pahrump poolfish dropped from

31,570 in 2012, to 16,813 in 2013, following the establishment of crayfish and from 12,285 in 2015, to 362 in 2016, following the establishment of mosquitofish (NDOW 2016). In response to the decline of the Pahrump poolfish population, SNFWO, NDOW, and Spring Mountain Ranch State Park salvaged 413 Pahrump poolfish and translocated them from Lake Harriett to the Lake Mead Fish Hatchery prior to renovation of the site.

Habitat or Ecosystem

Manse Spring, the ancestral location of Pahrump poolfish, was historically a large, clear limnocrene spring (a spring originating from a large, deep pool of water) with stable temperatures and currents. In 1875, discharge rates calculated at approximately 6 cubic feet per second (0.17 cubic meters per second) (Deacon and Williams 2010). Water temperature was a relatively constant 75 ºF (24 ºC) (range 74 to 77 ºF [23.3 to 25.0 ºC]) (Miller 1948; Deacon and Williams 2010), and the water was alkaline (Service 1980). The main spring pool was 29 feet (ft) (9 meters [m]) wide and 9 ft (3 m) deep at the head, 6.5 ft (2 m) wide and 1 ft (0.3 m) deep at the outlet, and 59 ft (18 m) long. A shallow ditch extended 10 to 20 ft (3 to 6 m) southward from the main spring pool (Deacon and Williams 2010). Water current ranged from slow to absent in the main spring pond and shallow ditch to swift in the outflow channel. The spring pool had a silty bottom and was dense in areas with macrophytes, including watercress (*Nasturtium* sp.), stonewort (*Chara* sp.), and pondweed (*Potamogeton* sp.) (Deacon and Williams 2010).

Although Miller (1948) described the genus *Empetrichthys* as being frequently observed in the deeper holes of warm desert springs and usually uncommon in shallow spring-fed ditches or marshy areas, at Manse Spring, Pahrump poolfish used all three of the different habitats: the spring pool, shallow ditch, and swifter outflow stream (Deacon and Williams 2010). Larger fish utilized the more open and deeper waters, and young fish utilized the near water surface layer in shallow areas with aquatic vegetation (Service 1980). After hatching, fry (young fish, post-larval stage) remained at the bottom or near other substrates, presumably for protection and to feed (Service 1980). Given the partitioning of habitat by age class, it is likely that different life stages use or need different resources (e.g., food items, cover for predator avoidance) or have different physiological tolerances or requirements.

Despite the nearly constant water temperatures of 75 ºF (24 ºC) at Manse Spring, transplanted Pahrump poolfish populations have demonstrated the ability to tolerate a much wider range of water temperatures. At Corn Creek, Pahrump poolfish survived at low temperatures of 39.2 ºF (4 ºC) under ice in a trough, and at Latos Pools, Pahrump poolfish withstood annual water temperature fluctuations from below 51 to 77 ºF (10.5 ºC to 25 ºC) (Selby 1977). At the Spring Mountain Ranch reservoir, Pahrump poolfish have been reported to enter torpor during winter (Baugh et al. 1988). Selby (1977), who investigated the thermal tolerance of this species in the laboratory, demonstrated that Pahrump poolfish could tolerate temperatures from at least 34.7 to 104 ºF (1.5 ºC to 40 ºC; lower temperatures were not tested) for short periods of time, with specific tolerances depending on original acclimation temperatures. This same study demonstrated that Pahrump poolfish are incapable of behavioral thermoregulation. Nonetheless, the wide thermal tolerance of Pahrump poolfish has allowed it to be successful in transplant sites that differ substantially in temperature regime from its native Manse Spring (Selby 1977).

Changes in Taxonomic Classification or Nomenclature

The Pahrump poolfish is a member of the Goodeidae family (order Cyprinodontiformes), which consists of approximately 40 freshwater fish species in 18 genera, the majority of which are known from central Mexico (Doadrio and Dominguez 2004; Webb et al. 2004). Only two genera of Goodeids– *Empetrichthys* (poolfish) and its closest relative *Crenichthys* (springfish) – are known from the United States, where they are or are restricted to isolated springs in southern and eastern Nevada (Miller 1948; La Rivers 1994; Grant and Riddle 1995). Over the past century, poolfish and springfish taxonomy has been controversial and these two genera have been aligned with several different families (reviewed by Grant and Riddle 1995). *Empetrichthys* and *Crenichthys* are now considered sister taxa within the subfamily Empetrichthyinae within the family Goodeidae, as proposed by Parenti (1981) and supported by subsequent studies (Grant and Riddle 1995; Doadrio and Dominguez 2004; Webb et al. 2004; Cooper and Pillar 2017). In addition to their geographic separation, *Empetrichthys* and *Crenichthys* have distinct life history (e.g., egg laying) and ecological traits (e.g., endemic to spring systems) that separate them from other Goodeids (Grant and Riddle 1995; Doadrio and Dominguez 2004; Webb et al. 2004).

The Pahrump poolfish was first documented as *E. merriami* by Gilbert (1893), during the Death Valley Expedition. Miller (1948) is credited with the official description used today after determining that the Pahrump poolfish (*E. latos*) was different from the Ash Meadows poolfish (*E. merriami*). It is one of only two known species within the genus *Empetrichthys* (Miller 1948; La Rivers 1994), and is the only extant species in this genus following extirpation of the Ash Meadows poolfish (*E. merriami*) in the late 1940s or early 1950s (Soltz and Naiman 1978; Miller et al. 1989). Miller (1948) recognized three subspecies, based on measurable and countable traits (i.e., morphometrics and meristics), of *Empetrichthys latos* from three distinct springs within seven miles of each other in Pahrump Valley, southern Nevada: Manse Ranch Pahrump poolfish (*Empetrichthys latos latos*) at Manse Spring; Pahrump Ranch Pahrump poolfish (*E. l. pahrump*) at Pahrump Spring; and Raycraft Ranch Pahrump poolfish (*E. l. concavus*) at Raycraft Spring. Both *E. l. pahrump* and *E. l. concavus* were extirpated in the 1950s when the springs they occupied either dried up or were drawn down due to excessive groundwater pumping for irrigation and subsequently filled in with soil for mosquito control (Minckley and Deacon 1968; Soltz and Naiman 1978; Miller et al. 1989; Minckley et al. 1991). Since *E. l. latos* is now the only extant representative of the species, the subspecific designation has been dropped (69 FR 17383 and references cited therein; ITIS 2013) and the fish is now known simply as the Pahrump poolfish (*E. latos*).

Genetics

A recent genetics study examining the phylogenetic relationships between and among *Empetrichthys* and *Crenichthys* has reaffirmed previous taxonomic inferences made to segregate these taxa (Cooper and Pillar 2017). Genetic distance between *Empetrichthys* and *Crenichthys* has been shown to be sufficiently high to warrant genus-level distinctions for each, while the low distance between those members of those two genus and other described species within *Goodeinae* confirm their grouping with the Goodeidae family.

Species-specific Research and Grant-supported Activities

The Service provides section 6 funding to the NDOW for the Pahrump poolfish. Specifically, the NDOW's responsibilities include:

- Coordinating the Pahrump poolfish Recovery Implementation Team;
- Conducting annual population monitoring at Pahrump poolfish refugia sites;
- Revising and implementing genetic management protocols for refugia Pahrump poolfish populations;
- Coordinating and assisting with Service Refuges and ES management and monitoring of the Corn Creek refugium;
- Providing assistance for planning and restoration of ponds at Corn Creek for Pahrump poolfish in coordination with Service Refuges;
- Assisting BLM in implementation of restoration actions at Shoshone Ponds refugium;
- Assisting Nevada Department of State Parks renovation of the poolfish refugium at Lake Harriet, Spring Mountain Ranch State Park.

New research conducted since the recovery plan of 1980 includes:

- Heckmann, R.A. 1988. The adaptive characteristics and parasitofauna of the Pahrump poolfish, *Empetrichthys latos latos*
- Baugh, T.M., J.E. Deacon, and P. Fitzpatrick. 1988. Reproduction and growth of the Pahrump poolfish (*Empetrichthys latos latos* Miller) in the laboratory and in nature
- Deacon, J.E. and J.E. Williams. 2010. Retrospective evaluation of the effects of human disturbance and goldfish introduction on endangered Pahrump poolfish
- Goodchild, S.C. and C.A. Stockwell. 2016. An Experimental Test of the Novel Ecological Communities of Imperiled and Invasive Species
- Campbell, D. Cooper and Kyle Piller. 2017. Let's jump in: A phylogenetic study of the great basin springfishes and poolfishes, *Crenichthys* and *Empetrichthys* (Cyprinodontiformes: Goodeidae)

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

<u>Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range</u>

The refugia locations for the Pahrump poolfish are not natural systems and need to be maintained and managed to ensure survival. The Shoshone Ponds Natural Area is prone to siltation, vegetation growth issues, and trespass cattle use (cattle issues may include: bank trampling, water quality, etc.). Spring Mountain Ranch State Park population resides in a reservoir that is vulnerable to bank breaches. The Corn Creek population resides largely in a cement lined pond and a small building which was built and adapted into an aquaria which needs to be cleaned and maintained.

Groundwater Pumping

Groundwater pumping remains a concern for the Pahrump poolfish. The desiccation of their ancestral site at Manse Spring from agricultural pumping was the cause for the establishment of refuge sites to protect the Pahrump poolfish. Adequate, reliable water sources are necessary to ensure that currently occupied ponds provide suitable habitat for the poolfish. Threats to water sources necessary for poolfish habitat have been minimized to the extent possible by the managing Federal and State agencies. For example, the Service filed for and received vested water rights at Corn Creek Springs from the State of Nevada that will ensure the water supply for the poolfish population at that location. In addition, the NDOW and the Nevada Division of State Parks hold State appropriative water rights to the springs supporting the habitats at Shoshone Ponds Natural Area and the State Park, respectively.

In the past, groundwater withdrawals were mainly for supporting agricultural activities. However, the present demand on limited water sources is shifting to accommodate the growing human population and development in southern Nevada. The Service recently provided a biological opinion to the BLM for the Southern Nevada Water Authority's Clark, Lincoln, and White Pine counties groundwater development project (Service 2012; BLM 2012). The Service's biological opinion analyzed project construction, operation, and maintenance through the year 2125, 75 years after full project build-out (Service 2012; BLM 2012). The Shoshone Ponds fall within the analysis area for the groundwater development project. Due to the uncertainties related to the likelihood and magnitude of drawdown-related effects, we cannot accurately predict how the Pahrump poolfish at the Shoshone Ponds Natural Area will be affected.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial, recreational, scientific, or educational purposes was not known to be a factor in the 1985 final listing rule (50 FR 39123). Overutilization for any purpose is not a threat at this time.

Factor C: Disease or Predation

Heckman (1988) examined Pahrump poolfish for parasites at all sites by, and less than 36% contained parasites including larval gill, blood, and mesenteric nematodes, protozoans (*Thecamoeba*, *Schizamoeba* and *Myxosporidia*), and trematode metacercaria (*Postdiplostomum*, and possibly other species). *Trichodina*, a common protozoan gill parasite, was also observed during 1987. Some minor pathology was observed, including petechiae, clubbing of gill filaments, moribund fish, low K-factor, and frayed fins. Given the low level of pathology, it is likely that the level of parasitism observed is natural. These diseases are not currently a threat to the Pahrump poolfish. No other disease has been recorded.

Illegal introductions of nonnative aquatic species to the habitats of poolfish have occurred historically and currently continue to pose a significant threat to the existence of this species. In a laboratory setting, juvenile production of Pahrump poolfish declines in the presence of nonnative mosquitofish (Goodchild and Stockwell 2016). In translocated populations, we have seen declines following the introduction of nonnatives, as seen with mosquitofish and crayfish at Spring Mountain Ranch State Park and Corn Creek. Currently, the population at Shoshone Ponds Natural Area is the only location that has not been significantly affected by nonnative aquatic species (see *History and Status of Refuge Populations* above for more details).

The effect of predation by the nonnative American bullfrog (*Lithobates catesbeianus*) on the Pahrump poolfish population at Corn Creek Springs has been investigated. Analyses of bullfrog stomach contents indicated that bullfrog predation on Pahrump poolfish is minimal (NDOW 1985, 1986, 1988, 1991). Predation from other nonnative predators, mostly of eggs and larvae, likely contributed to historic declines of poolfish in their native habitats, such as by goldfish in Manse Spring and common carp in the spring on Raycraft Ranch during the 1940's (LaRivers 1994).

Factor D: Inadequacy of Existing Regulatory Mechanisms

National Environmental Policy Act (NEPA)

NEPA (42 U.S.C. 4371 *et seq*.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such project with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Clean Water Act

Under section 404, the U.S. Army Corps of Engineers (Corps or USACE) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term "wetland" refers to areas meeting the Corps' criteria of hydric soils, hydrology (either sufficient annual flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any action with the potential to impact waters of the United States must be reviewed under the Clean Water Act, NEPA, and the Act. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

The Corps interprets "the waters of the United States" expansively to include not only traditional navigable waters and wetlands, but also other defined waters that are adjacent or hydrologically connected to traditional navigable waters. However, recent Supreme Court rulings have called this practice into question. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld this interpretation as it applied to two cases involving "isolated" wetlands. Currently, Corps regulatory oversight of such wetlands (e.g., vernal pools) is in doubt because of their "isolated" nature. In response to the Supreme Court decision, the Corps and the U.S.

Environmental Protection Agency (USEPA) have released a memorandum providing guidelines for determining jurisdiction under the Clean Water Act. The guidelines provide for a case-by-case determination of a "significant nexus" standard that may protect some, but not all, isolated wetland habitat (USEPA and USACE 2007). The overall effect of the new permit guidelines on loss of isolated wetlands, such as vernal pool habitat, is not known at this time.

Endangered Species Act (Act)

The Act is the primary Federal law providing protection for this species. The Service's responsibilities include administering the Act, including sections 7, 9, and 10 that address take. Since listing, the Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project.

Section 9 prohibits the taking of any federally listed endangered or threatened species. Section 3(18) defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct". Service regulations (50 CFR 17.3) define "harm" to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns that include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that result from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved Habitat Conservation Plan (HCP) that details measures to minimize and mitigate the project's adverse impacts to listed species.

Federal Land Policy and Management Act of 1976 (FLPMA)

The Bureau of Land Management is required to incorporate Federal, State, and local input into their management decisions through Federal law. The FLPMA (Public Law 94-579, 43 U.S.C. 1701) was written "to establish public land policy; to establish guidelines for its administration; to provide for the management, protection, development and enhancement of the public lands; and for other purposes". Section 102(f) of the FLPMA states that "the Secretary [of the Interior] shall allow an opportunity for public involvement and by regulation shall establish procedures…to give Federal, State, and local governments and the public, adequate notice and opportunity to comment upon and participate in the formulation of plans and programs relating to the management of the public lands". Therefore, through management plans, the Bureau of Land Management is responsible for including input from Federal, State, and local governments and the public. Additionally, Section 102(c) of the FLPMA states that the Secretary shall "give priority to the designation and protection of areas of critical environmental concern" in the development of plans for public lands. Although the Bureau of Land Management has a multiple-use mandate under the FLPMA which allows for grazing, mining, off-road vehicle use, etc., the Bureau of Land Management also has the ability under the FLPMA to establish and implement special management areas such as Areas of Critical Environmental Concern, wilderness, research areas, etc., that can reduce or eliminate actions that adversely affect species of concern (including listed species).

The Lacey Act

The Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian tribal law, treaty, or regulation, as well as the trade of any of these items acquired through violations of foreign law. The Lacey Act further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of "wild animal" includes parts, products, eggs, or offspring.

Nevada State Protection

The State of Nevada classifies the Pahrump poolfish as endangered under Nevada Administrative Code §§ 503.065. Its habitat on Federal or private land was not protected by State law when it was listed under the Act (Service 1985). Federal and State regulations providing protection for Pahrump poolfish are described below.

Under Nevada Administrative Code §§ 503.050, 503.065, 503.067, 503.075, 503.080, 503.090, 503.103, and 503.104 (Nevada Revised Statutes §§ 501.105, 501.110, 501.181, and 503.650), a species may be designated as protected, threatened, endangered, or sensitive. The State statutes and regulations aimed at protecting wildlife and plant species, respectively, are administered by the NDOW and the Nevada Division of Forestry, under the Department of Conservation and Natural Resources. Capturing, removing, or destroying animals and plants on the State's fully protected list is prohibited for wildlife under Nevada Administrative Code §§ 503.093 and 503.094 (Nevada Revised Statues §§ 501.105 and 501.181) and for plants under Nevada Administrative Code §§ 527.250 to 527.460 (Nevada Revised Statutes §§ 527.050 and 527.300), unless a special permit has been obtained from the NDOW or Nevada Division of Forestry.

Summary of Factor D

In summary, the Act is the primary Federal law that provides protection for this species since its listing as endangered in 1967. All other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, other laws and regulations have limited ability to protect the Pahrump poolfish in absence of the Act.

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (For these and other examples, see IPCC 2007; and Solomon et al. 2007). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007; Solomon et al. 2007). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), who concluded that it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl et al. 2007; Ganguly et al. 2009; Prinn et al. 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007; Meehl et al. 2007; Ganguly et al. 2009; Prinn et al. 2011).

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007; see also Glick et al. 2011). There is no single method for conducting such analyses that applies to all situations (Glick et al. 2011). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Summary of Factor E

While we recognize that climate change is an important issue with potential effects to listed species and their habitats, we lack adequate information to make accurate predictions regarding its effects to particular species at this time. Spring systems in Nevada are supplied mainly through aquifers, which are fed by snowmelt and precipitation in mountainous areas (Abele 2011). Groundwater recharge is spatially and temporally variable and largely occurs through a process called net infiltration. Net infiltration is a term used to describe the zone of surface evapotranspiration (Flint et al. 2001, in Flint et al. 2004). It can be affected by air temperature, precipitation, root zone, soil properties, and bedrock permeability (Flint et al. 2004). Under climate change projections, we anticipate further alteration of precipitation and temperature patterns. Therefore, climate change may exacerbate impacts from other factors currently affecting this species and its habitat.

Recovery Criteria

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

The recovery plan identifies a primary goal for the Pahrump poolfish recovery effort to successfully establish at least three viable, reproducing populations. Each of the populations should have a minimum of 500 adults. If each of the populations maintains at this number for three years, the species may then be considered for re-classification to threatened status. The habitat would have to be free of immediate and potential threats to permit this change in status.

If, after an additional three-year interval, the population continues to sustain 500 adult per year per location count, consideration should be given to delisting the species. The Service also identifies its ancestral site at Manse Spring as an essential habitat for the continued existence of the Pahrump poolfish and a high priority site for re-establishing a population. Additional recovery objectives outlined include: 1) Preserve and protect transplanted Pahrump poolfish populations, 2) establish and protect viable self-sustaining Pahrump poolfish populations in suitable new or restored habitats, 3) conduct ecological studies and apply findings to management of Pahrump poolfish and its habitats, 4) delineate essential habitat for species preservation, 5) enforce laws and regulations protecting Pahrump poolfish and its essential habitat, and 6) inform public of Pahrump poolfish status and recovery plan objectives.

Synthesis

When the recovery plan for the Pahrump poolfish was written in 1980, protecting habitat and populations of transplanted populations was primary need for survival and recovery of the Pahrump poolfish. Over three decades later, the need to protect habitat and transplanted populations remains. The majority of the tasks in the recovery plan that address this need are not fully completed or are ongoing. Additionally, there has been little progress made to re-establish Pahrump poolfish into their ancestral habitat (Manse Spring) as this site is privately owned. Manse Springs was recognized in the recovery plan as the highest priority site for establishing a population of Pahrump poolfish.

Threats to current Pahrump poolfish populations remain an issue for the species' recovery. Human-exerted pressures are likely to significantly reduce and limit groundwater sources on which Pahrump poolfish sites depend. Nonnative species including crayfish, mosquitofish, and mollies continue to be a significant threat to Pahrump poolfish populations.

The overall threat to Pahrump poolfish populations remains high. There are a number of factors, as discussed above, which threaten the continued existence and viability of healthy, self-sustaining populations. If these threats were eliminated or reduced, Pahrump poolfish may be considered for reclassification. Because threats remain high and not all populations are stable or viable, reclassification or delisting cannot be considered at this time.

III. RESULTS

Recommended Listing Action:

____ Downlist to Threatened

____ Uplist to Endangered

____ Delist (indicate reason for delisting according to 50 CFR 424.11):

____ *Extinction*

____ *Recovery*

____ *Original data for classification in error*

_X_ No Change

IV. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

- Improve/restore refuge populations
  - Improve Shoshone Ponds Natural Area
    - Maintain ponds and well outflow habitat by addressing issues such as grazing, aquatic vegetation removal, low dissolved oxygen levels, pond siltation, etc.
  - Develop management strategy for Spring Mountain Ranch State Park
    - Remove/manage invasive species
- Investigate potential for establishing or re-establishing populations
  - Develop interest in Manse Spring to allow reintroduction and protection of habitat
    - Look at options – purchase, conservation easement, mitigation, etc.
  - Safe Harbor/Urban ponds (e.g. Springs Preserve)
  - Surrogate for Ash Meadows killifish

V. REFERENCES CITED

Abele, S.L. 2011. Nevada Springs Conservation Plan. Springs Conservation Plan Working Group. The Nature Conservancy, Reno, NV.

Baugh, T.M., J.E. Deacon, and P. Fitzpatrick. 1988. Reproduction and growth of the Pahrump poolfish (*Empetrichthys latos latos* Miller) in the laboratory and in nature. Journal of Aquariculture and Aquatic Sciences 5: 1-5.

[BLM] Bureau of Land Management. 2012. Revised biological assessment for the Clark, Lincoln, and White Pine Counties groundwater development project. U.S. Department of the Interior, Bureau of Land Management. May 11, 2012.

Campbell, D.C. and K.R. Pillar. 2017. Let's jump in: A phylogenetic study of the great basin springfishes and poolfishes, *Crenichthys* and *Empetrichthys* (Cyprinodontiformes: Goodeidae). PLos ONE 12(10): e0185425. Http://doi.org/10.1371/journal.pone.0185425

Deacon, J. E., C. Hubbs and B. J. Zahuranec. 1964. Some effects of introduced fishes on the native fish fauna of southern Nevada. Copeia 1964(2): 384-388.

Deacon, J. E., T. B. Hardy, J. Landye, J. Pollard, W. Taylor and P. Greger. 1980. Environmental analysis of four aquatic habitats in east-central Nevada, June-July, 1980. Unpublished interim summary report to HDR Sciences (Contract No. HDR/RPA15). 218+ pp.

Deacon, J. E. and J. E. Williams. 1984. Annotated list of the fishes of Nevada. Proceedings of the Biological Society of Washington 97(1): 103-118.

Deacon, J.E. and J.E. Williams. 2010. Retrospective evaluation of the effects of human disturbance and goldfish introduction on endangered Pahrump poolfish. Western North American Naturalist 70: 425-436.

Deacon, J.E. 1984. Recovery efforts for the Pahrump killifish at the Shoshone North Pond. Contract E-1-1, Job 1, unpublished report submitted to the Nevada Department of Wildlife, August 24, 1984. 25pp.

Doadrio, I. and O. Domínguez. 2004. Phylogenetic relationships within the fish family Goodeidae based on cytochrome *b* sequence data. Molecular Phylogenetics and Evolution 31: 416-430.

Flint, A.L., L.E. Flint, J.A. Hevesi, and J.M. Blainey. 2004. Fundamental concepts of recharge in the Desert Southwest: a regional modeling perspective, in *Groundwater Recharge in a Desert Environment: The Southwestern United States*, edited by J.F. Hogan, F.M. Phillips, and B.R. Scanlon, Water Science and Applications Series, vol. 9, American Geophysical Union, Washington, D.C. 159-184.Ganguly, A., K. Steinhaeuser, D. Erickson, M. Branstetter, E. Parish, N. Singh, J. Drake, and L. Buja. 2009. Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves. PNAS. 106: 15555–15559.

Gilbert, C. H. 1893. Report on the fishes of the Death Valley expedition collected in southern California and Nevada in 1891, with descriptions of new species. North American Fauna No. 7, Part II, The Death Valley Expedition, A biological survey of parts of California, Nevada, Arizona, and Utah. U.S. Department of Agriculture, Division of Ornithology and Mammalogy, Government Printing Office, Washington: 229-384.

Glick, P., B.A. Stein, and N.A. Edelson (eds.). 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. National Wildlife Federation, Washington, DC. 168 pp.

Goodchild, S.G. 2016. Life history and interspecific co-persistence of native imperiled fishes in single species and multi-species *ex situ* refuges. Dissertation, North Dakota State University, Fargo, ND, June 2016.

Goodchild, S.C., and C.A. Stockwell. 2016. An Experimental Test of Novel Ecological Communities of Imperiled and Invasive Species, Transactions of the American Fisheries Society, 145:2, 264-268.

Grant, E.C. and B.R. Riddle. 1995. Are the endangered springfish (*Crenicthys* Hubbs) and pupfish (*Empetrichthys* Gilbert) Fundulines of Goodeids? A mitochondrial DNA assessment. Copeia: 209-212.

Heckmann, R.A. 1988. The adaptive characteristics and parasitofauna of the Pahrump poolfish, *Empetrichthys latos latos*. Unpublished report submitted to Nevada Department of Wildlife.

Hobbs, B.M., J.E. Heinrich, and J.C. Sjoberg. 2003. Summer food habits of the Pahrump poolfish (*Empetrichthys latos latos*). Unpublished report for the Nevada Department of Wildlife, Las Vegas, Nevada.

Huber, M., and R. Knutti. 2011. Anthropogenic and natural warming inferred from changes in Earth's energy balance. Nature Geoscience. Published online December 4, 2011; DOI: 10.1038/NGEO1327. 6 pp. plus supplemental material.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K., and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland. 104 pp.

ITIS (Integrated Taxonomic Information System). 2013. World wide web electronic database at www.itis.usda.gov, retrieved January 25, 2013.

La Rivers, I. 1994. Fishes and Fisheries of Nevada. University of Nevada Press, Reno, NV. Pp. 60-63, 88, 114-116, 191, 216-219, and 520-230.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver, and Z.C. Zhao. 2007. Global Climate Projections. Pp. 747–845. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY. 996 pp.

Miller, R. R. 1948. The cyprinodont fishes of the Death Valley system of eastern California and southwestern Nevada. Miscellaneous Publications, Museum of Zoology, University of Michigan 68: 1-155.

Miller, R. R., J. D. Williams, and J. E. Williams. 1989. Extinctions of North American fishes during the past century. Fisheries 14(6): 22-38.

Minckley, W. L. and J. E. Deacon. 1968. Southwestern fishes and the enigma of endangered species. Science 159: 1424-1432.

Minckley, W.L., G.K. Meffe, and D.L. Soltz. 1991. Pages 247-282 in W.L. Minckley and J.E. Deacon (editors). Battle against extinction: native fish management in the American West. University of Arizona Press, Tucson, Arizona.

[NDOW] Nevada Department of Wildlife. 1985. Field trip report to Nevada Department of Wildlife: Corn Creek bullfrog collection, September 21, 1985. Prepared by D. Withers. Las Vegas, Nevada.

NDOW. 1986. Field trip report to Nevada Department of Wildlife: Corn Creek bullfrog collection, July 16, 1986. Prepared by D. Withers. Las Vegas, Nevada.

NDOW. 1988. Field trip report to Nevada Department of Wildlife: Corn Creek bullfrog collection, May 26, 1988. Prepared by D. Withers. Las Vegas, Nevada.

NDOW. 1991. Field trip report to Nevada Department of Wildlife: Corn Creek bullfrog collection, February 15, 1991. Prepared by J. Heinrich. Las Vegas, Nevada.

NDOW. 1999. Region III, native fish and amphibian program, program activities report, January 1, 1998 through December 31, 1998. Unpublished report, February 1999. 81+ pp.

NDOW. 2001. Field trip report, June 4 and 5, 2001, Corn Creek, determine size of population of Pahrump poolfish.

NDOW. 2003. Field trip report, June 30 and July 1, 2003, Shoshone Ponds, White Pine County, NV. Las Vegas, Nevada.

NDOW. 2012. Field trip report, December 12 and 13, 2012, Lake Harriet, Spring Mountain Ranch State Park, monitoring for the presence of exotic crayfish, Clark County, NV. Prepared by K. Guadalupe. Las Vegas, Nevada.

NDOW. 2015. Field trip report, September 2 and 11, 2015, Lake Harriett, Spring Mountain Ranch State Park, Clark County, NV, to assess the population of Pahrump poolfish. Prepared by K. Guadalupe. Las Vegas, Nevada.

NDOW. 2016. Provisional data and summary of events. Prepared by K. Guadalupe. Las Vegas, Nevada.

Parenti, L. 1981. A phylogenetic and biogeographic analysis of cyprinodontiform fishes (Teleostei, Atherinomorpha). Bulletin of the American Museum of Natural History 168:335-557.

Prinn, R., S. Paltsev, A. Sokolov, M. Sarofim, J. Reilly, and H. Jacoby. 2011. Scenarios with MIT integrated global systems model: significant global warming regardless of different approaches. Climatic Change 104:515–537.

Selby, D.A. 1976. Letter addressed to Dr. R.J. Naiman, Oregon State University, Corvallis, Oregon, dated October 13, 1976. Subject: request for information on poolfish.

Selby, D. A. 1977. Thermal ecology of the Pahrump killifish, *Empetrichthys latos latos* Miller. Master Thesis, University of Nevada, Las Vegas, May 1977.

[Service] U.S. Fish and Wildlife Service. 1980. Recovery Plan for the Pahrump killifish. Endangered Species Program, Region 1, Portland, Oregon. 29+ pp.

Service. 2004. Endangered and threatened wildlife and plants; withdrawal of proposed rule to reclassify the Pahrump poolfish (*Empetrichthys latos*) from endangered to threatened status. Federal Register 69: 17383-17386.

Service. 2012. Biological and conference opinion for the Clark, Lincoln, and White Pine Counties groundwater development project. Nevada Fish and Wildlife Office, Reno, Nevada.

Sigler, W. F. and J. W. Sigler. 1987. Fishes of the Great Basin, a natural history. University of Nevada Press, Reno, NV. 273-275 pp.

Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood, and D. Wratt. 2007. Technical Summary. Pp. 19–91. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY. 996 pp.

Soltz, D. L. and R. J. Naiman. 1978. The natural history of native fishes in the Death Valley system. Natural History Museum of Los Angeles County, Science Series 30:24.

Udall, S.L. 1967. Native Fish and Wildlife, Endangered Species. Federal Register 32: 4001.

Webb, S.A., J.A. Graves, C. Macias-Garcia, A.E. Magurran, D.O. Foighil, and M.G. Ritchie. 2004. Molecular phylogeny of the livebearing Goodeidae (Cyprinodontiformes). Molecular Phylogenetics and Evolution 30:527-544.

Williams, J.E. 1996. Threatened fishes of the world: *Empetrichthys latos* Miller, 1948 (Cyprinodontidae). Environmental Biology of Fishes 45:272.

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW

Pahrump Poolfish (*Empetrichthys latos*)

Current Classification: Endangered

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened

____ Uplist to Endangered

____ Delist

_X_ No change needed

Appropriate Listing/Reclassification Priority Number: No Change

Review Conducted By: James Harter, Southern Nevada Fish and Wildlife Office

FIELD OFFICE APPROVAL:

Field Supervisor, Southern Nevada Fish and Wildlife Office

Approve Glen W. Knowles Date 12-20-19

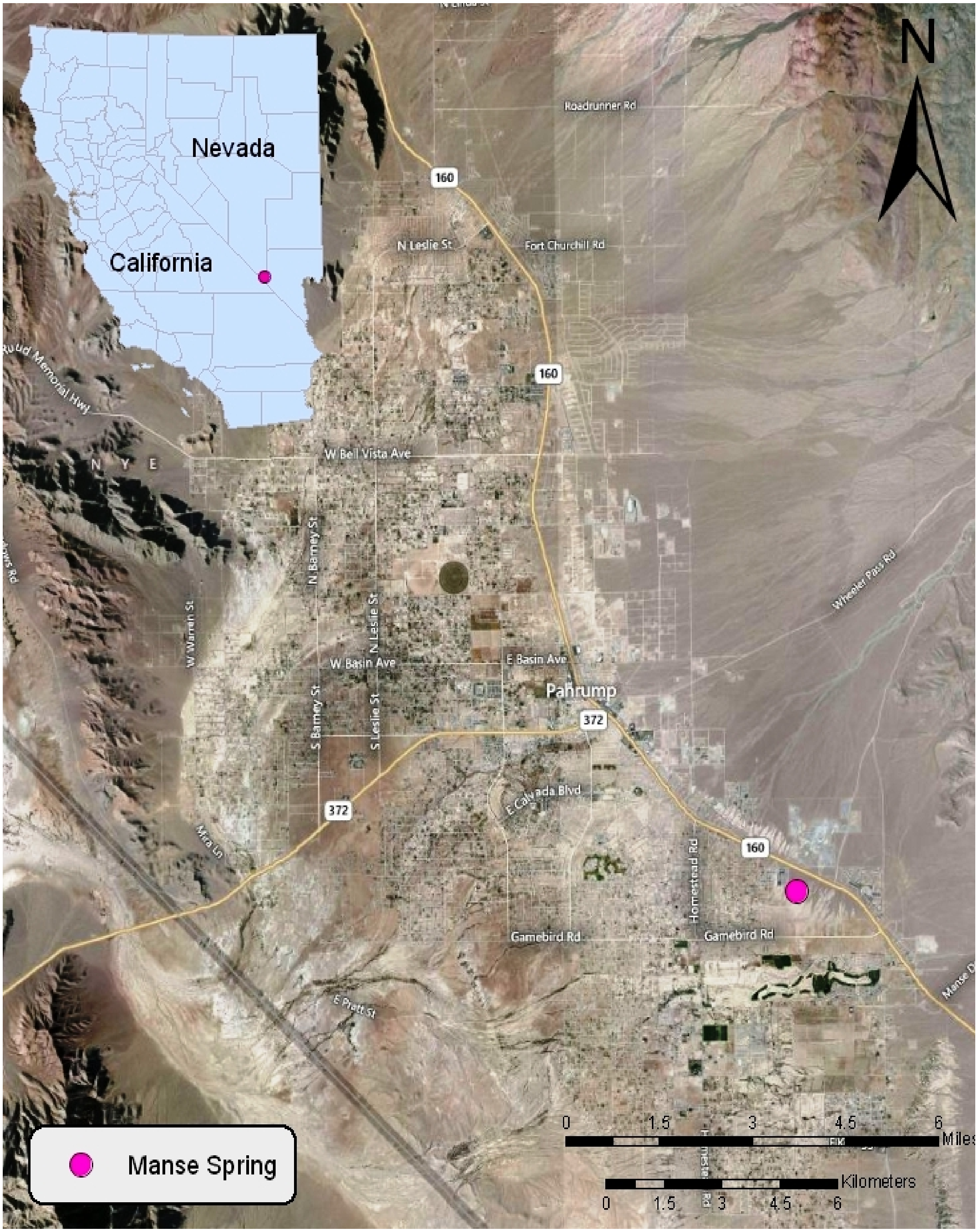

Figure 2: Historical location of Manse Spring where Pahrump poolfish were extirpated from in the 1960s, Pahrump, Nye County, Nevada.

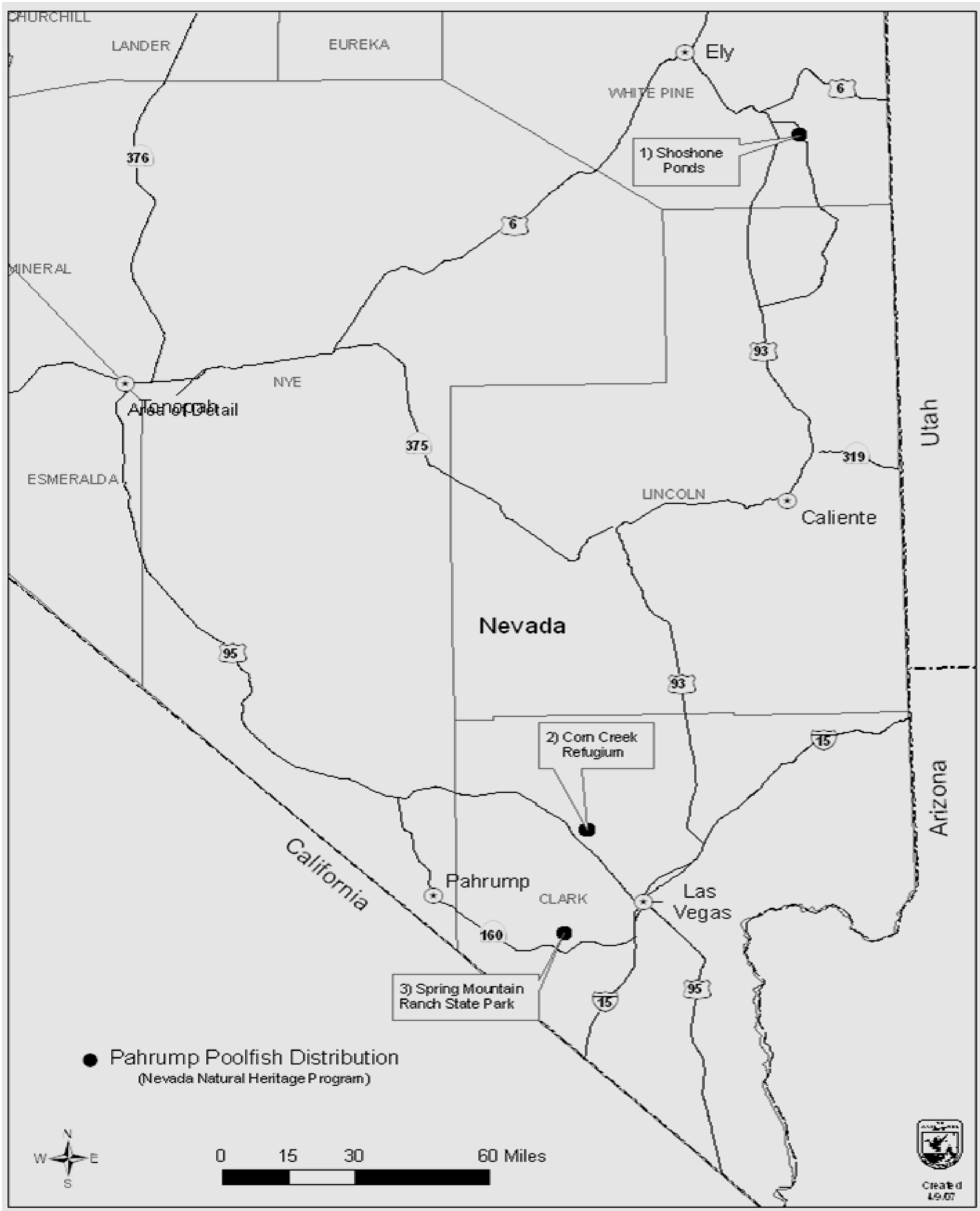

Figure 3: Locations where refugia for Pahrump poolfish have been established in Nevada.