

Final

# SALTON SEA SPECIES CONSERVATION HABITAT

## Desert Pupfish Adaptive Management and Monitoring Plan

Prepared for  
California Department of Water Resources

February 2017





Final

# SALTON SEA SPECIES CONSERVATION HABITAT

## Desert Pupfish Adaptive Management and Monitoring Plan

Prepared for  
California Department of Water Resources

February 2017

626 Wilshire Boulevard  
Suite 1100  
Los Angeles, CA 90017  
213.599.4300  
[www.esassoc.com](http://www.esassoc.com)



Irvine	Sacramento
Los Angeles	San Diego
Oakland	San Francisco
Orlando	Santa Monica
Pasadena	Seattle
Petaluma	Tampa
Portland	Woodland Hills

120083.14

**OUR COMMITMENT TO SUSTAINABILITY** | ESA helps a variety of public and private sector clients plan and prepare for climate change and emerging regulations that limit GHG emissions. ESA is a registered assessor with the California Climate Action Registry, a Climate Leader, and founding reporter for the Climate Registry. ESA is also a corporate member of the U.S. Green Building Council and the Business Council on Climate Change (BC3). Internally, ESA has adopted a Sustainability Vision and Policy Statement and a plan to reduce waste and energy within our operations. This document was produced using recycled paper.

# TABLE OF CONTENTS

## Salton Sea Species Conservation Habitat Project Desert Pupfish Adaptive Management and Monitoring Plan

	<u>Page</u>
<b>Chapter 1</b> .....	<b>1</b>
<b>Introduction</b> .....	<b>1</b>
1.1 SCH Project Overview .....	1
1.2 Purpose of Document .....	2
<b>Chapter 2</b> .....	<b>5</b>
<b>SCH Project Description</b> .....	<b>5</b>
2.1 Location.....	5
2.2 Project Elements.....	5
2.3 Operations and Maintenance.....	8
2.4 Long Term Monitoring and Maintenance.....	9
<b>Chapter 3</b> .....	<b>11</b>
<b>Desert Pupfish Status and Ecology</b> .....	<b>11</b>
3.1 Status and Critical Habitat .....	11
3.2 Population Status and Genetics .....	11
3.2.1 Populations.....	11
3.2.2 Genetic Units.....	12
3.3 Ecology and Habitat Requirements .....	13
3.4 Occurrence and Status at Project Area .....	14
<b>Chapter 4</b> .....	<b>17</b>
<b>Desert Pupfish Adaptive Management (CM-3)</b> .....	<b>17</b>
4.1 Overview .....	17
4.2 General SCH Monitoring.....	18
4.3 Desert Pupfish Monitoring.....	19
4.3.1 Location.....	19
4.3.2 Period and Frequency.....	19
4.3.3 Sampling Protocol.....	19
4.3.4 Habitat Assessment.....	20
<b>Chapter 5</b> .....	<b>23</b>
<b>Reporting and Adaptive Management</b> .....	<b>23</b>
5.1 Reporting.....	23

	<u>Page</u>
5.2 Population Assessment .....	24
5.3 Adaptive Management .....	24
5.3.1 Approach of SCH MAMP .....	24
5.3.2 Decision-Making Process .....	25
5.3.3 Triggers and Management Responses.....	26
5.3.4 Monitoring Program Adjustments .....	27
<b>Chapter 6 .....</b>	<b>29</b>
<b>References.....</b>	<b>29</b>

**Appendices**

A. Suitable Habitat for Desert Pupfish .....	A-1
B. Datasheet.....	B-1

**List of Figures**

Figure 1 Salton Sea Species Conservation Habitat Project Area.....	6
Figure 2 SCH Project – East New River, West Pond and East Pond.....	7
Figure 3 SCH Adaptive Management Organizational Structure .....	25
Figure 4 Decision Tree for Desert Pupfish Adaptive Management .....	27

**List of Tables**

Table 1 Performance Measures, Metrics, Threat Indicators and Triggers.....	18
--	----

# CHAPTER 1

---

## Introduction

### 1.1 SCH Project Overview

The Salton Sea (Sea) is currently maintained by inflows of agricultural return water but has been shrinking in size as inflows are reduced as a result of water conservation and other water management actions. A rapid and substantial increase in salinity and reduction in the size of the Sea is expected as a result of inflow reductions associated with Imperial Irrigation District's (IID) Water Conservation and Transfer Project (Water Transfer Project), which entails water conservation and transfer transactions pursuant to the Agreement for Transfer of Conserved Water executed by IID and the San Diego County Water Authority in 1998, and supplemented by the 2003 Quantification Settlement Agreement and related agreements (QSA). Declining water inflows will hasten the collapse of the Sea's fish population due to increasing salinity (expected to exceed 60 parts per thousand [ppt] by 2018) and other water quality stresses, such as temperature extremes, eutrophication, and related anoxia and algal productivity. The most serious and immediate threat to the Sea's ecosystem is the loss of fishery resources that support piscivorous birds.

The Salton Sea Species Conservation Habitat (SCH) Project (Project) is located along the southern shore of the Sea in Imperial County. The Project is sponsored by the California Natural Resources Agency (CNRA), and implemented through their departments the California Department of Fish and Wildlife (CDFW) and the California Department of Water Resources (DWR). The SCH Project's purpose is to provide replacement for near-term habitat losses (U.S. Army Corps of Engineers [Corps] and CNRA 2011). The SCH Project's target species are those piscivorous bird species that use the Sea and are dependent on shallow saline habitat for essential habitat requirements within their western geographic range.

The Project objectives include:

1. Provide appropriate foraging habitat for piscivorous bird species.
2. Develop physical structure and microhabitat elements required to support piscivorous bird species.
3. Support a sustainable, productive aquatic community.
4. Provide suitable water quality for fish.
5. Minimize adverse effects on desert pupfish.
6. Minimize risk of selenium toxicity.
7. Minimize risk of disease/toxicity impacts.

The creation, maintenance, and long-term monitoring of 3,770 acres of shallow saline ponds is designed to reduce the scientific uncertainty of identified long-term Sea restoration plans and partially reduce the aforementioned ecological hazards by providing a range of aquatic habitats, over a 75-year period, that will continue to support fish and wildlife species that are dependent on the Sea. The constructed ponds are designed to provide habitat that will support piscivorous bird species and sustainable aquatic communities, provide suitable water quality for fish species, minimize the risk of the bioaccumulation of selenium, and minimize the risk of disease and toxicity to wildlife and plants. Likely fish candidates to be established in the ponds include one or more varieties of tilapia, which are an important forage species for fish-eating birds. California Mozambique hybrid tilapia (*Oreochromis mossambicus* x *O. urolepis hornorum* hybrid) is the species once abundant in the Salton Sea.

## 1.2 Purpose of Document

Desert pupfish (*Cyprinodon macularius*) occur in the Project area. This small fish is protected as an endangered species under the federal and state Endangered Species Act. This species may be affected by Project construction, operation and maintenance activities, as disclosed in the Draft Environmental Impact Statement/Environmental Impact Report (DEIS/EIR) (Corps and CNRA 2011) and Biological Opinion (BO) (USFWS 2013). Habitat conditions in the SCH ponds are expected to be suitable for desert pupfish, although the primary purpose of the SCH Project is to provide forage fish for the piscivorous birds, not as a pupfish refuge.

Four conservation measures (USFWS 2013) will be implemented as part of the Project to protect desert pupfish:

1. Monitor the depth of water during maintenance of the Sea pump station. If the water depth is 1.8 m (6 feet) or less, the dredging footprint will be surrounded by netting, and desert pupfish will be trapped out of this enclosed space before suction dredging is performed. If salinity levels are beyond the tolerance of desert pupfish (approximately 68 ppt), avoidance and minimization measures would not be required as desert pupfish would not be present.
2. Prepare and implement a desert pupfish inoculation plan if pupfish do not naturally repopulate the ponds 1 year after ponds are filled with water.
3. Prepare and implement an adaptive management and monitoring plan to provide for the monitoring of desert pupfish relative abundance and distribution in the SCH ponds and desert pupfish connectivity from drains around the ponds.
4. Prepare and implement a desert pupfish protection and relocation plan.

As described in the BO, the purpose of this document, the SCH Desert Pupfish Adaptive Management and Monitoring Plan (DPAMMP) (Conservation Measure 3), is to identify triggers, performance measures, and threat indicators to provide recommendations to SCH managers for maintaining or adjusting operations to ensure desert pupfish persistence in the SCH ponds and drains around the ponds (EIR/EIS, Appendix E). The SCH Monitoring and Adaptive Management Plan (MAMP) provides an integrated framework for all Project operations, monitoring, evaluation, and management (CNRA 2015). The DPAMMP describes the pupfish-

specific monitoring protocols, thresholds, and decision making process by which the SCH managers will determine whether pupfish are present and persisting, and whether management actions such as inoculation (Conservation Measure 2) should be triggered. This DPAMMP will be appended to the MAMP and will be subject to the MAMP's overarching framework.

This page intentionally left blank

# CHAPTER 2

---

## SCH Project Description

### 2.1 Location

The SCH Project is located on the southern shore of the Sea, north of Westmorland in Imperial County, California. The Project site is bounded by Poe Road to the west and Hoskins Road to the east on approximately 4,098 acres of open water, exposed playa, shallow shoreline, and agricultural irrigation ditches and canals, of which 1,750 acres are managed by the U.S. Fish and Wildlife Service (USFWS) as part of the Sonny Bono Salton Sea (SBSS) National Wildlife Refuge (NWR).

### 2.2 Project Elements

The goal of the SCH Project is to create saline impoundments on the exposed playa to support fish and wildlife dependent on the Sea. The ponds will provide near-term habitat and serve as a proof-of-concept for future phases of the SCH Project.

The SCH Project area encompasses 3,770 acres of exposed playa at the mouth of the New River, at the southwest end of the Sea (**Figure 1**). Three independent pond units, Far West New, West New, and East New will be constructed and supplied with a combination of water from the New River and the Sea and blended to maintain an optimal salinity range. The SCH ponds will average 2-6 feet deep and have the following approximate maximum areas and volumes:

- Far West New: 514 acres, 2,305 acre-feet
- West New: 1,731 acres, 6,783 acre-feet
- East New: 1,139 acres, 2,870 acre-feet

The initial implementation phase will construct and operate two ponds (320-acres each, designated East Pond and West Pond) to create a total of 640 acres of saline pond habitat in the East New River section of the Project area (**Figure 2**). Each pond will have its own water supply infrastructure that can be operated independently, to allow manipulation of hydrologic parameters such as salinity and residence time as experimental “treatments.” The SCH Project will test different operating regimes (varying salinity and residence time) between the ponds and monitor physical and biological outcomes during the first 10 years.





*Section 2.4.1* and *Appendix D* of the DEIS/EIR provides a more detailed description of key Project features (Corps and CNRA 2011). Key Project components include: pond berms, pump stations, inflow and outflow structures, water control structures, a sedimentation basin, in-pond habitat features, and an irrigation drain interception ditch. These Project features are shown on Figure 2-8 of the DEIS/EIR and described in *Appendix D* of the DEIS/EIR. Berms will be constructed to create the necessary pond size, shape, and bottom configuration to provide a range of in-pond aquatic habitats. Interior berms will form smaller impoundments within the ponds and exterior berms will be constructed to separate the ponds from the Sea. Exterior berms will be aligned to not interrupt the flowpath of occasional stormflows from the watersheds that drain into the Sea.

Near the west end of Bowles Road, water from adjacent irrigation drains is currently pumped into an interception ditch, which provides connectivity for pupfish. At completion of construction and pond filling, the agricultural drain water will be pumped directly into the SCH ponds, which will provide extensive pupfish habitat.

## 2.3 Operations and Maintenance

The new ponds are expected to go through physical and chemical changes following wetting of the playa sediment and initial filling, as described in the *SCH Monitoring and Adaptive Management Plan (MAMP)* (CNRA 2015). Filling the ponds for the first time after construction is expected to take about three months using the designed pumps, and less time if portable pumps are also used. Both ponds will be filled and maintained at 30 ppt prior to acceptance of construction by the contractor. Initially, the ponds will be allowed to “season” for a period of several weeks to months while undergoing various stages of chemical and biological succession. Water chemistry will likely fluctuate as compounds leach from the newly wetted soils and microbial communities are initiated. Once phytoplankton, zooplankton and other invertebrates are established and salinity is within target range, then tilapia (forage species for piscivorous birds) will be introduced to the ponds.

The ponds will be operated to allow for different combinations of storage, salinity, and residence times (operations scenarios) to investigate how these factors could be adjusted to provide the best conditions for fish and birds. Water will be diverted from the New River and the Sea and blended to achieve the optimal salinity within the ponds. Water from the Sea will be pumped to the ponds via a 24-inch pipe. Water will enter the New River pump station via a 4 feet by 2 feet box culvert, where it will then be pumped via a 28-inch pipe to the sedimentation basins and to the ponds via habitat channels. Water from the ponds will return to the Sea via a weir outflow structure.

The SCH Project will be operated during the initial 10-year proof-of-concept period under scenarios designed to test which salinity regime results in the best combination or balance of invertebrate and fish productivity, bird use, seasonal fish survival, and selenium ecorisk minimization (Corps and Resources Agency 2011, 2013). The target salinity range will be 20-40 ppt, occasionally ranging from 0 ppt to 60 ppt. Scenario 1, the first operational scenario to be implemented, will test the lower (20 ppt in West Pond) and upper (40 ppt in East Pond) extremes of the operational range, to increase the likelihood of measuring the effect of salinity on Project

performance. Each pond will be operated at the same replacement rate with a different salinity. Scenario 1 will maintain salinity constant through the year. This scenario will be run for at least two years.

Other operations scenarios could be tested during this 10-year implementation period, depending on management goals and feedback from monitoring. Scenarios 2 and 3 would increase inflow 10 percent or 20 percent, respectively, over the replacement rate. This would produce outflow from the pond and thus reduce the residence time, at the cost of additional pumping. With more information from monitoring, operation scenarios can be adapted to improve Project performance.

Ongoing maintenance will include periodic dredging of the sedimentation basins; maintenance of interior and exterior berms, protective riprap, and pumps; and vegetation, erosion, and vector control. Material excavated from the sedimentation basin will be used to construct habitat features or add to the berms. The pumped diversion from the New River will be maintained to keep the diversion facilities free of sediment. The river bed elevation will also be monitored to detect any downcutting that may occur as the Sea's water level drops. The Sea pumping facilities will be maintained to reduce fouling caused by the hypersaline water flowing through the pumps. Draining the ponds will not be a routine maintenance activity, but may be required if a berm failed or under another type of emergency situation.

Maintenance will typically involve construction equipment such as an excavator at the New River and suction dredging equipment at the pump stations. The sedimentation basin will be constructed and operated in a manner that is unsuitable for desert pupfish. Additionally, desert pupfish do not occur in the New River where the pump intake is proposed.

## 2.4 Long Term Monitoring and Maintenance

The SCH Project includes a MAMP to obtain and refine information to inform future restoration efforts and define optimal parameters to support a sustainable, productive aquatic community (CNRA 2015). The main parameters subject to change include salinity, residence time, and depth. The parameters will be controlled by changing the amount and salinity of water delivered to the constructed ponds, the outflow to the Sea, and the total storage in the ponds. The MAMP will help guide post-implementation actions and assess Project performance during the 10-year proof-of-concept period.

The MAMP is discussed further in *Section 4.0* of this document.

This page intentionally left blank

## CHAPTER 3

---

# Desert Pupfish Status and Ecology

### 3.1 Status and Critical Habitat

The desert pupfish, listed as endangered in 1986, is a small fish, less than 3 inches long, belonging to the Cyprinodontidae family of fishes (Moyle 2002). This species is native to southeastern California, southern Arizona, northern Baja California, and Sonora, Mexico. Naturally occurring populations of desert pupfish are now restricted in the United States to California in the Salton Sea Basin: the Salton Sea, three tributary streams, shoreline pools and irrigation drains of, the Sea in California (Lau and Boehm 1991, Keeney 2016). This species is found in Mexico at scattered localities along the Colorado River Delta and in the Laguna Salada basin (Hendrickson and Varela-Romero 1989).

Critical habitat was designated in 1986 along portions of the San Felipe Creek, and two of its tributaries, Carrizo Wash and Fish Creek Wash, in Imperial County, California (USFWS 1986). The areas designated as critical habitat include approximately 11 miles of a channel along San Felipe Creek and all of its tributaries and a riparian buffer zone of 100 feet on both sides of the stream channel. A total of approximately 770 acres of critical habitat were designated. The desert pupfish reproduces successfully in San Felipe Creek. These stretches provide adequate food and cover. They are at least partially isolated from predatory and exotic fishes. Recent observations by the California Department of Fish and Wildlife (CDFW) indicate that mosquitofish are the most abundant non-native fish. Tilapia were abundant in 2013-2015 but much reduced in 2016, and sailfin mollies have not been seen since the 1990's (Keeney 2016).

### 3.2 Population Status and Genetics

#### 3.2.1 Populations

According to the USFWS 5-Year Review (USFWS 2010), there are collectively 11 extant populations of desert pupfish known in the wild in California (5 populations), Arizona (1), and Mexico (5) (Tier 1 populations in the Recovery Plan). Although many re-introductions have been attempted, approximately 16 transplanted populations of the desert pupfish exist in the wild at present, all in Arizona (Tier 2 populations in the Recovery Plan). There are 46 captive or refuge desert pupfish populations comprised of 27 in Arizona, 14 in California, and 4 in Sonora, Mexico (USFWS 2010, Keeney 2016). The range-wide status of desert pupfish is poor but stable. The fate of the species depends heavily upon future developments in water management of the Salton Sea and Cienega de Santa Clara in Mexico.

Five natural populations persist in California: San Felipe Creek, Salt Creek, Salton Sea, Salton Sea irrigation drains, and Hot Mineral Spa Wash (USFWS 2010). Historically, desert pupfish were abundant along the Sea's shoreline through the 1950s (Barlow 1961). During the 1960s, the numbers declined, and by 1978 they were noted as scarce and sporadic (Black 1980). Currently, desert pupfish numbers in the Sea are relatively low and patchily distributed in Salt Creek and San Felipe Creek, at the mouths of the New, Alamo and Whitewater rivers, within the mouths of irrigation drains that discharge directly to the Sea, and along the southern and northern shoreline of the Sea in shoreline pools (USFWS 2010; Keeney 2013 and 2016). The desert pupfish population in Salt Creek was stable to increasing, and had few non-native species (USFWS 2010; Keeney 2010). However, in the last several years lower Salt Creek has dried completely during summer and water quality has become more problematic (Keeney 2016). San Felipe Creek also has had a stable to increasing population, according to the 5-Year Status Review (USFWS 2010), but in recent years non-native fish have been found here (Keeney 2016).

There are 36 irrigation drains within the Project area that have been monitored by CDFW, USGS and IID over the last 25 years; these desert pupfish populations fluctuate seasonally, but have persisted. While populations in irrigation drains entering the Sea can be abundant (Keeney 2010 in USFWS 2010), fish populations there are still dominated by non-native fish (Martin and Saiki 2005). These drains allow connectivity to shoreline pools, at least seasonally, and may be necessary to prevent desert pupfish from becoming stranded within drain habitats that periodically dry out (Sutton 2002; Keeney 2013). Maintaining these populations and connections in the long-term has been determined to be necessary for the recovery of the species (USFWS 1993). Based on current understanding, this includes maintaining the drain populations and providing for desert pupfish movement between individual drains (USFWS 2010).

In addition to the naturally occurring populations, this species also occurs in several refuge locations (Tier 3 populations) within the Project area. The 14 refuge populations in California occur at Anza Borrego State Park (2), Oasis Springs Ecological Reserve (1), Dos Palmas Reserve (4), Living Desert Museum (4), University of California Riverside (1), Imperial Irrigation District grass carp facility (1), and Borrego Springs High School (1) (Keeney 2016). There was a desert pupfish refuge population at Salton Sea State Recreation Area, but desert pupfish no longer occur there, likely due to bird and raccoon predation as well as lack of soft substrate for fish to burrow into for escape (Keeney 2016). CDFW monitors and maintains these refuge populations.

### 3.2.2 Genetic Units

As discussed in the 5-Year Status Review (USFWS 2010), much of the research on desert pupfish since the 1993 recovery plan addresses genetics issues and the taxonomy of the *C. macularius* group. Since the isolated nature of desert pupfish populations reduces the flow of genes between sites, inbreeding and genetic drift can be reasonably expected to occur without intervention (Turner 1983, Echelle et al. 2007, Koike et al 2008, Loftis et al. 2009). Based on their work on the natural populations, Loftis (2007) and Echelle et al. (2007) recommended five management units for *C. m. macularius*: Laguna Salada, Cerro Prieto, Cienega de Santa Clara/El Doctor, San Felipe Creek, and the rest of the Salton Sea system (Echelle et al. 2007, Loftis et al. 2009).

Recent genetics studies indicate that the three naturally occurring populations in the Salton Sink: San Felipe Creek, Salt Creek, and Salton Sea (including irrigation drains)—should be treated as one genetic unit (Echelle 1999, Echelle et al. 2007).

### 3.3 Ecology and Habitat Requirements

This description of ecology and habitat requirements is based on descriptions and reviews in the desert pupfish recovery plan (USFWS 1983), critical habitat designation (USFWS 1986), 5-Year Status Review (USFWS 2010), and the Project’s Biological Opinion (USFWS 2013).

The desert pupfish has a tolerance for high temperatures, high salinities, and low dissolved oxygen concentrations that exceed the levels known for other freshwater fishes (USFWS 1986, 1993). Carveth et al (2006) reported an upper lethal tolerance of 42.4 degrees Celsius (C), plus or minus 0.2 degrees C, when acclimated to a temperature of 30 degrees C. Schoenherr (1990) reported critical thermal maximum (CTMax) as high as 42.6 and 42.7 degrees C, and a critical thermal minimum (CTMin) of 4.4 degrees C. They have been reported to survive oxygen levels as low as 0.1 to 0.4 parts per million (Lowe et al. 1967), and salinities nearly twice that of seawater (Barlow 1958). They are also capable of surviving extreme fluctuations in temperature (Lowe and Heath 1969) and daily salinity changes of as much as 10 to 15 ppt (Kinne 1960). Desert pupfish populations also experience significant temporal fluctuations in distribution and abundance (Varela-Romero et al. 2002).

Although desert pupfish are extremely hardy in many respects, they prefer quiet water with aquatic vegetation (Schoenherr 1992), as long as it is not too dense (Keeney 2016). Habitats include clear, shallow waters with soft substrates associated with cienegas, springs, streams, margins of larger lakes and rivers, shoreline pools, and irrigation drains and ditches. Pupfish typically prefer shallow water, but can occur at greater depths. CDFW captured pupfish in gill nets set at 7-8 feet in the mid-2000s. In San Felipe Creek, pupfish often utilize pools having depths of 3 feet (Keeney 2016). Pupfish seem to prefer a little flow, compared to areas with dense emergent vegetation and/or stagnant areas which often are preferred by sailfin mollies (Keeney 2016). Examples of suitable habitat are shown in **Appendix A**.

Physical habitat characteristics that are generally favorable to desert pupfish (Black 1980, Moyle 1976, Soltz and Naiman 1978, Schoenherr 1992, Keeney 2013 and 2016) include:

- sand-silt substrate, or other soft or unconsolidated substrate such as pea-sized gravel, with some topographic variability
- abundance of filamentous algae and rooted aquatic plants such as widgeon grass (*Ruppia maritima*) and chara, or muskgrass (*Chara spp.*) to provide food, cover and structure for pupfish and their invertebrate prey
- relatively shallow water (1 foot or less in depth), with a range of depths from 0.5 inch gradually sloping to approximately 3 feet
- minimal surface water velocity (< 1.0 feet per second)
- water temperatures above freezing during the winter

- salinity less than 68 ppt
- channel or pond bottom not completely filled in with emergent vegetation

When desert pupfish were abundant in the shoreline pools of the Sea, Barlow (1958, cited in Sutton 1999) noted that pupfish of all ages moved in and out of shallow areas in shoreline pools during the day, apparently to avoid temperatures higher than 36 degrees C. They spent the nights in the shallowest, coolest areas of the pools. During the winter pupfish did not move into the shallows until mid-afternoon, where they remained into the night (Barlow 1958 cited in Sutton 1999).

Desert pupfish mature rapidly and may produce up to three generations per year. They become sexually mature at 15 millimeter (mm) total length, but most do not breed until their second summer when they reach 75 mm total length (Moyle 2002). Spawning occurs throughout the spring and summer months, about late February through late September (Matsui 1981 cited in Lau and Boehm 1991). Spawning males typically defend a small spawning and feeding territory in shallow water. The eggs are usually laid and fertilized on a flocculent substrate and hatch within a few days. After a few hours, the young begin to feed on small plants and animals. Desert pupfish are omnivorous, feeding on small invertebrates and algae, as well as detritus, macrophytes and occasionally their own eggs. Individuals typically survive for about a year (USFWS 1986).

Desert pupfish are vulnerable to competition or predation and thus can be displaced by non-native fishes (Martin and Saiki 2009). Schoenherr (1992) reported behavioral interference by sailfin mollies and Zill's tilapia (*Tilapia zilli*) during mating and spawning. That said, desert pupfish were unusually dominant (greater than 93 percent of the catch) in the U.S. Bureau of Reclamation (Reclamation) ponds, where mosquitofish, sailfin mollies and Mozambique and Zill's tilapia were also present in low numbers (Saiki et al. 2011). U.S. Geological Survey (USGS) sampled the Reclamation ponds with minnow traps in water averaging 18-46 cm deep, with the deepest area 120 cm (Saiki et al. 2011). Pupfish were the dominant species collected from the Reclamation ponds, in contrast to the irrigation ditches where non-native species were most dominant (Saiki et al. 2008).

### **3.4 Occurrence and Status at Project Area**

Surveys for the desert pupfish were not conducted as part of the planning for the SCH Project, but past occurrences of the species are documented in the California Natural Diversity Database (Corps and CNRA 2011). Based on ongoing monitoring by CDFW, desert pupfish are presumed extant in the project area (USFWS 2013). Additionally, because desert pupfish move between the irrigation drains and the Sea (Sutton 2002), desert pupfish could be present anywhere within the edge of the Sea containing suitable habitat and within drains that are tributary to the Sea.

Habitat quality in some irrigation drains has been degraded due to overgrown emergent vegetation that chokes out open habitat and impedes pupfish movement. While IID is responsible for maintaining the drains by clearing sediment and vegetation, it appears that most of these drains have not been maintained regularly, especially in the lower portions nearest to the Sea

(Keeney 2016). There is little, if any, connectivity to the Sea, and what connectivity remains typically occurs during the spring. Many drains have so much dense vegetation in the lower sections that pupfish are no longer able to swim above or below this barrier. Some once-abundant populations in drains and shoreline pools on the south Sea shoreline and northeast of the Project site (Vail 6 Drain, mainly the lower portion which is the shoreline pool located at Lack and Lindsey Roads; and the shoreline pool known as McKendry Pond) have disappeared in recent years due to excessive vegetation and lack of water (Keeney 2016).

Currently, one irrigation drain, labeled Salton Sea Sump (SS-8) on the IID drain map book, discharges into the interception ditch at the Phase 1 Project area, east of the New River delta at the west end of Bowles Road. CDFW conducted surveys in 2013 and 2015, but no pupfish were captured or seen (Keeney 2016). On October 11, 2016, a CDFW survey found both the SS-8 drain and the playa where the Phase 1 SCH ponds will be constructed were dry and did not provide suitable habitat for desert pupfish. However, a return survey on November 6 found both water and fish in the SS-8 drain, including desert pupfish, mosquitofish, sailfin mollies and tilapia. Habitat quality was low, given the intermittent flows and lack of established food resources. CDFW staff surmise that a nearby private reserve is the source of some of this drain water in the SS-8 drain.

CDFW staff also surveyed the New River on October 11, 2016. Trapping was conducted (6 minnow traps for 2 hours) in microhabitat that was the most suitable available but still of poor quality for pupfish. Only one western mosquitofish was collected, although others were observed in the river (Keeney 2016). Desert pupfish are not known to occur nor are they expected to occur in the New River because of the high sediment loads, excessive velocities, and presence of predators (Crayon 2013).

This page intentionally left blank

# CHAPTER 4

## Desert Pupfish Adaptive Management (CM-3)

---

### 4.1 Overview

As stated earlier, the Project's operations, monitoring, evaluation, and management are integrated in the *SCH Monitoring and Adaptive Management Plan* (MAMP) (CNRA 2015). The MAMP outlines a framework to evaluate the effectiveness of the SCH Project and guide adaptive management (CNRA 2015). The MAMP describes Project objectives, defines expected or desired outcomes, and describes monitoring activities to track progress toward objectives and compliance with regulatory permits during the initial implementation phase (first 10 years). The MAMP also outlines the assessment and decision-making process that will guide adaptive management, including potential management responses that may be triggered by monitoring.

This DPAMMP provides further specificity for monitoring of desert pupfish in the SCH ponds and connectivity from drains around the ponds. This DPAMMP will be incorporated into the MAMP as an appendix. This plan addresses the following:

1. Performance measures and desired conditions for desert pupfish
2. Desert pupfish population assessment to evaluate population trends in ponds over time;
3. Criteria to evaluate whether SCH ponds will support desert pupfish;
4. Triggers, performance measures, and threat indicators
5. Annual reporting requirements;
6. Decision making process for SCH managers; and
7. Contingency plan should the ponds not support viable populations of desert pupfish.

The SCH Project objective for desert pupfish is to minimize adverse effects on desert pupfish. The desired conditions are:

1. Desert pupfish will be present in sufficient numbers to ensure self-sustaining populations (2,000 adults per pond) and will persist in the SCH ponds for the life of the Project;
2. Connectivity will be maintained for populations in adjacent irrigation drains and the Sea, via an interception ditch, until the ponds are filled and can provide habitat.

The interception ditch is already connected to the drains, and monitoring has documented use by desert pupfish in fall 2016. Performance measures, metrics, and suggested indicators and triggers for long-term management are provided in **Table 1**.

**TABLE 1**  
**PERFORMANCE MEASURES, METRICS, THREAT INDICATORS AND TRIGGERS**

Performance Measure	Monitor Element	Metric	Threat Indicator	Trigger
Desert pupfish will be present in the ponds in sufficient numbers to ensure self-sustaining populations (2,000 adults per pond)	Pupfish	Distribution – frequency of occurrence among sampling sites	Frequency of pupfish occurrence in the ponds is less than 20% of sites (i.e. 80% of locations sampled have no pupfish)	
		Relative Abundance: mean CPUE per trap (pupfish per trap hour) and per sampling site (multiple traps per site)	Pupfish relative abundance at 50% of the sites is low (CPUE <1 pupfish per trap hour) or declining. Estimated population <2,000 adults.	Few pupfish are detected (<100 adults) in the ponds for summer or fall sampling periods.
		Condition – age classes, health of individual fish	Lack of juveniles indicating poor recruitment	
Pond conditions will be suitable for desert pupfish	Habitat	Physical habitat structure	Lack of desired habitat features at more than 50% of sampled locations	Lack of desired habitat features at more than 80% of sampled locations
		Aquatic vegetation	<10% aquatic vegetative cover	No aquatic vegetation cover
	Fish	Community composition	High abundance of known competitors or predator species (>5 fish per trap hour)	High abundance of known competitors or predators (>5 fish per trap hour)

## 4.2 General SCH Monitoring

Conditions in the SCH ponds will be monitored following protocols detailed in the MAMP (*Section 5- Monitoring Elements*) (CNRA 2015). Indicators of SCH Project performance include measures of habitat (e.g., area, depth, physical structure, aquatic plant species/cover, and water quality), target species (e.g., richness, diversity, abundance, habitat use), trophic function (e.g., composition and density of forage species), and stressors (e.g., water quality and selenium concentrations). Key monitoring elements include the following:

- Physical Habitat - flow rate, depth, wetted area, islands, snags, submerged vegetation, and other habitat elements;
- Water Quality - salinity, temperature, pH, dissolved oxygen, nutrients;
- Aquatic Biota - algae, plankton, invertebrates, fish community (species, distribution, abundance);
- Birds - species, abundance and distribution, use of habitat features, breeding and nesting, sick or dead birds; and
- Contaminants - selenium concentrations in water, sediment, bird eggs, and other biota (invertebrates, fish).

General fish monitoring will occur at least twice a year (likely April-May and September-October), and could be up to four times per year if warranted and resources allow. Sampling will occur at a minimum of 10 sites per SCH pond.

## 4.3 Desert Pupfish Monitoring

### 4.3.1 Location

Pupfish sampling sites will be co-located with general sampling sites for water quality, sediment quality, invertebrates and fish monitoring. Sampling will occur at stratified random locations (at least 10) in each pond, with sampling efforts distributed among habitat strata such as water depth and proximity to structural elements (e.g., islands and berms, tamarisk slash islands).

### 4.3.2 Period and Frequency

Pupfish monitoring will occur twice a year, in spring (April-May) and fall (September-October), consistent with guidelines provided in the Desert Pupfish Recovery Plan. Spring sampling would provide an index of abundance after overwintering mortality; late summer or early fall sampling would provide an assessment of reproductive success and recruitment. Additional sampling may be conducted during the summer, especially during the first year of pond establishment, and subject to available CDFW resources.

### 4.3.3 Sampling Protocol

#### Capture

The preferred capture method for desert pupfish is baited minnow traps, specifically Gee's minnow trap (9 inch by 17.5 inch, with 1.25 inch-square mesh and double funnel-mouth entrances) of galvanized steel wire. The traps are baited with perforated plastic bags, each filled with 1 ounce of canned, fish-flavored, cat food. The traps are typically deployed in water at least 9 inches deep, sufficient to cover the entire trap.

Traps are set only during the day since pupfish are most active during the day. The preferred duration of trap sets is 1-2 hours, although traps can be checked and emptied, then reset for another 1-2 hours. Overnight sets may result in pupfish mortality due to changes in water quality and sometimes water quantity, presence of too many fishes in traps, vandalism, theft of traps, storm events, and other possible causes. Spacing can be variable due to difference in habitats surveyed, but in the drains, traps should generally be spaced 25-50 feet.

Dip netting can also be used, especially in isolated small areas. Seining is less effective, due to underwater snags and difficulties landing a seine, as well as pupfish escape behavior of diving into soft sediment under the seine's lead line (Keeney 2016). Also, seining is more stressful to juveniles.

Capture will be conducted with care taken to minimize handling and stress as well as exposure to heat, low dissolved oxygen, and crowding.

## Handling and Data Collection

Fish handling will be kept to the minimum necessary to remove fish from the trap or net. Fish capture and removal operations will be planned and conducted to minimize the amount and duration of handling. Biologists will maintain captured fish in water to the maximum extent possible during trapping/netting, handling, and transfer for release. Individuals handling fish will ensure that their hands are free of harmful products, including but not limited to sunscreen, lotion, and insect repellent.

Captured fish will be placed in lidded coolers (preferred), buckets or holding tanks that are fitted with aerators. Tanks/buckets should be placed in the shade if possible to prevent increases in water temperature. Desert pupfish numbers and lengths will be measured. If conditions are stressful (i.e., very high temperatures), biologists may discontinue length measurements, especially for the more vulnerable juvenile pupfish.

The directing biologist will document and maintain accurate records of the operations onto data sheets (**Appendix B**). Conditions to be recorded include: specific locations of capture and release, date and time trap was set and pulled, water depth, water temperature, salinity, species and number of fish captured, and observations of substrate type and vegetation. If directed by USFWS or CDFW, species' identification, numbers, and lengths (of the first 30 individuals) for fish species of interest will also be recorded during holding and prior to relocation and release.

Biologists will ensure that water quality conditions are adequate in the buckets, coolers, or holding tanks used to hold and transfer captured fish. Biologists will use aerators to provide well-oxygenated water. Consider using containers that are light-colored, lidded, and fitted with a portable aerator; small coolers meeting this description are preferred over buckets. Containers should be well-rinsed and free of any chemicals or detergent residues. The directing biologist will ensure that conditions in the holding containers are monitored frequently and operations adjusted appropriately to minimize fish stress.

### 4.3.4 Habitat Assessment

As part of the basic fish monitoring protocol in the MAMP, physical habitat attributes such as depth, substrate, vegetation, and cover will be noted for each sampling site in the SCH ponds.

Particular note will be taken of the following habitat attributes that are favorable for desert pupfish presence (*3.3 Ecology and Habitat Requirements*):

- sand-silt substrate, or other soft or unconsolidated substrate such as pea-sized gravel, with some topographic variability
- abundance of filamentous algae and rooted aquatic plants such as widgeon grass, chara or muskgrass to provide food, cover and structure for pupfish and their invertebrate prey
- relatively shallow water (1 foot or less in depth), with a range of depths from 0.5 inches gradually sloping to approximately 3 feet
- minimal surface water velocity (< 1 foot per second)

- water temperatures above freezing during the winter
- salinity less than 68 ppt
- channel or pond bottom not completely filled in with emergent vegetation

This page intentionally left blank

# CHAPTER 5

## Reporting and Adaptive Management

---

### 5.1 Reporting

The results of the desert pupfish monitoring will be included in the annual report prepared as part of the overarching MAMP. This written report will describe the monitoring and management activities and will be provided to the SCH Project sponsors (CDFW, DWR, Corps) and regulatory agency (USFWS) by March 1 of the subsequent year. The summary report will include at minimum:

- Status and trends of fish and desert pupfish in SCH ponds
- Conditions in SCH ponds – physical conditions, aquatic vegetation, trends in water quality, comparison between ponds
- Rationale and decision criteria for initiating inoculation of ponds, if implemented
- Location of activities
- Methods and equipment
- Conditions during fish sampling and inoculation (physical habitat, water quality, etc.)
- Desert pupfish captured (numbers, size/age class), transported and released into SCH pond(s)
- Information on fish condition, including mortalities and disposition of specimens

This information will be incorporated as part of the SCH Project’s overall monitoring and adaptive management program. As described in the MAMP, an annual progress report will summarize all monitoring activities and data collected in the previous year, update prior reports in a cumulative fashion, and include raw data as well as data analysis and comparison with compliance and performance criteria, as applicable. The annual report will describe pond operations scenario, GIS maps of sampling locations, data for each monitoring element (operations, physical, water quality, and biological), habitat conditions and environmental data during monitoring, and any recommendations for improvement of the protocol.

Data, analyses, and publications developed from this DPAMMP will be organized, stored, and made publicly accessible through a commonly distributed data management system. Common protocols will be developed and applied when possible. All geospatial data will include full metadata and will be compliant with the Federal Geographic Data Committee (FGDC) standards. CDFW will establish and maintain the data management system. The data collected as part of all components of the broader Sea restoration program will be archived and made accessible in CDFW’s Biogeographic Information and Observation System (BIOS) map viewer and all

documentation including metadata would be accessible to the public via metadata clearinghouses and CDFW's document library.

CDFW will archive the monitoring reports. Synthesis reports will be prepared at the end of Year 5, and the end of the 10-year proof-of-concept period with final recommendations for long-term SCH management. Data management and quality control will follow guidance in the MAMP and further directions from CDFW as developed.

## **5.2 Population Assessment**

In general, the scientists and managers responsible for the Project will regularly synthesize and analyze the monitoring data and evaluate the status and trends in target resources, and the effectiveness of Project activities. An overall review will be conducted annually to evaluate Project performance.

For desert pupfish status and trends, managers will evaluate the following attributes:

- **Distribution and Abundance** – the relative abundance (number of pupfish per trap, as catch per unit effort [CPUE]), frequency occurrence of pupfish in traps, and patterns among the sampling locations within the ponds. Estimates of total population abundance may be conducted if deemed necessary and as CDFW staff time and budget allow. Population estimates can be obtained using the appropriate mark-recapture or removal methods (Hayes et al. 2007).
- **Size and Condition** – the size distribution can reveal age classes and whether recruitment of juveniles is occurring. The sex ratio and occurrence of gravid females is another factor in recruitment. General condition of individual fish can be used to detect disease or stress.
- **Fish Community** – species and abundance of other fishes can indicate the potential for competition or predation, and whether the ponds are sufficiently productive to support fish in general.
- **Habitat Quality** – the distribution, availability (through the year), and quality of important habitat elements.

## **5.3 Adaptive Management**

### **5.3.1 Approach of SCH MAMP**

Monitoring and adaptive management is an iterative approach that uses regular monitoring and assessments to evaluate progress towards project objectives. The MAMP outlines a monitoring framework to evaluate the effectiveness of the SCH Project and guide adaptive management. The MAMP describes project objectives, defines expected or desired outcomes, and describes monitoring activities to track progress toward objectives and compliance with regulatory permits during the initial implementation phase. The MAMP also outlines the assessment and decision-making process that will guide adaptive management, including potential management responses that may be triggered by monitoring. If monitoring reveals issues that require more in-depth study to reduce uncertainty for management, then the SCH Project managers, with input from experts,

will identify and prioritize key questions for further monitoring or study. Focused investigations would be developed and implemented separately, based on priority and availability of funding and expertise.

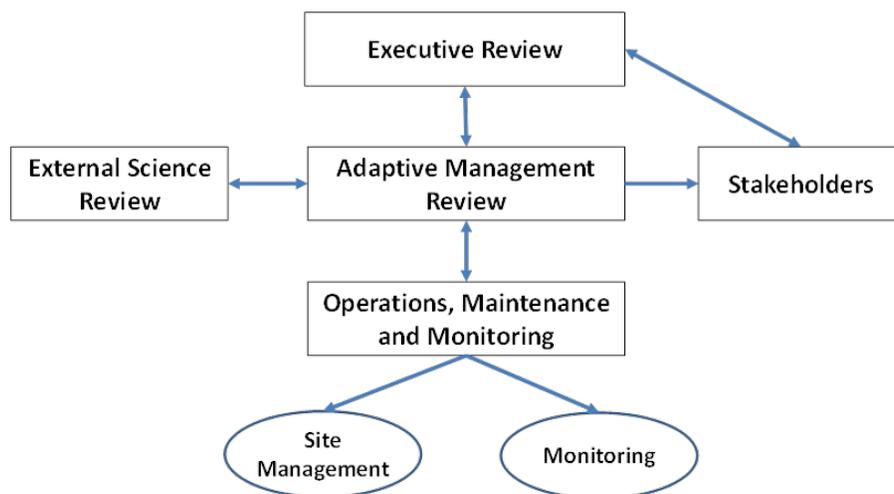
The SCH Project follows the steps of the adaptive management cycle:

1. Plan – Identify goals and objectives, summarize expectations (conceptual models) for project outcomes, and identify uncertainties and key questions for assessment,
2. Design – Summarize designs and operational scenarios for habitat ponds,
3. Implement – Construct and operate the ponds according to initial operating scenarios,
4. Monitor – Describe monitoring methods for measuring indicators of desired outcomes and triggers of management actions,
5. Evaluate – Analyze, synthesize, and manage data to document project outcomes, assess progress toward objectives, detect any negative outcomes, and reduce uncertainty, and
6. Adapt and Learn – Communicate findings to decision-makers and managers to determine if and when to adjust management actions and/or monitoring to improve project performance and inform future actions.

### 5.3.2 Decision-Making Process

A decision-making framework is established in the MAMP to provide recommendations to SCH managers for maintaining or adjusting operations (CNRA 2015, *Section 7.1*). The organizational structure for monitoring and adaptive management is portrayed in **Figure 3**.

**Figure 3 SCH Adaptive Management Organizational Structure**



Data about desert pupfish will be collected principally by CDFW biologists tasked with operations, maintenance and monitoring. Data from this level will be forwarded for analysis and interpretation at the Adaptive Management Review (AMR). The AMR level engages the CDFW project managers with technical experts, and is solely responsible for making decisions and taking actions related to the management of SCH. The AMR group will include expertise from other agencies, and external science reviewers.

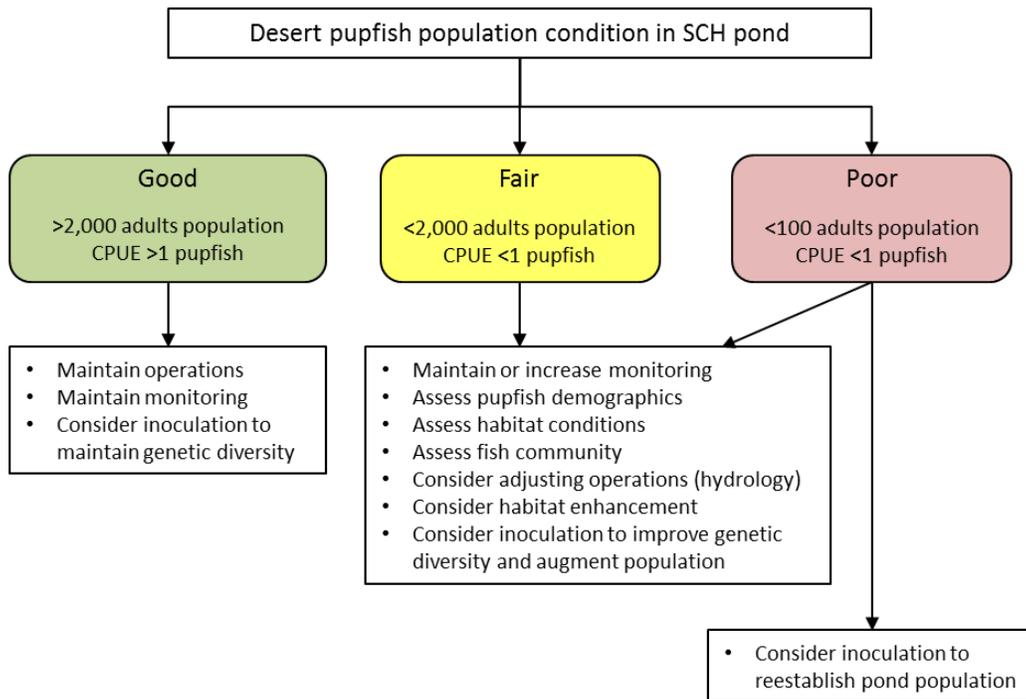
### 5.3.3 Triggers and Management Responses

Monitoring results will be reviewed at the AMR level and compared with threat indicators and management triggers to determine whether project objectives are being met (Table 1). If the threat indicators are approached, the AMR may suggest further attention and possibly management triggers are activated, the AMR will suggest potential management actions that will be discussed during the annual meeting or any necessary follow-up meetings. Example actions can include more detailed diagnostic monitoring; corrective actions if known, necessary and feasible; adjustment of short-term operations or long-term management plans; and/or further study if necessary to reduce uncertainties.

A decision tree and contingency plan is outlined in **Figure 4**. If the desert pupfish population is in “good” or self-sustaining condition (relatively abundant, >1 mean CPUE per pond per sampling period, > 2,000 adults estimated population), then regular pond operations continue and pupfish monitoring continues. Inoculation may also be conducted periodically to maintain genetic diversity in the SCH population if desert pupfish populations are considered self-sustaining.

If desert pupfish are very patchily distributed, rare (<1 mean CPUE, <2,000 adults estimated population), or on a declining trend (“fair condition”), then managers should evaluate potential causes. Possible actions to aid diagnosis of the situation include: increasing trapping to improve detection ability, assessing demographics (Are there juveniles? Is recruitment occurring?), assessing habitat conditions (Is there suitable cover, water quality, food? Has there been an extreme climate event?), and assessing the fish community (competition or predation risk). Potential habitat management responses could include but are not limited to adjusting operations of the pond (flow rate, water blending for salinity) or aquatic habitat enhancement.

Finally, if desert pupfish are below 100 adults for two or more consecutive sampling periods (“poor condition”), and habitat conditions are suitable, then managers might consider implementing the Inoculation Plan to augment or (re)introduce pupfish.

**Figure 4 Decision Tree for Desert Pupfish Adaptive Management**

### 5.3.4 Monitoring Program Adjustments

The MAMP and the associated DPAMMP are living documents that will be updated when necessary, in consultation with CDFW, USFWS and the Corps, based on data from the initial phases of implementation.

For desert pupfish specifically, the project performance, triggers, and procedures for monitoring, capture, relocation, population assessment, and inoculation will be assessed during the annual review of SCH activities. Adjustments to the specific Desert Pupfish Plans (Rescue and Relocation Plan; Inoculation Plan; and DPAMMP) may be recommended due to changing site conditions, additional phases of Project implementation, status of source population(s), improved gear or methods, or other new information. Minor adjustments are expected to occur over the monitoring period to maintain completeness and feasibility of the monitoring program.

Reinitiation of consultation with USFWS will be considered if there is a major habitat shift or change. A PCN will be prepared for each subsequent phase of the project.

This page intentionally left blank

# CHAPTER 6

## References

---

- Barlow, G.W. 1958. High salinity mortality of desert pupfish, *Cyprinodon macularius*. *Copeia* 1958:231-232.
- Black, G.F. 1980. Status of the desert pupfish, *Cyprinodon macularius* (Baird and Girard), in California. California Department of Fish and Game, Inland Fisheries, Endangered Species Program Special Publication 80-1, Sacramento, CA.
- California Natural Resources Agency (CNRA). 2015. Salton Sea Species Conservation Habitat Project Monitoring and Adaptive Management Plan. Prepared for the California Natural Resources Agency by: Cardno (Santa Barbara, California) and Environmental Science Associates (Sacramento, California).
- Carveth, C.J., A.M. Widmer, S.A. Bonar. 2006. Comparison of upper thermal tolerances of native and nonnative fish species in Arizona. *Transactions of the American Fisheries Society* 135:1433-1440.
- Crayon, Jack. 2013. California Department of Fish and Wildlife, Bermuda Dunes, California. Email with Felicia Sirchia, USFWS, Palm Spring, California, January, 2013. *As cited in:* U.S. Fish and Wildlife Service. 2013. Biological Opinion on the California Natural Resources Agency Salton Sea Species Conservation Habitat Project, Imperial County, California. FWS-IMP-12B0018-13F0058. Carlsbad Fish and Wildlife Office, Carlsbad, California. 34 pp.
- Echelle, A.A. 1998. Genetic variation in desert pupfish. Report to U.S. Fish and Wildlife Service, Parker, Arizona; Oklahoma State University, Stillwater.
- Echelle, A.A., D. Loftis, H. Koike, and R.A. Van Den Bussche. 2007. Pupfish genetics: genetic structure of wild and refuge stocks of desert pupfish. Final report to U.S. Fish and Wildlife Service, Coop. Agreement No. 201814J826, Oklahoma State Univ., Stillwater. 69 pp.
- Hayes, D.B., J.R. Bence, T.J. Kwak, and B.E. Thompson. 2007. Abundance, biomass, and production. Pages 327-374 *in* C.S. Guy and M.L. Brown, editors. *Analysis and interpretation of freshwater fisheries data*. American Fisheries Society, Bethesda, Maryland.
- Keeney, Sharon. 2013. California Department of Fish and Wildlife, Bermuda Dunes, California. Email with Felicia Sirchia, USFWS, Palm Spring, California, January, 2013. *As cited in:* U.S. Fish and Wildlife Service. 2013. Biological Opinion on the California Natural Resources Agency Salton Sea Species Conservation Habitat Project, Imperial County, California. FWS-IMP-12B0018-13F0058. Carlsbad Fish and Wildlife Office, Carlsbad, California. 34 pp.

- Keeney, Sharon. 2016. California Department of Fish and Wildlife, Inland Deserts Region 6. Bermuda Dunes, California. Email and phone communications regarding status of pupfish and habitat in Salton Sea area, desert pupfish genetics, protection and capture methods, decontamination protocols with Ramona Swenson, Environmental Science Associates, September and October, 2016.
- Kinne, O. 1960. Growth, food intake, and food conversion in a euryplastic fish exposed to different temperatures and salinities. *Physiol. Zool.* 33:288-317.
- Koike, H., A.A. Echelle, D. Loftis, and R.A. Van Den Bussche. 2008. Microsatellite DNA analysis of success in conserving genetic diversity after 33 years of refuge management for the desert pupfish complex. *Animal Conservation* 11(2008):321-329.
- Lau, S. and C. Boehm. 1991. A distribution survey of desert pupfish (*Cyprinodon macularius*) around the Salton Sea, California. California Department of Fish and Game, Inland Fisheries Division. Final Report for Section 6 Project No. EF90XII-1. 21 pp.
- Loftis, D.G. 2007. Genetic structure of remnant wild populations of the desert pupfish complex (Cyprinodontidae: *Cyprinodon macularius* and *C. eremus*). M.S. Thesis, Oklahoma State University, Stillwater. 42 pp.
- Loftis, D.G., A.A. Echelle, H. Koike, R.A. Van den Bussche, and C.O. Minckley. 2009. Genetic structure of wild populations of the endangered desert pupfish complex (Cyprinodontidae: *Cyprinodon*). *Conservation Genetics* 10:453-463.
- Lowe, C.H., and W.G. Heath. 1969. Behavioral and physiological responses to temperature in the desert pupfish *Cyprinodon macularius*. *Physiol.* 2001 42:53-59.
- Lowe, C.H., D.S. Hinds, and E.A. Halpern, 1967. Experimental catastrophic selection and tolerances to low oxygen concentrations in native Arizona freshwater fishes. *Ecology* 48:1013-1017.
- Martin, B.A. and M.K. Saiki. 2009. Trophic relationships of small nonnative fishes in a natural creek and several agricultural drains flowing into the Salton Sea, and their potential effects on the endangered pupfish. *Southwestern Naturalist* 54(2):156-165.
- Matsui, M.L. 1981. The effects of introduced teleost species on the social behavior of *Cyprinodon macularius californiensis*. M.S. Thesis, Occidental College, Los Angeles. 61 pp.
- Minckley, W.L. 1995. Translocation as a tool for conserving imperiled fishes: experiences in western United States. *Biological Conservation* 72(1995):297-309.
- Moyle, P.B. 1976. *Inland Fishes of California*. University of California Press.
- Moyle, P.B. 2002. *Inland Fishes of California (Revised and Expanded)*. University of California Press Ltd., London. 502 pp.
- Saiki, M.K., B.A. Martin, and T.W. May. 2008. Year 3 summary report: baseline selenium monitoring of agricultural drains operated by the Imperial Irrigation District in the Salton Sea Basin. U.S. Geological Survey Open-File Report 2008-1271, Dixon, California. 70 pp.

- Saiki, M.K., B.A. Martin, and T.W. Anderson. 2011. Unusual dominance by desert pupfish (*Cyprinodon macularius*) in experimental ponds within the Salton Sea Basin. *Southwestern Naturalist*, 61(2):385-392. doi: <http://dx.doi.org/10.1894/F12-CMT-06.1>
- Schoenherr, A.A. 1990. A comparison of two populations of the endangered pupfish (*Cyprinodon macularius*). Second annual report. California Department of Fish and Game.
- Schoenherr, A.A. 1992. A natural history of California. University of California Press. Los Angeles, California. 772 pp.
- Sutton, R.J. 1999. The desert pupfish of the Salton Sea: a synthesis. Prepare for Salton Sea Authority, La. Quinta, California. August 5, 1999. 13 pp.
- Sutton, R.J. 2002. Summer movement of desert pupfish among habitats at the Salton Sea. *Hydrobiologia* 473:223-228.
- Turner, B.J. 1983. Genetic variation and differentiation of remnant natural populations of the desert pupfish, *Cyprinodon macularius*. *Evolution* 37:690-700.
- U.S. Army Corps of Engineers (Corps) and California Natural Resources Agency (CNRA). 2011. Salton Sea Species Conservation Habitat Project Draft Environmental Impact Statement/Environmental Impact Report. Prepared for the California Natural Resources Agency by: California Department of Water Resources and California Department of Fish and Game with assistance from Cardno ENTRIX, Santa Barbara, California.
- U.S. Fish and Wildlife Service (USFWS). 1986. Endangered and threatened wildlife and plants; determination of endangered status and critical habitat for the desert pupfish. *Federal Register* 51:10842-10851.
- U.S. Fish and Wildlife Service (USFWS). 1993. Desert pupfish recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.
- U.S. Fish and Wildlife Service (USFWS). 2010. Desert pupfish (*Cyprinodon macularius*) 5-year review: summary and evaluation. Arizona Ecological Services Office, Phoenix, Arizona.
- U.S. Fish and Wildlife Service (USFWS). 2016. Biological opinion on the California Natural Resources Agency Salton Sea Species Conservation Habitat Project, Imperial County, California. FWS-IMP-12B0018-13F0058. Carlsbad Fish and Wildlife Office, Carlsbad, California. 34 pp.
- Varela-Romero, A., G. Ruiz-Campos, L.M. Yepiz-Velazquez, and J. Alaniz-Garcia. 2002. Distribution, habitat, and conservation status of desert pupfish (*Cyprinodon macularius*) in the lower Colorado River basin, Mexico. *Review in Fish Biology and Fisheries* 12:157-165.

This page intentionally left blank

# Appendix A

## **Suitable Habitat for Desert Pupfish**

This page intentionally left blank

These photographs by Sharon Keeney CDFW show examples of excellent habitat conditions for desert pupfish.

- Figure A-1 San Felipe Creek, Imperial County
- Figures A-2 Dos Palmas Preserve (S-1 Pond), Riverside County
- Figures A-3 to A-4 Salt Creek (Upper and Lower), Riverside County
- Figures A-5 to A-9 Irrigation drain channel habitat, as illustrated at Avenue 76 Drain at the northern end of the Salton Sea, Riverside County.
- Figures A-10 to A-12 Microhabitat features (soft substrate, pondweed) and fishes, including desert pupfish and non-native fish (redbelly tilapia, sailfin molly), in irrigation drain habitat, Avenue 76 Drain, Riverside County.
- Figures A-13 to A-14 Desert pupfish and other fishes (mosquitofish, redbelly tilapia) in irrigation drain habitat, Avenue 76 Drain, Riverside County.
- Figure A-15 Spawning desert pupfish and male in breeding coloration, at Dos Palmas Preserve, Riverside County.



**Figure A-1** – San Felipe Creek, Imperial County, toward south west end of the Salton Sea. This is one of three localities where desert pupfish naturally occur. Photo: Sharon Keeney, CDFW.



**Figure A-2** – Dos Palmas Preserve, Riverside County, toward north east side of Salton Sea. The S-1 Pond shown here has excellent pupfish habitat. Photo: Sharon Keeney, CDFW.



**Figure A-3** – Upper Salt Creek, Riverside County, one of three creeks where desert pupfish naturally occur. Photo: Sharon Keeney, CDFW.



**Figure A-4** – Lower Salt Creek, Riverside County, one of three creeks where desert pupfish naturally occur. Photo: Sharon Keeney, CDFW.



**Figure A-5** – Irrigation drain (Avenue 76), Riverside County, at the northern end of the Salton Sea. The drain has several outlet channels that provide diverse microhabitats. Note the slow-moving and clear water (not stagnant), sand-silt substrate, abundant (but not too dense) vegetation, including widgeon grass interspersed with open areas. A 2015 survey documented thousands of desert pupfish. Photo: Sharon Keeney, CDFW.



**Figure A-6** – Irrigation drain (Avenue 76), Riverside County, with habitat for desert pupfish. Photo: Sharon Keeney, CDFW.



**Figure A-7** – Irrigation drain (Avenue 76), Riverside County, with habitat for desert pupfish. Note floating and submerged vegetation, mixed with open areas, and clear water. Photo: Sharon Keeney, CDFW.



**Figure A-8** – Irrigation drain (Avenue 76), Riverside County, with habitat for desert pupfish. Note floating and submerged vegetation, mixed with open areas, and clear water. Photo: Sharon Keeney, CDFW.



**Figure A-9** – Irrigation drain (Avenue 76), Riverside County, with habitat for desert pupfish. Note aquatic vegetation, and clear slow-moving water. Photo: Sharon Keeney, CDFW.



**Figure A-10** –Microhabitat features include soft substrate and submerged aquatic vegetation (wigeon grass) in irrigation drain (Avenue 76), Riverside County. Photo: Sharon Keeney, CDFW.



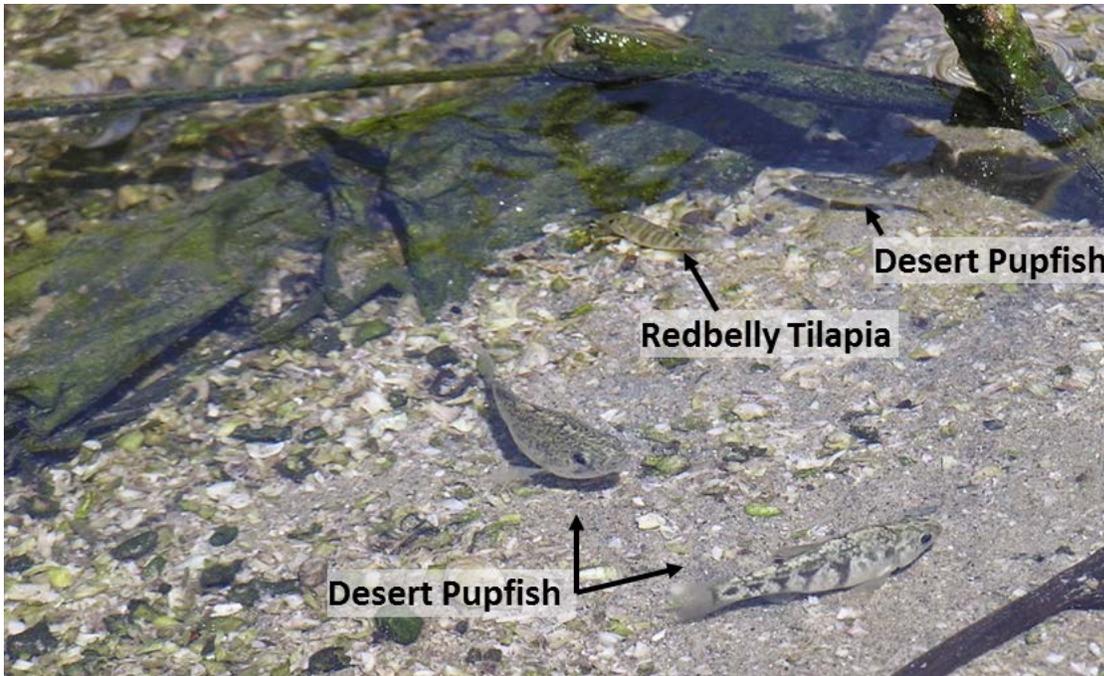
**Figure A-11** – Desert pupfish and non-native fishes in drain habitat, with soft substrate and submerged aquatic vegetation (wigeongrass) in irrigation drain habitat, Riverside County. Photo: Sharon Keeney, CDFW.



**Figure A-12** – Desert pupfish and non-native fishes (mostly porthole livebearer) in irrigation drain habitat, Riverside County. Photo: Sharon Keeney, CDFW.



**Figure A-13** – Desert pupfish and mosquitofish in an irrigation drain at the north Salton Sea (Arthur 0.5 Drain, Riverside County), showing preferred habitat (soft substrate with structure, and shallow, clear, slow-moving water). Photo: Sharon Keeney, CDFW.



**Figure A-14** – Desert pupfish and juvenile redbelly tilapia in an irrigation drain at the north Salton Sea (Arthur 0.5 Drain, Riverside County), showing soft substrate with structure and shallow, clear, slow-moving water. Photo: Sharon Keeney, CDFW.



**Figure A-15** - Spawning pair of desert pupfish (above and below), and male pupfish in blue breeding coloration (right), at the Dos Palmas Preserve, Riverside County. Photos: Sharon Keeney, CDFW



---

This page intentionally left blank

# Appendix B

## Datasheet

This page intentionally left blank

Desert Pupfish Distribution Monitoring Protocol

**IID Desert Pupfish Trapping Form**

**Observer:** \_\_\_\_\_

**Date:** \_\_\_\_\_

Drain Name: \_\_\_\_\_

**Drain Information:**

Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Vegetation: \_\_\_\_\_

Vegetation Density:: \_\_\_\_\_

Bank Slope\*: \_\_\_\_\_

Salinity: \_\_\_\_\_

Conductivity: \_\_\_\_\_

Temperature: \_\_\_\_\_

TDS: \_\_\_\_\_

Turbidity: \_\_\_\_\_

Dissolved Oxygen: \_\_\_\_\_

pH: \_\_\_\_\_

Connectivity:  Yes  No

Water Velocity\*: \_\_\_\_\_

Substrate: \_\_\_\_\_

**Traps:**

Number of Traps: \_\_\_\_\_ Spaced: \_\_\_\_\_ feet apart.

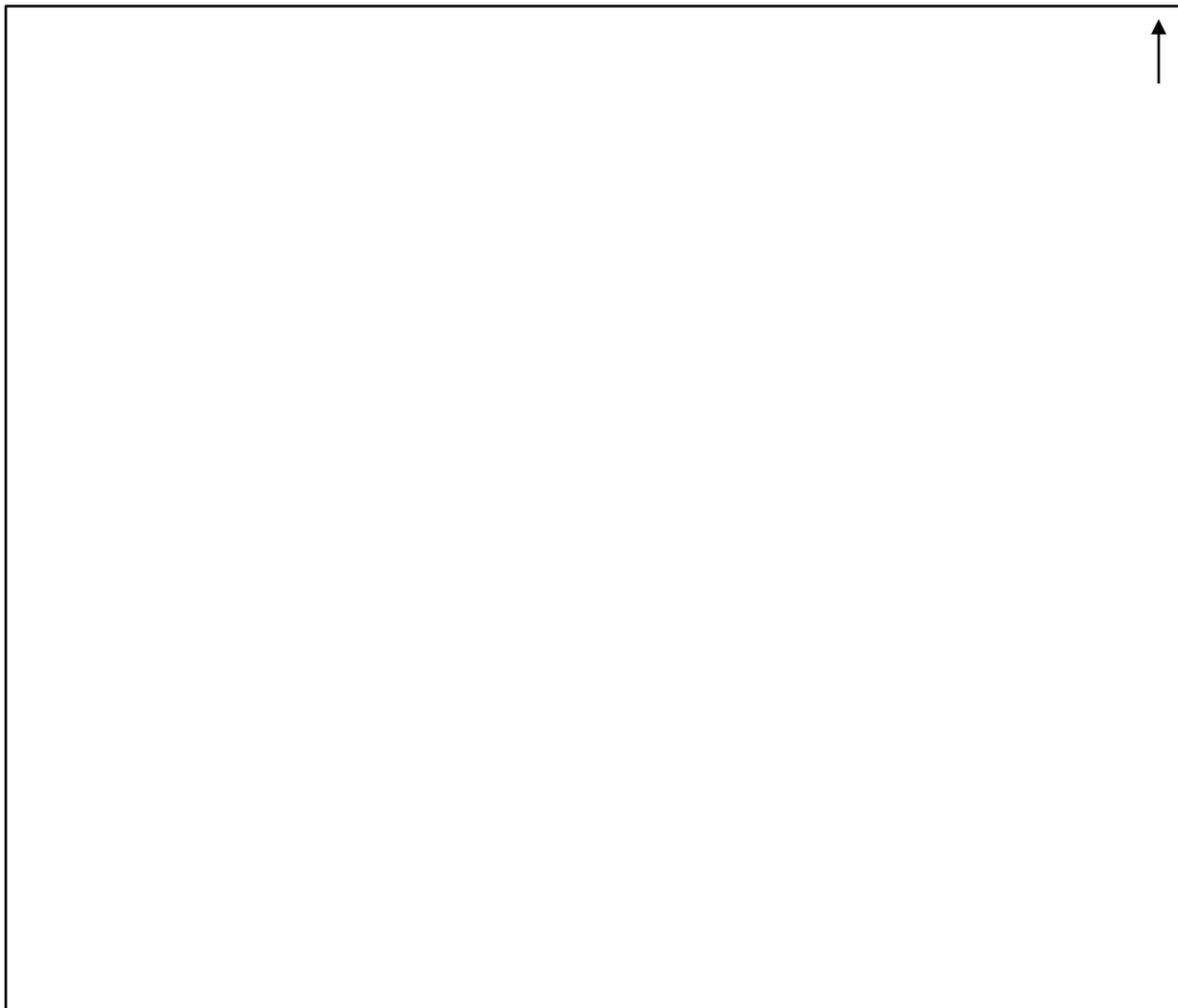
Trap #	Start Time	End Time	Desert Pupfish	Mosquitofish	Sailfin Molly	Tilapia	Red Shiner	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Others (snails, crayfish, etc.): \_\_\_\_\_

**NOTES:**

Desert Pupfish Distribution Monitoring Protocol

**Map of Area**



Sketch area of drain trapping. (Note where traps are located by number)

Total Fish Species:

<b>Species</b>	<b>Total Number</b>	<b>Male/Female</b>	<b>Length (range)</b>
Desert Pupfish			
Mosquitofish			
Sailfin Molly			
Tilapia			
Red Shiner			

\*Bank Slope: Gentle, Moderate or Steep

Water Velocity: Slow, Medium or High