State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

FIVE-YEAR SPECIES REVIEW OF OWENS PUPFISH (Cyprinodon radiosus)

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Owens Pupfish, photo by Jeff Weaver

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I. EXECUTIVE SUMMARY

The Owens Pupfish (*Cyprinodon radiosus* Miller) is a small freshwater fish that is endemic to the Owens Basin in eastern California, near the communities of Mammoth Lakes, Bishop, Big Pine and Lone Pine (Figure 3). Owens Pupfish face ongoing threats, have an exceptionally limited current distribution, and their overall status has remained largely unchanged since their listing under the California Endangered Species Act (CESA) in 1971. Predation by, and competition with, non-native aquatic species within their range, loss of the majority of their historic habitat, genetic factors, water development activities, and predicted outcomes of climate change are the principal threats to Owens Pupfish.

Owens Pupfish is currently listed as endangered under CESA (Fish and G. Code § 2050 et seq.; Cal. Code Regs. tit. 14 § 670.5 subd. (a)(2)(K)). Pursuant to Fish and Game Code section 2077, subd. (a), the California Department of Fish and Wildlife (Department/CDFW) has prepared this Five-Year Species Review to evaluate whether conditions that led to the original listing of Owens Pupfish are still present or have changed. This review is based on the best scientific information currently available to the Department regarding each of the components listed under section 2072.3 of the Fish and Game Code and section 670.1, subds. (d) and (i)(1)(A) of Title 14 of the California Code of Regulations (C.C.R.). In addition, this document contains a review of the identification of habitat that may be essential to the continued existence of the species, and the Department's recommendations for management activities and other recommendations for recovery of the species. (Fish & G. Code, § 2077, subd. (a).)

In completing this Five-Year Species Review for Owens Pupfish, the Department finds there is sufficient scientific information to indicate the conditions and associated threats that led to the listing of Owens Pupfish as endangered are still present and, in some cases, have worsened. The Department, therefore, recommends no change to the status of Owens Pupfish on the list of endangered species at this time.

II. INTRODUCTION

A. Five-Year Species Review

This Five-Year Species Review addresses Owens Pupfish. Upon a specific appropriation of funds by the Legislature, the Department shall, or if other funding is available, in the absence of a specific appropriation, may, review species listed as endangered or threatened under CESA every five years to determine if the conditions that led to the original listing are still present (Fish and G. Code § 2077, subd. (a)). Owens Pupfish is also listed as endangered under the Federal Endangered Species Act. Pursuant to Fish and Game Code section 2077, subd. (b), the United States Department of the Interior, U.S. Fish and Wildlife Service (Service) was contacted in an effort to coordinate this species review with their five-year review process (last completed in 2009). However, the Service does not plan to complete a species review until their Fiscal Year 2021-22 (Bjorn Erickson, USFWS pers. comm. 2019). Consequently, the Department has initiated this independent review.

Using the best scientific information available to the Department, this Five-Year Species Review includes information on the following components pursuant to § 2072.3 and § 2077, subd. (a), of the Fish and Game Code and § 670.1, subd. (d), of Title 14 of the C.C.R.: species' population

trend(s), range, distribution (including a detailed distribution map), abundance, life history, factors affecting the species' ability to survive and reproduce, the degree and immediacy of threats, the impact of existing management efforts, the availability and sources of information, identified habitat essential for the continued existence of the species, and the Department's recommendations for future management activities and other recovery measures to conserve, protect, and enhance the species.

B. Listing and Species Review History

Owens Pupfish was listed as endangered under the Federal Endangered Species Act in 1967 and under the California Endangered Species Act in 1971, among the first group of taxa in the nation to be listed. Owens Pupfish is also a Fully Protected Fish under Fish and Game Code § 5515, subd. (b), but with a take allowance granted under Fish and Game Code §2089.7. The main identified threats to the species at the time of listing are unknown but likely included: habitat loss and associated severely restricted distribution, coupled with threats (predation and competition) from non-native introduced species.

In 1984, the Owens Pupfish Recovery Plan was published (USFWS 1984).

In 1990, the state 5-year status update for Owens Pupfish was published (CDFG 1990).

In 1998, the federal Owens Basin Wetland and Aquatic Species Recovery Plan was published (USFWS 1998). This plan supplanted the 1984 Owens Pupfish Recovery Plan (USFWS 1998).

In 2009, the federal 5-year status update for Owens Pupfish was published (USFWS 2009).

This Five-Year Species Review was initiated in July 2019 and prepared by Jeff Weaver, in the Department's Fisheries Branch, Native Fishes Conservation and Management Program. Nick Buckmaster[a], Environmental Scientist, Steve Parmenter[b], Senior Environmental Scientist (Specialist) and lead biologist for Owens Pupfish, Rob Titus[c], Senior Environmental Scientist (Supervisory) and Claire Ingel[d], Senior Environmental Scientist (Specialist) ([ab]CDFW Inland Deserts Region, Bishop Field Office, [cd]CDFW Fisheries Branch), also contributed substantially to this review.

C. Notifications and Information Received

On November 26, 2019, the Department notified persons who had expressed their interest in CESA actions in writing to the Commission and had provided contact information to the Commission (Fish and G. Code, § 2077(a)). The e-mail notification included a link to the Department's dedicated web page for five-year reviews of threatened and endangered species at https://www.wildlife.ca.gov/Conservation/CESA/Five-Year-Reviews.

III. BIOLOGY

A. Taxonomic and Physical Description

Owens Pupfish are small, deep-bodied, and laterally compressed, members of the killifish family (Cyprinodontidae) that rarely exceed 6 cm (2.5 in) in length (USFWS 2009). The Owens Pupfish was described by Robert Rush Miller (1948) based on a collection from West Spring, Fish Slough, northwest of Bishop, California (Figure 1). Males and females can be easily

distinguished from one another by coloration during breeding season, owing to their distinctive seasonal sexual dimorphism (Miller 1948). Year-round, females are dusky olive-green in color, with purplish iridescence and several dark vertical bars aligned in a row along the sides. During the spring and summer spawning season, males are bright blue with gold or brassy sides and broad vertical bars. During the non-breeding season males resemble females, except barring may be absent (CDFG 1990). Adult males are generally larger and deeper-bodied than adult females (Moyle 2002).

The species is distinguished from other pupfishes by the anterior placement of the dorsal fin, long caudal peduncle (the narrow part of a fish's body to which the caudal or tail fin is attached), absence of spine-like projections on scale circuli (growth rings), and absence of a terminal black band on the caudal fin (USFWS 2009). Owens Pupfish also have a greater number of dorsal, pelvic, pectoral, and anal fin rays than other pupfish species; the specific epithet in their scientific name, "radiosus," refers to the abundance of these fin rays (Miller 1948). The Owens Pupfish is most closely related to the Desert Pupfish (*Cyprinodon macularius*) but may have been isolated from it, and other related pupfishes of the southwestern United States, for over two million years (Moyle 2002).

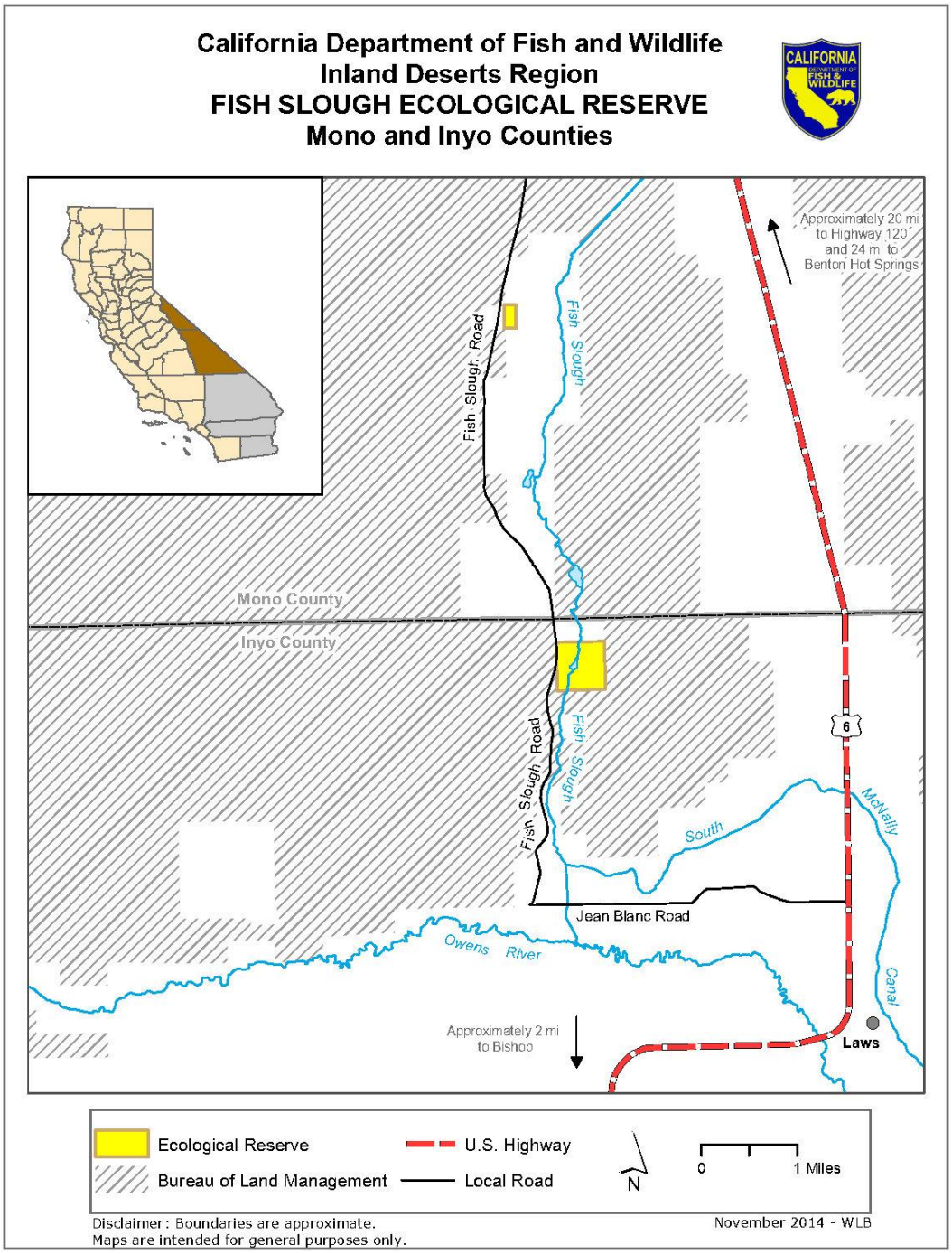

Figure 1. Map of Fish Slough Ecological Reserve, located approximately 2 miles northwest of Bishop, California. Map inset highlights the location of the Owens Basin in Mono and Inyo counties, California.

B. Life History and Ecology

Four fish species comprise the Owens Basin native fish assemblage: Owens Pupfish, Owens Tui Chub (*Siphateles bicolor snyderi),* Owens Speckled Dace (*Rhinichthys osculus* ssp.), and Owens Sucker (*Catostomus fumeiventris*) (USFWS 1998). All are omnivorous and, with the exception of Owens Tui Chub, non-predatory. All four are habitat generalists with presumably little interspecific competition related to habitat utilization, resource partitioning, or demography (USFWS 1998). All Owens Basin fishes are also vagile (highly mobile with the ability to rapidly colonize vacant habitats), and have high reproductive capacity (USFWS 1998), suggesting all four occupied most, if not all, historically available aquatic habitats within their range.

Owens Pupfish congregate in small schools and feed mostly on aquatic insects (Kennedy 1916). Pupfish are, in general, opportunistic omnivores whose diet varies seasonally. They also eat algae, terrestrial insects that fall into the water, crustaceans, plankton, and even their own dead and eggs (Brunnell 1970). No information specific to Owens Pupfish was found in the literature regarding their physiological tolerances. However, pupfishes, in general, are known for their remarkable tolerances to temperature, pH, and other factors. Schoenherr and Feldmeth (1992) studied the thermal tolerances of the closely related Desert Pupfish, noting that their tolerances are “legendary.” They indicated existing published data on critical thermal minima and maxima for Desert Pupfish ranged from extremes of 7°C to 44.6°C (44.6°F to 112.3°F). Moyle (2002) states that water temperatures [in Owens Pupfish habitats] probably ranged annually from about 10°C to 25°C (50°F to 77°F). Moyle (2002) also indicated that, related to the seasonal timing of spawning initiation, temperatures in Owens Pupfish habitats with strong seasonal temperature fluctuations range from about 7°C to 26°C (44.6°F to 80°F). Spawning occurs over soft substrates in spring and summer. Male pupfish are territorial, defending areas of substrate from competing males. Female pupfish occupy habitats along the margins of areas defended by males (Mire 1993). Mire and Millett (1994) observed that female Owens Pupfish may be involved in spawning acts up to 200 times per day, laying 1-2 eggs at a time. Eggs incubate for approximately 6 days before hatching in water temperatures ranging from 24°C to 27°C (75°F to 81°F), with an average of 95 percent of spawned eggs fertilized. Juvenile pupfish grow rapidly to sexual maturity in 3 to 4 months (Barlow 1961). They are usually able to spawn before their first winter and their lifespan is rarely greater than 1 year (Soltz and Naiman 1978). However, Owens Pupfish live as long as 3 years in refuge habitats with more constant thermal regimes (Mire 1993 in USFWS 2009).

C. Habitat Necessary for Species Survival

The key features of Owens Pupfish habitats are slow flowing, high quality fresh waters, with well-developed beds of aquatic plants that provide cover and support abundant aquatic insects for forage (Figure 2). Preferred substrates are comprised of sand, silt, or other fines (USFWS 2009). The habitats they occupy include: springs, lakes, sloughs, ponds, backwaters and other slower waters in the Owens Basin. Adults frequently occupy deeper water than juveniles, but all life stages may be found in the various microhabitats available in the environment with little preference (Sada and Deacon 1994). Miller and Pister (1971) summarized field studies that showed pupfish were most abundant in shallow sloughs bordering the Owens River and marshes and springs adjacent to the river.

There appear to be several differences between the habitats of Owens Pupfish and that of other pupfish species. Aquatic habitats in and adjacent to the Owens River are generally colder, frequently covered by ice during winter, and lower in conductivity and salinity than habitats of other pupfish species (Cole 1981). A fundamental element of the habitat conditions necessary

for the survival of Owens Pupfish is the absence of nonnative species that are predatory or may outcompete pupfish, potentially leading to their localized extirpation.

Figure 2. Representative Owens Pupfish habitat. Location: BLM Spring in Fish Slough, northwest of Bishop, CA. Photo courtesy of Nick Buckmaster, CDFW.

IV. DISTRIBUTION AND ABUNDANCE

A. Range and Distribution

Owens Pupfish are endemic to the Owens Basin (comprised of Owens, Round, and Long valleys) in Mono and Inyo counties, California (USFWS 2009). Although the Owens Pupfish was not formally described until 1948, the distribution and relative abundance of Owens Pupfish were noted by early explorers and scientists (USFWS 1998). Fisheries surveys during the early 1900s documented pupfish in habitats throughout the Owens Valley (Kennedy 1916, Snyder 1917). Survey results indicated that Owens Pupfish occupied most valley-floor aquatic habitats from Fish Slough (Figure 1), approximately 19 km (12 mi) north of Bishop, south to Lone Pine (Kennedy 1916, Snyder 1917, Miller 1948), a linear distance of approximately 113 km (70 mi). This early documentation is likely due to the ease with which pupfish can be seen in their relatively shallow clearwater habitats, the seasonally eye-catching bright blue coloration of male pupfish, and their “playful” behavior, which is actually male breeding territory defense behavior. Davidson (1859) reported pupfish as common throughout the Owens River, but absent from tributary streams. Pupfish may have utilized the Owens River Delta at Owens Lake (USFWS 2009) but their historic presence in Owens Lake itself is unknown (Moyle 2002).

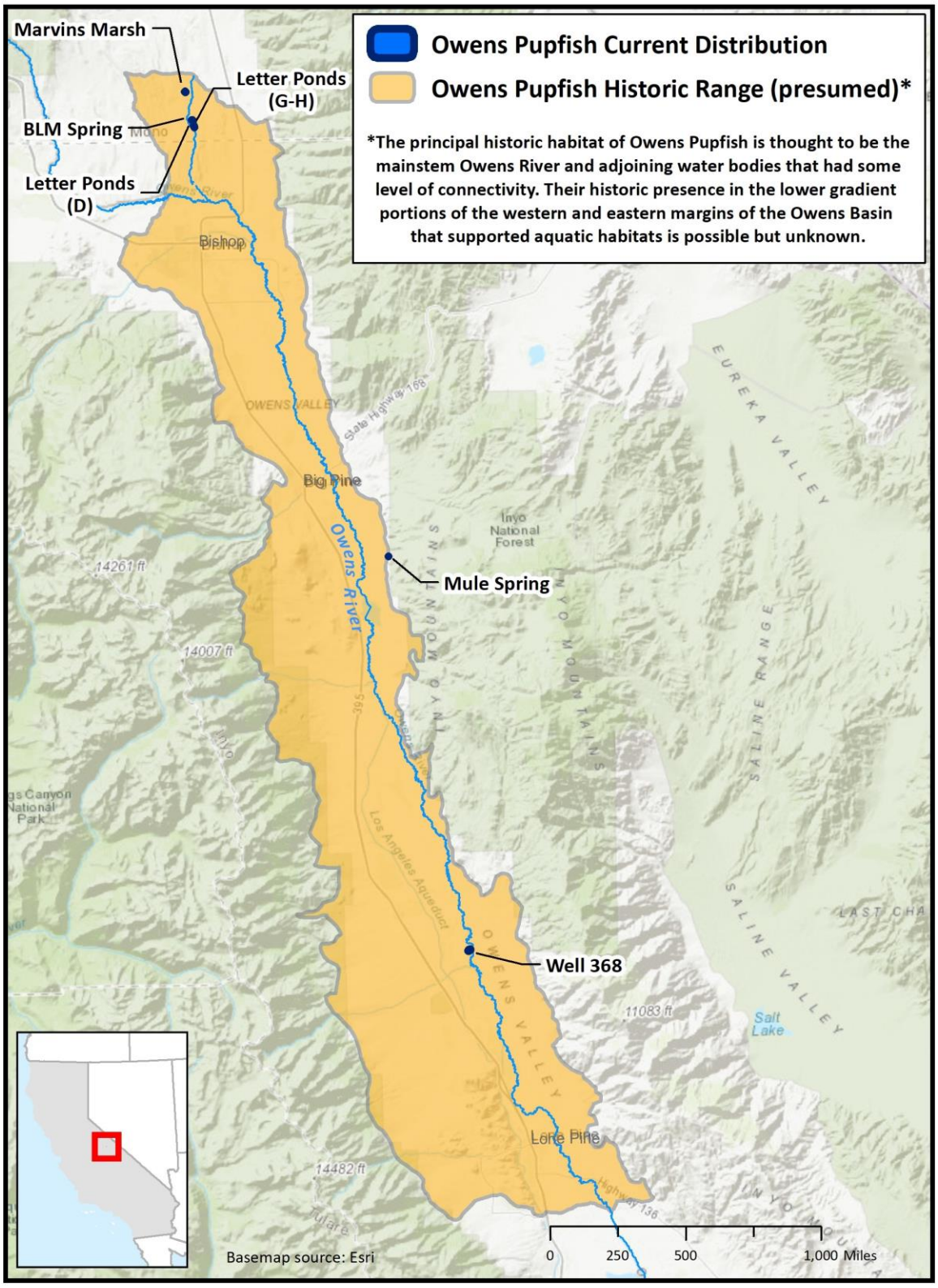

Figure 3. Map of historic range and current distribution of Owens Pupfish in Mono and Inyo counties, California.

Steward (1933) reported that the native Paiute tribe captured large numbers of pupfish with basket-like nets and dried them for use as winter food, indicative of their notable historic abundance. Their range and distribution are now severely restricted (Figure 3), owing to two principal historic and ongoing threats: predation by non-native species and habitat loss.

B. Population Trend and Abundance

Museum records indicate that the period from 1930 to 1970 was characterized by a rapid decline in abundance and distribution of Owens Basin native fishes, including the pupfish (Miller 1969, Sada 1989 in USFWS 1998). However, it should be noted that even earlier declines likely occurred due to undocumented introduction of non-native, predatory and competitive, fishes and other organisms (e.g., bullfrogs and crayfish) during the settlement of the area by European-Americans. The first segments of the Los Angeles Aqueduct, built to divert Owens Basin waters to provide municipal supply to Los Angeles, were completed in 1913 and led to the dewatering of much of the Owens River and associated aquatic habitats. Further declines likely occurred during this period, due to the construction of Long Valley Dam in 1941. Long Valley Dam was built at the head of the Owens River Gorge as part of a hydropower project, which led to the complete dewatering of the Lower Owens Gorge reach from 1953 to 1991. Adjoining marsh and pond complexes were invariably dried in the process of the Owens River dewatering, leading to extensive habitat loss. However, a considerable number of groundwater seeps and springs persisted in the Owens Basin through the 1980s. The dewatering and disappearance of these seeps and springs in recent decades is likely due to excessive groundwater pumping (N. Buckmaster, CDFW, pers. comm., 2019).

Owens Pupfish were believed to be extinct from 1942 until 1964 (Miller 1969), when a single population of approximately 200 individuals was rediscovered in Fish Slough (Miller and Pister 1971). When listed under the Federal Endangered Species Act in 1967, the Owens Pupfish was still limited to this single population. All extant populations have been propagated from this remnant stock (USFWS 1998). As of 2013, five populations of Owens Pupfish were documented to exist (Finger et al. 2013). These populations continue to persist and include: BLM Spring, BLM Ponds, and Marvin's Marsh, the three of which are isolated subpopulations within the broader Fish Slough area; Mule Springs; and Well 368 (Figure 3). The estimated population sizes and trends for these five groups are indicated in Table 1 below (USFWS 2009 and N. Buckmaster, CDFW, pers. comm., 2019). A former refuge population of <100 individuals in Warm Springs was documented to have been extirpated in 2009 (S. Parmenter and N. Buckmaster CDFW, pers. comm., 2019).

Table 1. Descriptions of refuge sites and populations of Owens Pupfish. *Estimated population sizes and trends provided by S. Parmenter, CDFW (in USFWS 2009).

Site	Size (acres)	Introduction year	Estimated population size*	Population trend*
BLM Spring	0.17	1969	1,000-10,000	increasing/stable
BLM Ponds	0.01	1982	100	stable
Marvin's Marsh	0.07	1986	100-1,000	decreasing
Mule Springs	0.01	1995	3,000 (+/-300)	stable
Well 368	0.05	1988	100-1,000	stable

V. THREATS AND SURVIVAL FACTORS

A. Factors Affecting Ability to Survive and Reproduce

Title 14 of the C.C.R. section 670.1(i)(1)(A) requires the Commission to consider the following factors when determining whether a species should be listed as threatened or endangered in California: present or threatened modification or destruction of its habitat; overexploitation; predation; competition; disease; and other natural occurrences or human-related activities.

Modification or destruction of habitat

Many aquatic habitats in the Owens Basin have been substantially degraded or lost due to introduction of non-native species, land use practices, and extensive water development activities. Historic maps of the area show surprisingly extensive wetland complexes around the Owens River and its tributaries (Appendix D), particularly given the naturally arid nature of the Owens Basin. Present or threatened (future) loss of Owens Pupfish habitat may occur primarily as a result of aquatic plant encroachment, groundwater overdraft associated with agricultural or water export operations, as well as continued and potentially increasing surface water diversions.

Aquatic plant encroachment—While cattail (*Typha* sp.) and other aquatic emergent vegetation are native to the area, active management of existing pupfish habitats is required to prevent their encroachment, including routine manual removal and/or prescribed fires to maintain open water habitats that Owens Pupfish require.

Groundwater pumping—Groundwater, or aquifer, pumping is largely associated with agricultural irrigation and municipal supply demands in the Owens Basin. Unregulated groundwater pumping may result in overdraft of the aquifer in the Tri-Valley region of the Owens Valley Groundwater Basin area, which underlies the Benton, Hammil, and Chalfant valleys in Mono County. The remainder of the Owens Valley Groundwater Basin, comprised of Round and Owens valleys in Inyo County, is managed under the “Agreement Between the County of Inyo and the City of Los Angeles and its Department of Water and Power on a Long Term Groundwater Management Plan for Owens Valley and Inyo County” or “Long-Term Water Agreement” (hereafter referred to as Agreement) (N. Buckmaster, CDFW, pers. comm., 2019). In California, groundwater withdrawal must be managed and monitored in those basins that have been adjudicated or are required to develop and implement a Groundwater Sustainability Plan (GSP) under the Sustainable Groundwater Management Act (SGMA; SB 1168, SB 1319, and AB 1739, effective January 1, 2015). Because the aquifer in the Tri-Valley Basin has not been adjudicated and is part of a basin that has been classified as low-priority under SGMA, groundwater withdrawals in this basin are not currently subject to limits pursuant to a court decree or GSP. Without such limits, groundwater pumping could result in a reduction or complete lack of water input to existing isolated springs and headwater springs of streams in the Owens Basin. This change would result in a further reduction or loss of the already extremely limited aquatic habitat occupied by the Owens Pupfish (USFWS 2009). For example, from the early 1900s to the 1960s, there was a 40 percent decrease in water flow from the springs at Fish Slough (Pinter and Keller 1991), which is a principal refuge for the pupfish. In the notably arid region where Owens Pupfish occur, further reductions in aquifer recharge to support surface water habitats may pose a substantial threat to the species.

Surface water diversions—As noted, much of the aquatic habitat in the Owens Valley has been eliminated or modified since the early 1900s. Most of the water rights (and lands) in the Owens

Basin are owned by the City of Los Angeles and operated by the Los Angeles Department of Water and Power (LADWP). LADWP operates and maintains dams, diversion structures, groundwater pumps, and canals to capture and convey much of the water from the Owens Basin to Los Angeles. Currently, the demand for water from the Owens Basin is high and continues to grow, as human population growth and associated metropolitan development in southern California expand. The remaining water (both surface and groundwater) is used extensively for agriculture and municipal purposes in the Owens Basin. These anthropogenic changes to aquatic habitats in the Owens Basin have eliminated much of the suitable habitat for Owens Pupfish. Consequently, their populations were reduced from common and wide-ranging to only a few small populations in heavily managed refuge sites (USFWS 2009).

While some hydrological restoration and mitigation has occurred in the Owens River Basin, the direct benefits to Owens Pupfish have been minimal. For example, in 1991, a ruptured pipeline in LADWP's hydroelectric infrastructure resulted in returned flows to the Owens River (Owens Gorge), the resulting development of the Agreement referenced in the Groundwater pumping subsection of this report, and the preparation of an associated Environmental Impact Report (EIR) to address potential impacts from restored instream flows and modified operations. In 1997, as a result of ongoing disputes related to the adequacy of the EIR and implementation of the Agreement, a Memorandum of Understanding (MOU) among the litigants (LADWP and Inyo County) and interveners (Sierra Club, Owens Valley Committee, California Department of Fish and Game, and California State Lands Commission) required LADWP to release a permanent base flow of 40 cubic feet per second in the lower Owens River. The MOU was incorporated with amendments into an Amended Stipulation and Order by the Superior Court of the State of California, County of Inyo and incorporated into the broader Lower Owens River Project. The LADWP initiated the releases required under the MOU and, in 2007, the court determined that LADWP had complied with the permanent base flow release requirement in the MOU (Inyo County Water Department website). These flows reestablished important aquatic habitat in nearly 60 miles of the lower Owens River, much of which was historical habitat for the Owens Pupfish. Unfortunately, the increase in available habitat has not benefited the Owens Pupfish. The section of river where aquatic habitat was established is now dominated by non-native species, which prey on or compete with the Owens Pupfish (USFWS 2009). In addition, LADWP has not fully implemented components of the project that are specifically intended to benefit imperiled native fishes, including the Owens Pupfish, so realization of the suite of desired outcomes has not yet occurred (N. Buckmaster, CDFW, pers. comm., 2019).

Overexploitation

Overexploitation as a result of commercial, recreational, scientific, or educational activities was not considered a threat at the time of listing, and there is no information to suggest that it has become a threat more recently (USFWS 2009).

Predation and Competition

Non-native predators and competitors are a serious and principal threat to the Owens Pupfish. At the time of listing in 1967, predation by non-native fish, e.g., Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*M. dolomieu*), Brown Trout (*Salmo trutta*), and Bluegill Sunfish (*Lepomis macrochirus*), threatened the species. Since listing, non-native Mosquitofish (*Gambusia affinis*), Crayfish (*Pastifasticus leniusculus*), and American Bullfrogs (*Rana catesbeiana*) have been introduced into the pupfish's habitat and pose a threat to Owens Pupfish. Non-native predators eat both young and adult Owens Pupfish; they also compete with Owens Pupfish for food and habitat. Owens Pupfish face direct competition with Mosquitofish,

particularly related to foraging for mosquito (Family Culicidae) larvae, which is an important component of their seasonal diet. Mosquitofish are abundant and widespread in Owens Basin aquatic habitats and occupy the same ecological niche as pupfish, making them a major threat. Owens Pupfish populations are also particularly vulnerable to predation, due to their behavioral traits and evolution in the absence of predators. As an example, a single Largemouth Bass was documented to have reduced the pupfish population in BLM Spring from an estimated >5000 adults and juveniles in early 2017 to 12 observed adults and zero juveniles in early 2018 (N. Buckmaster, CDFW, pers. comm. 2020). All remaining populations may be threatened by the introduction of even a single predator. Non-native predators are currently present in much of the habitat pupfish historically occupied. Therefore, establishing new populations of Owens pupfish will require reintroductions to occur in locations where non-native predators can be excluded (USFWS 2009).

Disease

Disease was not known to be a threat to Owens Pupfish at the time of listing in 1967, and there is no information to suggest that it has become a threat.

Other natural occurrences or human-related activities

Other factors that may negatively affect the ability of Owens Pupfish to persist include genetic threats, climate change and stochasticity.

Genetics—According to Finger et al. (2013) Owens Pupfish are less genetically diverse than most other pupfishes of the desert southwest (including Amargosa, Desert and Sonoyta pupfishes). This study also indicated that Owens Pupfish refuge populations have undergone extreme genetic bottlenecks in the past (e.g., the observed overall population low in 1964 of approximately 200 individuals, from which all current populations are derived). Population bottlenecks occur when there is a drastic reduction in population size and often result in a loss of genetic variation. Bottlenecks are of conservation concern because they increase genetic drift and the chance of inbreeding, which can reduce diversity, fitness, adaptive potential, population viability and, by extension, increase the risk of extinction in small populations (e.g., Quattro and Vrijenhoek 1989; Frankham et al. 2002 in Finger et al. 2013). Additional findings indicated that all refuge populations of Owens Pupfish have differentiated (likely due to their complete isolation from one another and via the process of genetic drift), have also lost genetic diversity and will continue to do so without deliberate and ongoing intervention and management (Finger et al. 2013).

Perhaps of greatest concern is the fact that each refuge population, with the apparent exception of the Well 368 population, possesses unique or “private” alleles (genetic material). As such, intensive human intervention and intentional admixing of populations in accordance with a genetics management plan will be required to maintain maximum genetic diversity. Without this level of management, if any subpopulation is lost or continues to diverge, that population will take with it a portion of the genetic diversity that has been lost by all others (represented by private alleles). Every extant population has been recently and artificially subdivided, and all are subject to potential extirpation, as witnessed at Warm Springs in the recent past (Finger et al. 2013). The extensive distribution of private alleles among the existing refuge populations, unless corrected, may lead to genetic problems that could undermine their long-term persistence. This situation necessitates the creation of additional, larger, and more diverse refuge habitats and associated pupfish populations.

Climate change—Increasing temperatures and more extreme weather patterns associated with climate change are also likely to negatively affect Owens Pupfish, which exist in an already arid region in the "rain shadow" of the Sierra Nevada. Owens Pupfish habitats are fed by aquifers and surface flow, which are dependent on snow melt for recharge. It is predicted that climate change will lead to a reduction in snowpack throughout much of the Sierra Nevada, due to warmer temperatures and a shift in precipitation toward rainfall in late winter and early spring months. Sierra Nevada snowpack levels are already demonstrably variable from year to year, with some of the lowest levels in recorded history during the prolonged and severe drought from 2012 to 2016. However, the Owens Valley is at the base of the southernmost portion of the Sierra Nevada, where the range attains maximum elevations. Thus, the effects of climate change may be mitigated, at least to some extent, by greater accumulation and retention of snowpack in this portion of the range (Moyle et al. 2015). However, Moyle et al. (2013) determined that other Owens Basin fish taxa (such as Owens Speckled Dace and Owens Sucker) are highly vulnerable to climate change, indicating extinction may occur if measures to counter climate change effects are not taken. Given that Owens Speckled Dace are also limited to a few (three known) populations (Moyle et al. 2015), the potential threat(s) of climate change to Owens Pupfish may be similar. The predicted hotter and drier future climate, paired with an ever-increasing human demand for water resources in the Owens Basin, strongly indicates that aquatic habitats must be carefully protected if the Owens Pupfish is to persist. Given the area's history of water exportation and competing demands for remaining water supplies to meet agricultural, municipal, recreational, and ecological needs, future climate warming and increased variability and extremity of weather patterns will undoubtedly exacerbate existing challenges.

Stochasticity—With such small and isolated populations, Owens Pupfish are particularly susceptible to stochastic (random) threats, including demographic, genetic and environmental stochasticity or catastrophic events (Shaffer 1981 in USFWS 2009). Portions of the Owens Basin, (e.g., Long Valley in the northern part of the basin) are volcanically active and earthquakes could lead to disruption of subsurface flows that feed springs or contribute to other surface flows, potentially threatening Owens Pupfish refuge habitats. Likewise, shifts in geothermal activity and associated rerouting of subsurface flows could lead to inundation of Owens Pupfish habitats, rendering them lethal by increasing water temperatures or altering water chemistry outside of their physiological tolerances. Long Valley (site of the massive 10 x 20 mile Long Valley Caldera) is listed by the California Volcano Observatory as one of the top three sites in the state with the highest chance of an eruption (U.S. Geological Survey (USGS) California Volcano Observatory website). Furthermore, the Long Valley Caldera is a blast volcano, increasing the chances of catastrophic impacts to the local environment due to the explosive nature of this type of volcanic eruption (Worldatlas.com website). The United States Geological Survey rates the threat potential of Long Valley as "Very High" (USGS Volcano Hazards Program website).

B. Degree and Immediacy of Threats

Numerous threats exist that may negatively affect the future persistence of Owens Pupfish; however, historic introductions of non-native aquatic organisms and associated predation and competition, along with historically extensive aquatic habitat alteration and reduction, are the primary threats that have led to their greatly reduced abundance, severely restricted distribution, and endangered listing status. As indicated, ongoing threats include the following: potential introduction of non-native species into refuge habitats; climate change; increasing demand for municipal, agricultural, and other water supplies; isolation and associated impacts from genetic drift, differentiation, and bottlenecks; reliance of all populations on routine removal of emergent

vegetation in very small or artificial (or both) refuge habitats; and stochastic events that may reduce or eliminate small, isolated populations. However, the degree and immediacy of these threats is unknown. It is likely that introduction or ongoing presence of non-native fishes ranks highest among potential threats (N. Buckmaster, CDFW, pers. comm., 2019).

VI. MANAGEMENT AND RECOVERY

A. Impact of Existing Management Efforts

i. Owens Pupfish population establishment

Historic management of Owens Pupfish has included numerous habitat creation or restoration projects and resulted in 88 translocations since the species was rediscovered in 1964 (Appendix A, Appendix B). However, over 90% of these translocations failed (Appendix C), and no attempt has been made to establish new populations since 2007 (S. Parmenter, CDFW pers. comm. 2019).

ii. Owens Pupfish population monitoring

Ongoing population monitoring is a key management element in evaluating Owens Pupfish status and trends. Currently, the Bishop Paiute Tribe, in coordination with Bureau of Land Management (BLM) and the Department, conduct weekly monitoring of BLM Spring (the largest extant habitat) to ensure no non-native predators are introduced into this habitat. In addition to BLM spring, the Department currently conducts State Wildlife Grant-funded surveys of the remaining Owens Pupfish populations quarterly. Single mark-recapture estimates of the Owens Pupfish population in Mule Spring, Well 368, BLM Ponds, and Marvin's Marsh will be completed in 2019 (N. Buckmaster, CDFW pers. comm. 2019). Ongoing monitoring efforts are described in Table 2 (below).

Table 2. Overview of ongoing Owens Pupfish population monitoring.

Location	Monitoring Method	Frequency	Responsible Party
BLM Spring	Visual and Snorkel Surveys	Weekly	Bishop Paiute Tribe, CDFW, BLM
Mule Spring	Visual Surveys	Monthly	CDFW, BLM
Letter Ponds	Visual and minnow trapping Surveys	Quarterly	CDFW
Marvin's Marsh	Visual and minnow trapping Surveys	Annually	CDFW
Well 368	Visual Surveys	Annually	LADWP, CDFW

iii. Rehabilitation of the River Spring Lakes Ecological Reserve

Options to expand Owens Pupfish populations into new habitats in the Owens Basin are very limited. Most otherwise suitable habitats are occupied by non-native species or are located on LADWP or other private property (or both). One of the few options is the River Spring Lakes Ecological Reserve (Ecological Reserve; Figure 4), which was purchased by the State of California in 1980 and contains a 640-acre spring-wetland complex, known as a ciénega. The property was acquired for the purpose of creating a refuge for imperiled Owens native fishes and to preserve one of the few large spring-wetland complexes

remaining in the Inyo/Mono Desert for fish and wildlife habitat needs. The Ecological Reserve contains Amargosa River Pupfish, which were stocked by Robert Rush Miller in 1940, along with Salt Creek Pupfish. It is possible these two species hybridized after stocking; however, no genetic studies have been performed to determine this (N. Buckmaster, CDFW pers. comm. 2019).

The Department secured funding in 2016 to rehabilitate the Ecological Reserve by eradicating the introduced Amargosa and Salt Creek pupfishes, with the intention of introducing Owens Pupfish. The rehabilitation was completed in 2019 (N. Buckmaster, CDFW pers. comm. 2019). Following short-term monitoring to ensure the successful removal of the existing pupfish population, the Ecological Reserve will be stocked with Owens Pupfish from existing refuges. This introduction will increase the area of occupied Owens Pupfish habitat by five orders of magnitude and, because of its large size, the Ecological Reserve will likely prevent additional loss of genetic variation and serve as a more climate change-resilient refuge than existing sites. Its remote location, in a little-traveled part of the state, should also serve as a buffer against intentional stocking of nonnative fishes, as has repeatedly occurred in other more accessible Owens Pupfish refuge sites.

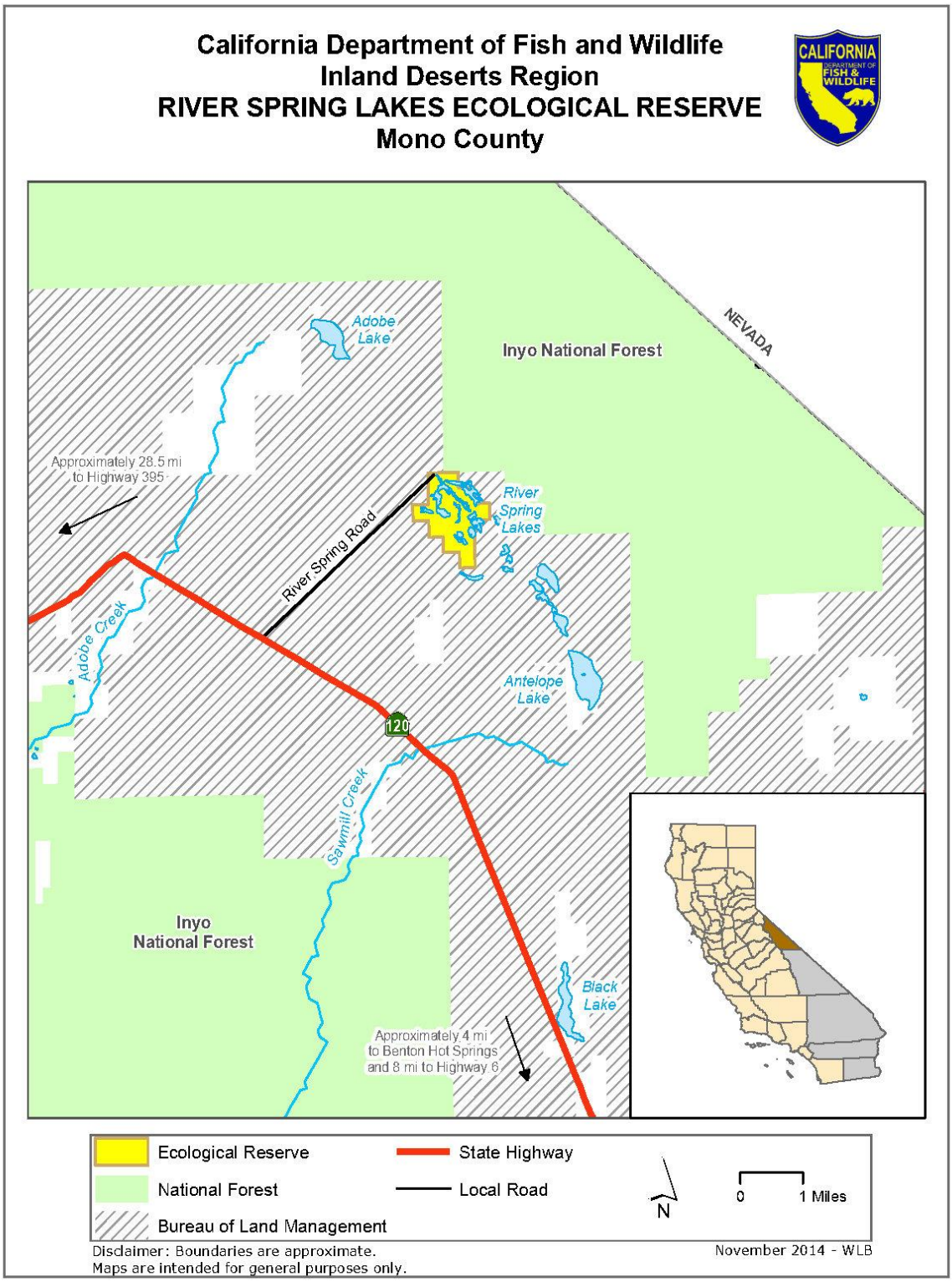

Figure 4. Vicinity map of River Spring Lakes Ecological Reserve, approximately 31 km (19 miles) east-southeast of Mono Lake in Mono County, CA.

B. Recommendations for Management Activities and Other Recommendations for Recovery of the Species

The Department recommends the following actions to ensure the long-term persistence of Owens Pupfish:

1. Continue maintenance of existing habitats and population monitoring:
   - Continue routine visual monitoring of occupied pupfish habitats and perform manual removal of emergent vegetation on an as-needed basis.
   - Continue population monitoring as prescribed in Table 2.
   - Continue visual surveys of BLM Spring to detect non-native fish introductions.

2. Expand existing distribution:
   - Reintroduce Owens Pupfish to the Owens Valley Native Fish Sanctuary and to Warm Spring (previous refuge habitats).
   - Prioritize and implement next steps in the Owens Pupfish introduction effort into the River Spring Lakes Ecological Reserve.

3. Develop and implement a genetic management plan to guide managed gene-flow between all populations:
   - Utilize a genetics management plan to inform Owens Pupfish translocations and for the purposes of potential future mixing of populations to ensure maximum genetic variation in all populations.
   - Integrate, where warranted and feasible, the findings and recommendations of Finger et al. (2013), including founding new populations composed of 30-50 founders from each of the extant populations and regularly translocating up to 10 migrants per generation among stable populations.

VII. RECOMMENDATION TO THE COMMISSION

Pursuant to Fish and Game Code section 2077, the Department has prepared this Five-Year Species Review based upon the best scientific information available to the Department to determine if conditions that led to the original listing are still present. Based on this Five-Year Species review, the Department submits the following recommendation to the Commission:

In completing this Five-Year Species Review for Owens Pupfish, the Department finds there is sufficient scientific information to indicate that the conditions that led to the listing of Owens Pupfish as endangered are still present, and recommends no change to the status of Owens Pupfish on the list of endangered species at this time.

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WORLDATLAS.COM website. Https://www.worldatlas.com/articles/which-states-in-the-us-have-most-active-volcanoes.html

B. Personal Communication

E-mail message from Bjorn (Peter) Erickson (USFWS) on July 22, 2019, indicating the Owens Pupfish federal 5-year review will not be initiated until their FY 2021.

Multiple e-mail messages with Nick Buckmaster (CDFW, Bishop Field Office) from July-November, 2019.

C. Other

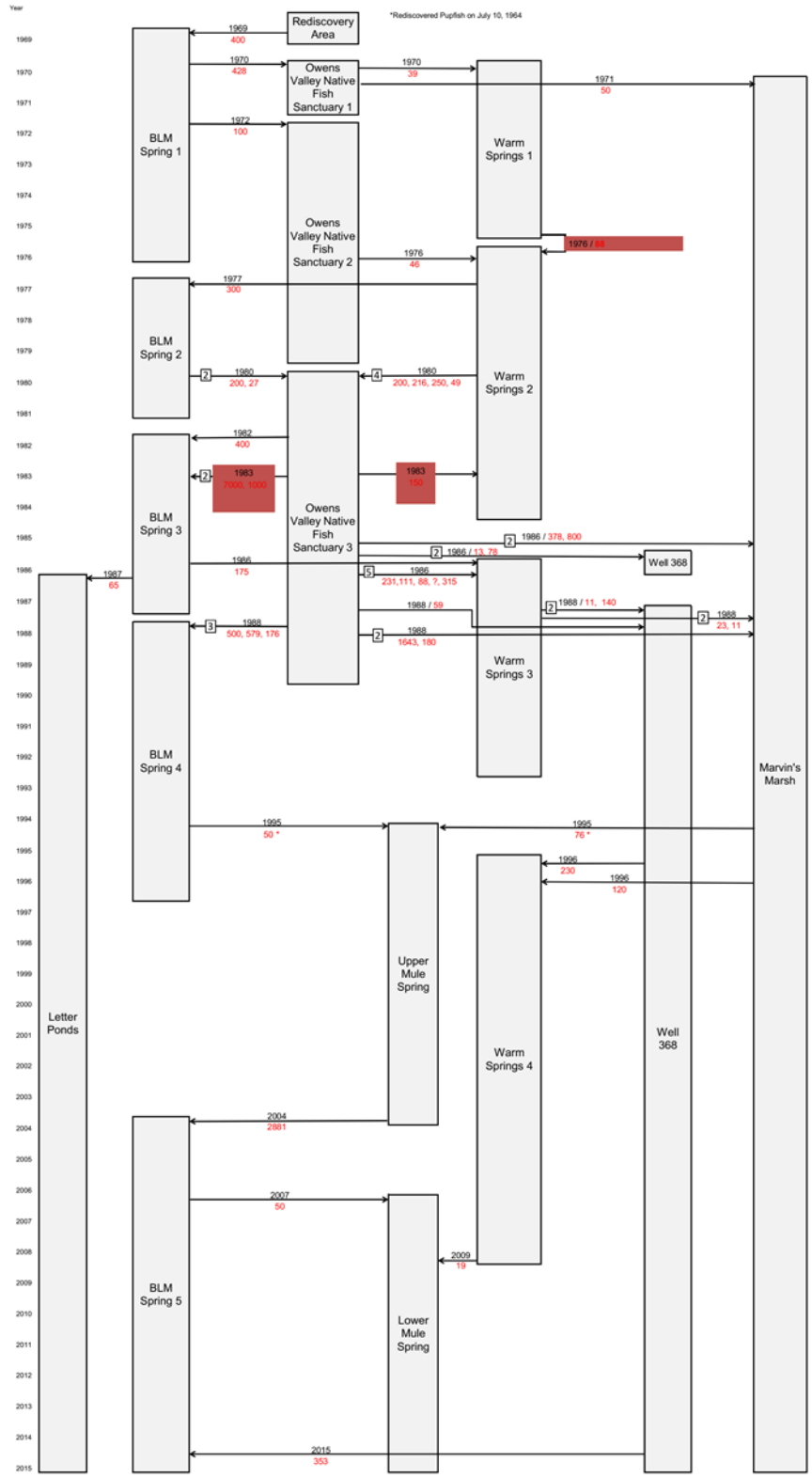
N/A

IX. LIST OF FIGURES

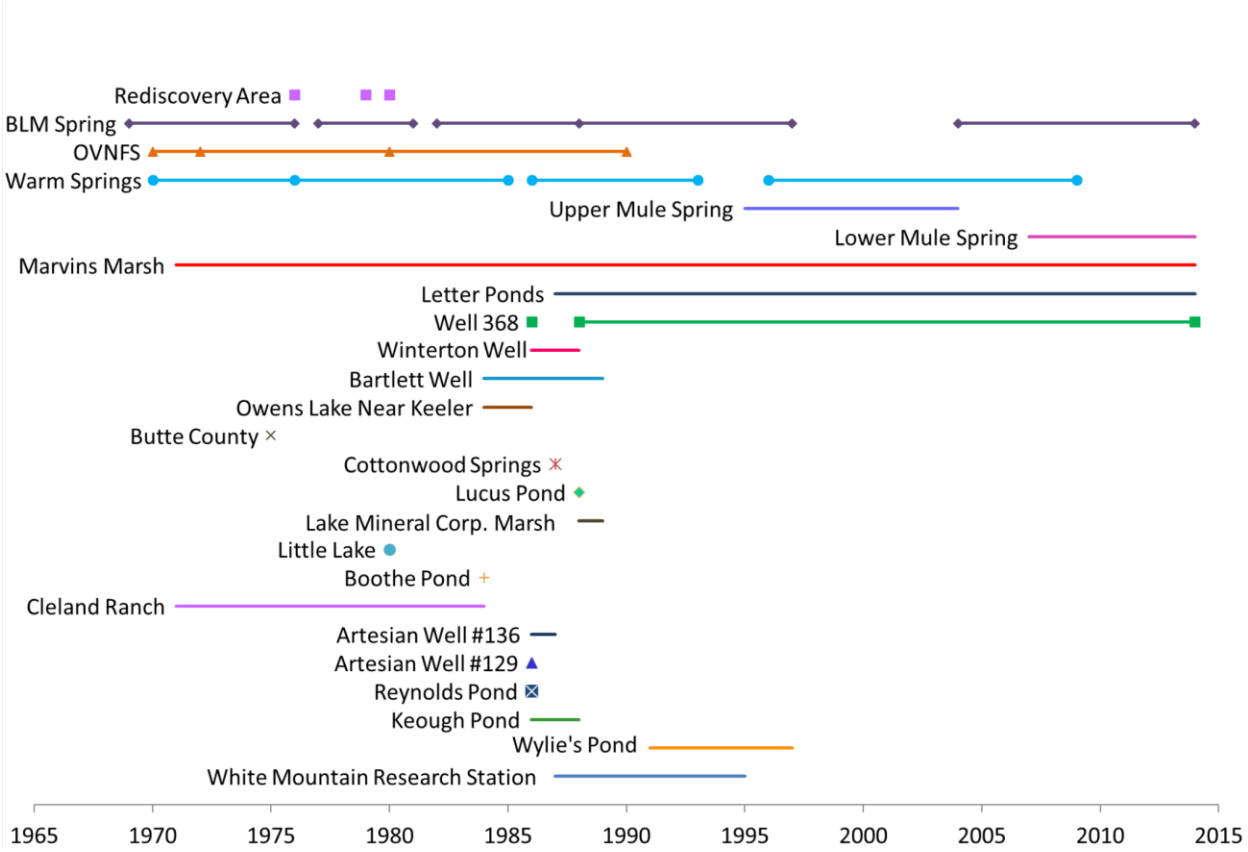
X. LIST OF TABLES

XI. LIST OF APPENDICES

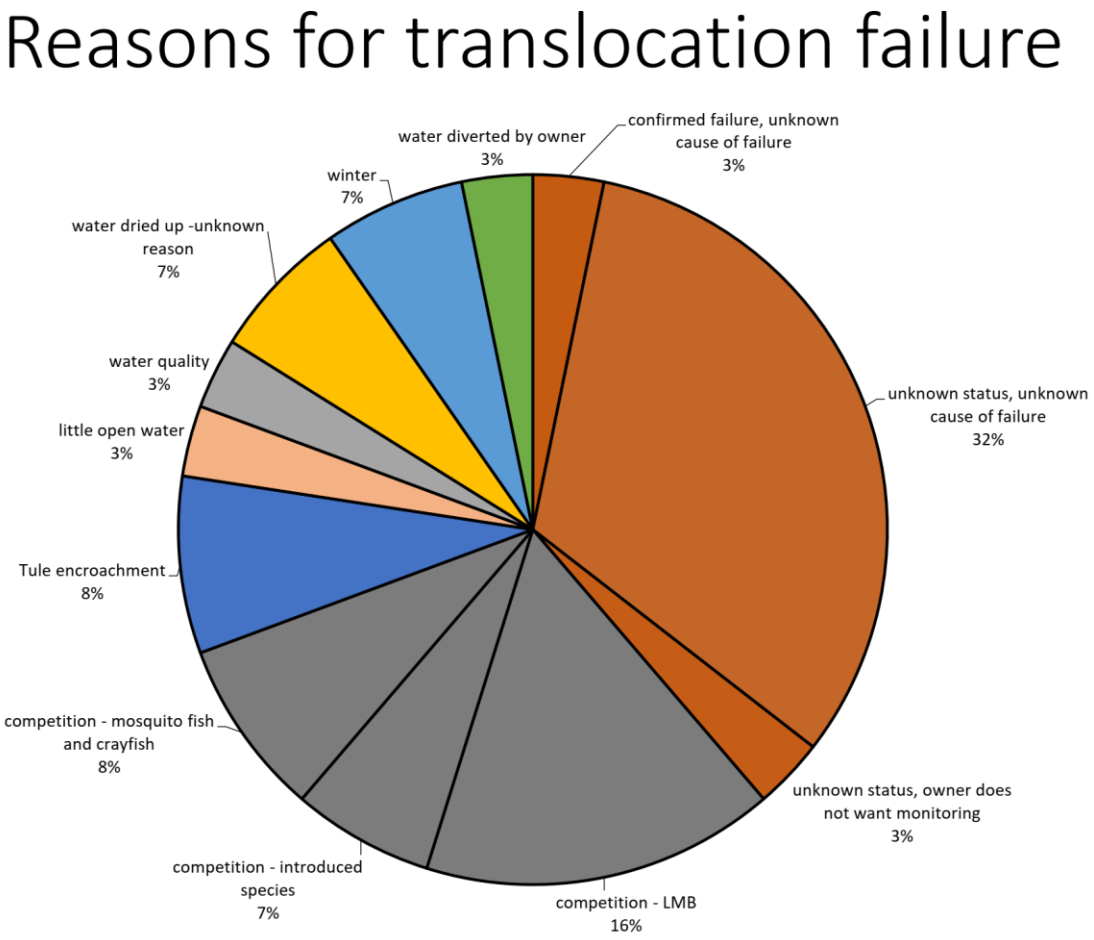
Appendix A. Owens Pupfish translocations from 1969-2015. (Source: S. Parmenter, CDFW 2019).



Appendix B. Presence of Owens Pupfish in various transplant locations 1969-2018 (Source: S. Parmenter, CDFW 2019).



Appendix C. Causes of Owens Pupfish translocation failures (Source: S. Parmenter, CDFW 2019).



Appendix D. Historical (1913) map of a portion of the Owens Basin, featuring extensive wetland complexes associated with the Owens River and representing likely Owens Pupfish historic habitats.