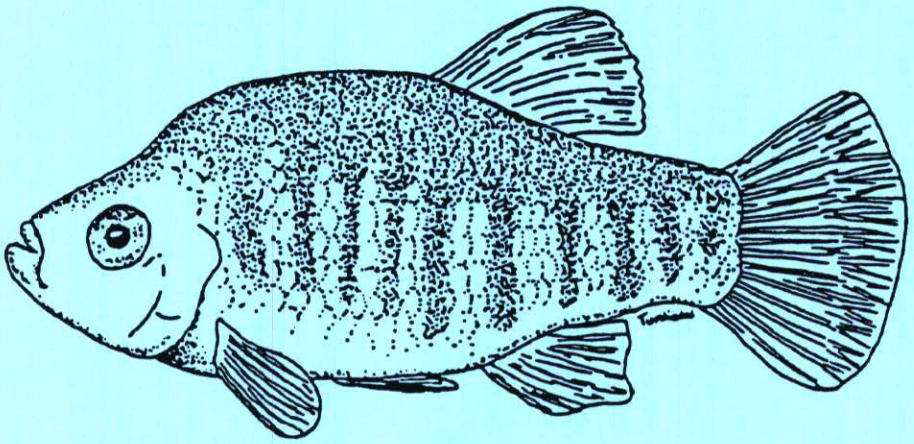
DESERT PUPFISH RECOVERY PLAN



U.S. FISH & WILDLIFE SERVICE

DEPARTMENT OF THE INTERIOR

Phoenix, Arizona **September 1993**

DESERT PUPFISH (*Cyprinodon macularius*)

RECOVERY PLAN

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for

Region 2

U.S. Fish and Wildlife Service
Albuquerque, New Mexico

with assistance from

Arizona Game and Fish Department
and
Tonto National Forest

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Approved: _____
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DISCLAIMER

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available, subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies (involved in the plan formulation), other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

LITERATURE CITATIONS

U.S. Fish and Wildlife Service. 1993. Desert Pupfish Recovery Plan. Phoenix, Arizona. 67 pp.

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Fish and Wildlife Reference Service:

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The fee for the Plan varies depending on the number of pages of the Plan.

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EXECUTIVE SUMMARY

Current Species Status: Listed as endangered throughout its range. Composed of two subspecies in the U.S.: a Colorado River form and a Quitobaquito form. Natural populations of the Colorado River form have been extirpated from Arizona, restricted to three natural locations in California and the non-natural irrigation drains around the Salton Sea. The Colorado River form also occupies certain restricted locations of the Colorado River Delta in Sonora and Baja California, Mexico. The Quitobaquito form persists in a single, modified spring at Organ Pipe Cactus National Monument, Arizona. Distribution of a third, undescribed form in Rio Sonoyta of Sonora, Mexico is unknown, but believed to be quite limited.

Habitat Requirements and Limiting Factors: Cienegas, springs, small streams and margins of large rivers. Has tolerance for wide temperature fluctuation, low oxygen concentrations, and high salinity. Does not cope effectively with introduction of non-native fish. Habitat loss, habitat modification, pollution, and competition and predation from non-native fish threaten the species' survival.

Recovery Objective: Downlisting of the Colorado River form (delisting of Colorado River form is not considered feasible in the foreseeable future), and protection of the other two subspecies (downlisting of Quitobaquito form appears to be unattainable).

Recovery Criteria: Secure, maintain and replicate all naturally occurring extant populations. Re-establish replicate populations in the most natural, identifiable habitats within the probable historical range. Each replicated population will not be considered established until the population has persisted for a minimum of ten years. Protection and establishment of refugium populations of Quitobaquito and Rio Sonoyta forms.

Actions Needed:

1. Protect natural populations and their habitats.
2. Re-establish populations.
3. Establish a refugium population of Quitobaquito pupfish.
4. Develop protocol for exchange of genetic material.
5. Monitor natural and replicated populations.
6. Determine factors affecting population persistence.
7. Information and education.

Costs - (000's):

Year	Need 1*	Need 2	Need 3	Need 4	Need 5	Need 6	Total
1994	26	30	20	8	31	7	122
1995	50	30	20	23	55	6	184
1996	45	25	20	8	56	7	161
1997	36	25	20	10	56	7	154
1998	26	25	20	10	38	7	126
1999-2008	100	150	0	165	40	70	525
Total Costs	283	285	100	224	276	104	1,272

Date of Downlisting: Downlisting is expected to occur in 2009 for the subspecies C. macularius macularius, if downlisting criteria are met.

* - not including acquisition costs.

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I. INTRODUCTION

The desert pupfish (Cyprinodon macularius Baird and Girard) (1853) is a small cyprinodontid fish that once ~~was widespread~~ and abundant in portions of southern Arizona and southeastern California, United States, and northern Baja California and Sonora, Mexico (Miller 1943). Historical habitats varied in size, complexity, character and permanence, and included cienegas, springs, streams, and margins of larger lakes and rivers (Minckley 1973). The desert pupfish has received considerable attention from behaviorists, systematists, physiological ecologists, and geneticists but many aspects of its basic biology remain unstudied. Although remarkably tolerant of extreme environmental conditions (Deacon and Minckley 1974), the species is threatened with extinction throughout its native range primarily because of habitat loss or modification, pollution, and introductions of exotic fishes [U.S. Fish and Wildlife Service (Service) 1986].

Naturally-occurring populations of desert pupfish are now restricted in Arizona to Quitobaquito Springs and in California to two streams tributary to, and a few shoreline pools and irrigation drains of, the Salton Sea. The species is found in Mexico at scattered localities along Rio Sonoyta, on the Colorado River Delta, and in the Laguna Salada basin. The desert pupfish is listed as endangered by the United States (Service 1986), the International Union for Conservation of Nature and Natural Resources (Miller 1979, IUCN 1990), and the States of Arizona [Arizona Game and Fish Department (AGFD) 1988] and California [California Department of Fish and Game (CADFG) 1980, Bolster 1990]. The Mexican government has also listed the species as endangered [Secretaría de Desarrollo Urbano y Ecología (SEDUE) 1991].

Description

The desert pupfish was described by Baird and Girard (1853) from specimens collected in the San Pedro River, Arizona. The taxon now includes two recognized subspecies, Cyprinodon m. macularius and C. m. eremus, and one undiagnosed form which ~~occurs in~~ the ~~Rio Sonoyta~~, Sonora, ~~Mexico~~ (McMahon and Miller 1985, Miller and Fuiman 1987). Cyprinodon m. eremus is endemic to Quitobaquito Springs, Organ Pipe Cactus ~~National Monument,~~ Pima County, Arizona (Miller and Fuiman 1987). All other populations are referred to C. m. macularius. A third named subspecies, C. m. californiensis (Girard 1859, Miller 1943, Hubbs et al. 1979) from near ~~San Diego, California~~, is no longer recognized as valid and is now considered C. m. macularius (Miller and Fuiman 1987). Lucania browni Jordan and Richardson (~~1907) from~~ a hot spring in ~~northeastern Baja California~~ was also synonomized with C. m. macularius (Miller 1943, Minckley 1973, Miller and Fuiman 1987).

Analysis of allozyme variation (Turner 1983) of six desert pupfish populations [Quitobaquito Spring, Boyce Thompson Arboretum (progeny of fish from Cienaga de Santa Clara, Mexico) (=Santa Clara Slough) and four from the Salton Sink] showed mean heterozygosity values within the range reported by Kornfield and Nevo (1976) for the ecologically comparable (Miller 1981) euryhaline killifish Aphanius dispar. The study also detected differences among the three geographic areas and among the four Salton Sink populations, and a low level of inter-population differentiation.

A description of Cyprinodon macularius is summarized from Baird and Girard (1853), Miller (1943), Minckley (1973), and Moyle (1976):

> The body is thickened, chubby or markedly compressed laterally in adult males. The mouth is superior and highly protractile, and is equipped with tricuspid jaw teeth. Spine-like projections are characteristic of scale circuli. The dorsal profile is smoothly rounded.

> Background coloration is silvery in females and juveniles. The sides have narrow, vertical dark bars interrupted laterally and giving an appearance of a disjunct lateral band. Fins are colorless except for a dark ocellus in the dorsal and (rarely) a dark spot on the anal fin. Mature males in breeding condition are brightly colored with the caudal fin and posterior portion of the caudal peduncle yellow or orange, sometimes intense orange-red. Other fins are dark. The body is iridescent light-to-sky blue, especially on the dorsal surface of the head and predorsal region.

The pupfish endemic to Quitobaquito Spring, Arizona, has been long recognized as a distinct form (Miller 1943, Hubbs and Miller 1948, Cole 1963, Cole and Whiteside 1965, Minckley 1973) but not formally described until recently (Miller and Fuiman 1987). The Quitobaquito pupfish (Cyprinodon macularius eremus) differs from other populations of C. macularius primarily as follows (Miller and Fuiman 1987):

> The males have a longer, wider and deeper head, and broader and deeper body. Distances from the tip of the snout to the pelvic fin insertion, and from snout to anal fin insertion are greater in males. In females, the head is deeper, the body is slightly deeper, the dorsal fin base is longer, and the depressed anal fin is shorter. The dorsal fin origin is more posterior than for typical C. macularius, and is the same for males and females. Pelvic fins are reduced in size (as they are in other Rio Sonoyta populations) compared to most C. macularius.

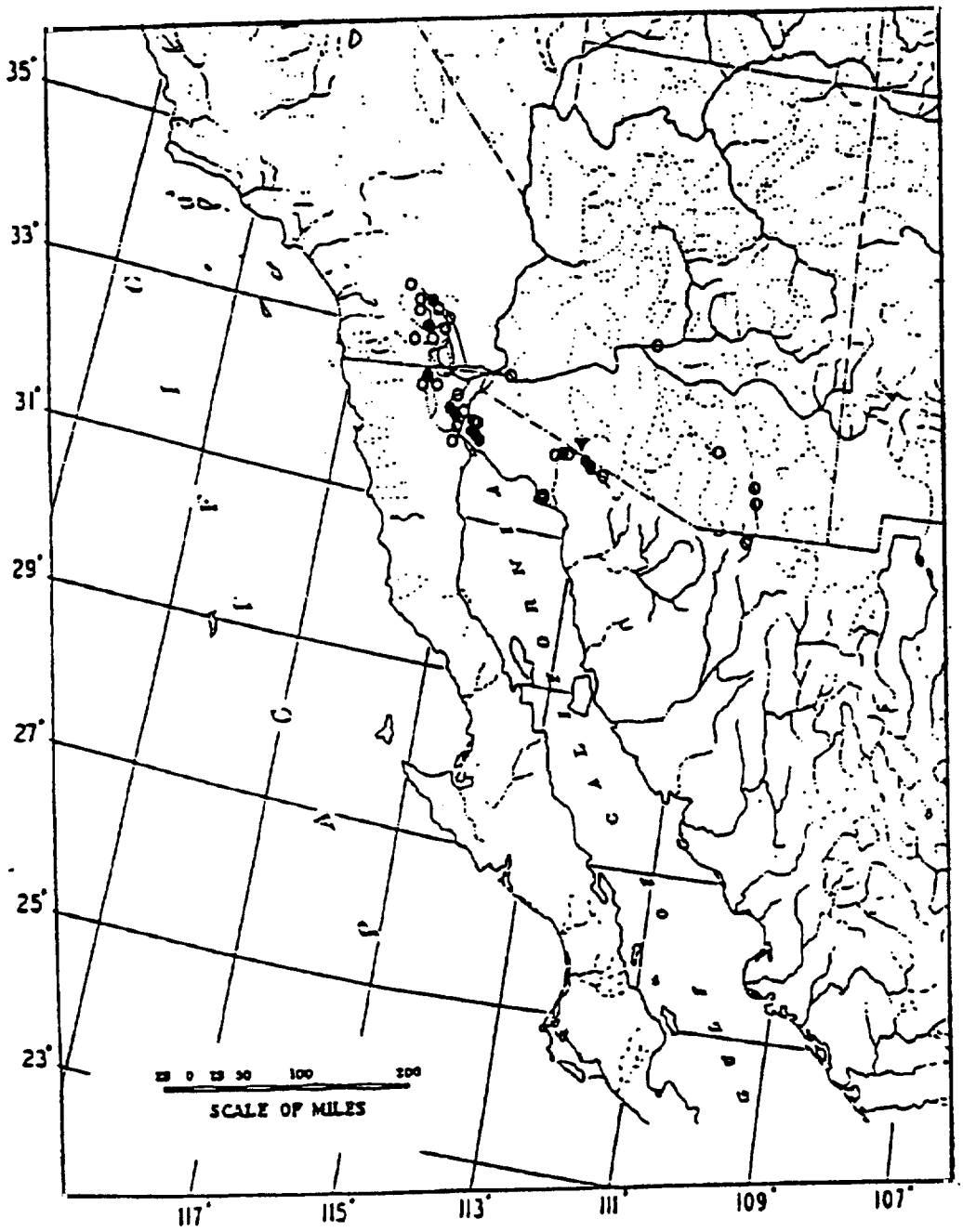
McMahon and Miller (1985) and R.R. Miller (in Minckley 1985) concluded that pupfish from the mainstream Rio Sonoyta differ substantially from those in Quitobaquito Spring, although not at more than a subspecific level. Miller and Fuiman (1987) further note the distinctiveness of Rio Sonoyta populations compared with Quitobaquito pupfish and considered the former an intermediate link between C. m. macularius and C. m. eremus.

Distribution and Abundance

Historical. Desert pupfish historically occupied the Gila River basin below about 1,500 meters (m) elevation in Arizona and Sonora, including the Gila, Santa Cruz, San Pedro, and Salt Rivers; the lower Colorado River in Arizona and California downstream from the vicinity of Needles to the Gulf of California and onto its delta in Sonora and Baja California; the Rio Sonoyta of Arizona and Sonora; Puerto Penasco, Sonora; and the endorheic Laguna Salada basin of Baja California (Figure 1) (Minckley 1973, 1980; Miller and Fuiman 1987; Miller written communication 1993). Although collections are wanting, suitable habitat was available and the species probably occurred as well in the Agua Fria, Hassayampa, and Verde Rivers of Arizona. In California, it historically occurred in springs, seeps and slow-moving streams in the Salton Sink basin (Eigenmann and Eigenmann 1888, Evermann 1916, Thompson 1920, Jordan 1924, Coleman 1929, Jaeger 1938, Miller 1943, Black 1980b), and possibly in the slow-moving waters along the lower Colorado River (Garman 1895, Gilbert and Scofield 1898, Turner 1983). The Quitobaquito form occurred naturally only in Quitobaquito Spring, Arizona. Historic collection localities are provided in Figure 1.

Distribution of desert pupfish was widespread but probably not continuous within its historic range. Populations occupying stable springs and headwater habitats may have persisted for millennia and experienced relatively little long-term change in numbers. Those occupying rivers and adjacent habitats almost certainly varied numerically in response to local climatic and habitat

Figure 1. Historic collections and present distribution of desert pupfish; open circles represent historic records, closed circles denote extant natural populations of Cyprinodon macularius macularius, and the triangle locates Quitobaquito Spring (Cyprinodon macularius eremus).



conditions. Small populations were found in small habitats and elsewhere during harsh conditions, with expansion into larger habitats when environmental conditions moderated. Populations of larger streams and rivers likely were ephemeral, perishing when drought desiccated their habitat, and dispersing to populate areas watered by flooding. Such a scenario, when repeated over the evolutionary history of the species, would likely have led to panmixia among populations within broad geographic areas.

After the Salton Sink was most recently flooded in the early 1900s by diversion of the Colorado River, desert pupfish colonized what is now known as the Salton Sea (Thompson and Bryant 1920). The Salton Sea, its tributary streams and irrigation drains, supported large desert pupfish populations until precipitous population declines, attributed especially to introductions of exotic species (Miller and Fuiman 1987, Schoenherr 1988) began in the early 1960s (Black 1980b).

Historic abundance of pupfish at Quitobaquito remains unknown because the habitat has been modified by impoundment and diversion by humans (Bryan 1925, Johnson et al. 1983). Habitat likely was relatively small under pristine conditions, and areal densities of fish probably varied little other than seasonally under natural conditions.

Present. Natural populations of the Colorado River subspecies of desert pupfish persist in at least a dozen locales in the United States and Mexico (Fig. 1; Table 1, Appendix), and at least 20 and up to 24 transplanted (non-aquarium) populations are extant (AGFD files; Bagley et al. 1991, Brown and Abarca 1992, Table 2, Appendix). Among the last is a large stock derived from Cienaga de Santa Clara and maintained at Dexter National Fish Hatchery, New Mexico. Quitobaquito pupfish are in its single native habitat (Fig. 1), one population of known genetic purity is established at Arizona State University, several potentially mixed stocks exist (Table 2), and a number of display or aquarium stocks are extant (AGFD files).

Arizona. Naturally occurring populations of Cyprinodon macularius macularius have been extirpated from Arizona. However, the subspecies has been transplanted from Dexter National Fish Hatchery (Cienaga de Santa Clara origin) to a number of locations within the state (Table 2). Transplant sites included natural habitats, livestock watering tanks, constructed refugia, and aquaria under State, Federal, or private ownership. At least 8 and as many as 12 Arizona transplant locations supported pupfish in spring 1991, with population sizes of more than 1,000 individuals (Table 2).

A large population of Cyprinodon m. eremus is endemic to Quitobaquito Springs, Organ Pipe Cactus National Monument (Fig. 1). Total estimated abundance in the 0.22 hectare (Fisher 1989) pond varies annually from about 5,000 to 10,000 under normal conditions [Kynard and Garrett 1979, Bagley et al. 1991, Brown and Abarca 1992, U.S. National Park Service (NPS) 1992]. A captive stock of Quitobaquito pupfish is currently held at Arizona State University in Tempe (Table 2).

Other populations presumably derived from Quitobaquito Spring, but of questionable genetic purity because of potential genetic contamination by other species or subspecies, were established and may persist at Bog Hole Tank (Coronado National Forest, Santa Cruz County), Finley Tank (Audubon Society Research Ranch near Elgin, Santa Cruz County), Arizona-Sonora Desert Museum (near Tucson, Pima County), and Tohono Chul Park, Tucson (Table 2). These populations should be destroyed because they all are outside the historic range of the subspecies, are of questionable genetic purity, and threaten recovery of downstream populations.

California. Natural populations of desert pupfish are presently restricted in California to San Felipe Creek and its associated wetland, San

Table 1. Summary of known natural populations now existing in the United States and Mexico.

Cyprinodon macularius eremus

1) Quitobaquito Springs, Arizona

Cyprinodon macularius macularius

1) Salton Sink (San Felipe/San Sebastian Marsh, upper Salt Creek, and shoreline pools and irrigation drains of Salton Sea, California);

2) El Doctor (3 localities) and Cienaga de Santa Clara (2 localities);

3) Laguna Salada, Baja California; and

4) Cerro Prieto (2 localities), Baja California, Mexico

Cyprinodon macularius ssp.

1) Rio Sonoyta, Sonora

Table 2. Summary of extant transplanted stocks of desert pupfish. Records from spring 1991 unless otherwise designated. Included are location, ownership, transplant date(s), habitat type, approximate population size, and original source of fish (AGFD and CADFG files).

Cyprinodon macularius macularius

1. AZ, Maricopa Co., Tempe; private (W.L. Minckley); 1976, 1988; artificial (concrete) pond; <500 fish; Santa Clara Slough, Mexico.

2. AZ, Graham Co., Howard Well; U.S. Bureau of Land Management; 1983; artificial stock tank supplied by drilled artesian well; status uncertain as of March 1993; Santa Clara Slough, Mexico.

3. AZ, Maricopa Co., Glendale, Deer Valley High School; Glendale School District; 1983, 1987; 1991; artificial (earthen) pond; >500 fish; Santa Clara Slough, Mexico.

4. AZ, Pinal Co., Boyce Thompson Arboretum; University of Arizona; 1983, 1984, 1985; artificial (earthen) impoundment supplied in part by treated sewage and mine water; >500 fish (contaminated by fathead minnow); Santa Clara Slough, Mexico.

5. NM, Chavez Co., Dexter, National Fish Hatchery; U.S. Fish and Wildlife Service; 1983; artificial (earthen) pond supplied by well water; >500 fish; Santa Clara Slough, Mexico.

6. AZ, Pima Co., Tucson, Flowing Wells Junior High School; Tucson School District; 1986; artificial (concrete) pond; <500 fish; Santa Clara Slough, Mexico.

7. Mexico, Sonora, Hermosillo, Centro Ecológico de Sonora; State of Sonora; 1986; artificial pond; >1,000 fish; Rio Sonoyta, Mexico.

8. AZ, Graham Co., Roper Lake State Park; State of Arizona; 1987; artificial (earthen) pond supplied by spring water; status uncertain as of March 1993; Santa Clara Slough, Mexico.

9. AZ, Maricopa Co., Phoenix, Desert Botanical Garden; private; 1987; artificial (concrete) pond; <500 fish; Santa Clara Slough, Mexico.

10. AZ, Pima Co., Buehman Canyon; State of Arizona; 1989; natural, perennial stream; status uncertain as of March 1993; Santa Clara Slough, Mexico.

11. AZ, Maricopa Co., Hassayampa River Preserve; The Nature Conservancy; 1989; artificial (earthen) impoundment supplied by quasi-natural (modified) spring; status uncertain as of March 1993; Santa Clara Slough, Mexico.

12. AZ, Maricopa Co., Glendale; private (R.Engle-Wilson); 1989; artificial (concrete) pond; <500 fish; Santa Clara Slough, Mexico.

13. AZ, Pima Co., Tucson, Arizona Historical Society; private; 1989; artificial (concrete) pond; unknown number of fish; Santa Clara Slough, Mexico.

14. AZ, Graham Co., Cold Spring Seep; BLM; 1990; artificial impoundment (2 small pools); status uncertain as of March 1993; stocked with 50 fish from Flowing Wells Jr. High School, Tucson, and 150 fish from Dexter NFH (both Santa Clara Slough stock).

15. CA, Riverside Co., The Living Desert; private ownership; 1972; two artificial (concrete) ponds; current number unknown; Salton Sea, California.

16. CA, San Diego Co., Palm Spring, Anza-Borrego Desert State Park; 1978; State of California; artificial (concrete) pond, current number unknown; Salton Sea, California.

17. CA, San Diego Co., Visitor Center, Anza-Borrego State Park; 1979; State of California; artificial (concrete) pond, current number unknown; Salton Sea, California.

18. CA, Riverside Co., Oasis Spring Ecological Reserve; 1977, 1979; State of California; artesian well and two earthen ponds; current number unknown; Salton Sea, California.

19. CA, Riverside Co., Salton Sea State Recreation Area; 1982; State of California; artificial (concrete) pond; current number unknown; Salton Sea, California.

20. CA, Riverside Co., Simone/McCallum Pond, Thousand Palms Oasis; 1987; private (The Nature Conservancy); natural spring/artificial (earthen) pond; current number unknown; Salt Creek, California.

21. CA, Riverside Co., Visitor Center Pond, Thousand Palms Oasis; 1989; private (The Nature Conservancy); natural spring/artificial (earthen) pond; current number unknown; Salt Creek, California.

22. CA, Riverside Co., Rancho Dos Palmas; 1990; private (BLM); artificial (earthen) pond; current number unknown; Salt Creek, California.

23. CA, San Diego Co., Palm Canyon, Anza-Borrego Desert State Park; State of California; 1981; artificial (concrete) pond; current number unknown; San Felipe Creek, California.

24. CA, Riverside Co., The Living Desert; private ownership; 1985, 1987; artificial (earthen) pond; current number unknown; San Felipe Creek, California.

25. Numerous captive aquarium populations (See Appendix).

Cyprinodon macularius eremus, including stocks of questionable genetic purity.

1. AZ, Santa Cruz Co., Bog Hole; U.S. Forest Service; 1977; artificial (earthen) impoundment on natural drainage; < 500 fish; potentially mixed stocks.

2. AZ, Santa Cruz Co., Finley Tank; Audubon Society; 1978; artificial (earthen) impoundment fed by springwater; >500 fish; potentially mixed stocks.

3. AZ, Pima Co., Tucson, Arizona-Sonora Desert Museum; private; 1981; artificial (concrete) ponds; >500 fish; potentially mixed stocks.

4. AZ , Pima Co., Tucson, Tohono Chul; private; 1987; artificial (concrete) pond; <500 fish; potentially mixed stocks.

5. AZ, Maricopa Co., Tempe; Arizona State University; State of Arizona; 1989; artificial (concrete) pond; >500 fish; Quitobaquito Springs (Organ Pipe Cactus National Monument), Arizona, via Arizona Game and Fish Department.

6. Numerous captive aquarium populations (See Appendix, AGFD files).

Sebastian Marsh, Imperial County; upper Salt Creek, Riverside County; and a few isolated shoreline pools and irrigation drains along the Salton Sea, Imperial and Riverside Counties., (Fig. 1; Miller and Fuiman 1987, Nichol et al. 1991). Relatively small refugium populations have been transplanted to Arrowweed Spring (Imperial County), Butte County Mosquito Abatement District (Butte County), Rancho Dos Palmas, Salton Sea State Recreation Area, The Living Desert (two populations), Thousand Palms Oasis (two locations), and Oasis Spring Ecological Reserve (Riverside County), and Palm Spring, Palm Canyon, and Visitor Center, located at Anza-Borrego State Park in San Diego County (Table 2).

Mexico. Natural populations of the yet-undescribed form of desert pupfish persist in Sonora in Rio Sonoyta (Fig. 1). Cyprinodon m. macularius is in several spring-fed marshes in the vicinity of the village of El Doctor and in Cienega de Santa Clara, Sonora. Desert pupfish in Baja California are found on the Colorado Delta, in Laguna Salada, in an expansive wetland associated with a geothermal powerplant at Cerro Prieto, and in a ditch downstream of the Cerro Prieto marshland (Fig. 1; Hendrickson and Varela-Romero 1989). A captive population of pupfish from the Rio Sonoyta was established at Centro Ecológico de Sonora (CES) in Hermosillo, but a stock obtained from Santa Clara Slough and also held there was recently extirpated. There are no other records of desert pupfish transplants within Mexico.

Life History

Research on desert pupfish has included study of taxonomy and biogeography (Miller 1943 and 1981, Hubbs and Miller 1948, Miller and Fuiman 1987, Hendrickson and Varela-Romero 1989, others), physiology (e.g., Barlow 1958a, Kinne 1960, Kinne and Kinne 1962a and b, Sweet and Kinne 1964, Lowe et al. 1967, Courtois and Hino 1979, Schoenherr and Feldmeth 1991), genetics (e.g., Turner 1983 and 1984; Echelle 1991, Echelle and Dowling 1992, Echelle and Echelle 1993), and behavioral ecology (e.g., Cowles 1934, Barlow 1958b and 1961; Arnold 1972, Loiselle 1980 and 1982, Matsui 1981, McMahon 1984, McMahon and Tash 1988). Because of this broad spectrum of examination, the desert pupfish may be the best known member of the cyprinodontid family of fishes.

Habitat. Desert pupfish occupied a diversity of habitats ranging from cienagas and springs to small streams and margins of larger bodies of waters. Most habitats were shallow and had soft substrates and clear water. Abundance of aquatic vegetation and invertebrates probably varied seasonally, with lowest levels associated with harshest conditions.

Pupfish have an extraordinary ability to survive under conditions of high water temperature (to 45°C, Lowe et al. 1967), low dissolved oxygen concentration [0.1-0.4 milligrams per liter (mg/L), (Barlow 1958b)], and high salinity [salt concentrations twice (68 grams per liter) that of seawater, Lowe et al. 1967], which exceed tolerances of virtually all other freshwater fishes (see also Kinne 1960, Kinne and Kinne 1962 a,b). They also survive abrupt, absolute changes in both salinity [10-15 grams per liter (gm/L)] and temperature (22-26°C) (Kinne 1960, Lowe and Heath 1969) that are lethal to most fishes. In less harsh environments where a greater diversity of fishes was found (e.g., margins of larger streams and rivers), pupfish typically occupied water shallower than that inhabited by adults of most other species.

Reproduction. Under conditions of abundant food and suitable temperature (mid-to-upper 20s °C), desert pupfish may become sexually mature as early as six weeks of age at 1.5 centimeters (cm) total length (Moyle 1976). Although they may breed during their first summer, most do not breed until their second summer, when their length may have reached a maximum of 7.5 cm (Moyle 1976). Male pupfish are usually highly aggressive during the breeding season (early spring into winter when water temperature exceeds about 20°C). During this period they establish, actively patrol, and defend individual territories that

are typically in water less than 1 m deep and associated with a small structure or incongruity on the substrate (Barlow 1961). Males in natural habitats normally defend 1 to 2 square meters of bottom, depending on their individual size, density of other male pupfish, and water temperature (Moyle 1976). Minimum male territory size may be 45 to 60 square cm, the density at which population stability is achieved in aquaria (Minckley 1973).

Male breeding behaviors include territoriality and consort pair breeding (a non-territorial system in which males show low levels of aggression) (Kodric-Brown 1981). Territoriality occurs in large habitats with high primary productivity, limited breeding substrates, and high population densities. Consort-pair breeding is characteristic of populations in habitats of low primary productivity, low population density, and abundant breeding habitat (Kodric-Brown 1981). Because territoriality is the most common breeding system in desert pupfish (Barlow 1958b and 1961; Cox 1966, Kodric-Brown 1981), it is further described below.

Adult females swim in loose schools and forage inconspicuously. A female that is ready to spawn leaves the school when attracted by a territorial male (Cowles 1934, Barlow 1961). As the two fish move toward one another, the female tilts head-first toward the bottom and takes a small piece of substrate into her mouth. After resuming a horizontal position, she spits out the material. This sequence may be repeated several times until she ceases motion near the bottom. The male then assumes a position against and parallel to the female, and the two fish contort together to form an "S" shape. The male's anal fin next cups around the vent region of the female, and she vibrates and produces a single, relatively large [ca. 2 millimeters (mm) diameter (Constanz 1981)] egg, which is immediately fertilized. The spawning act takes less than a minute but may be repeated in quick succession to deposit several eggs. In the laboratory, female pupfish of varying size may lay 50 to more than 800 eggs in a single season (Crear and Haydock 1971). Eggs appear to be randomly deposited within the male territory and there is no directed parental care. However, male activities within the territory effectively exclude other fishes, which may enhance chances for successful incubation (Minckley 1973). Incubation time varies with water temperature, hatching in the laboratory occurs in about 10 days at 20°C (Crear and Haydock 1971).

Growth. Growth rate is dependent upon age, habitat and environmental conditions, and population density. In the laboratory, young fish derived from the Salton Sea population exhibited optima growth at 30°C and 35 gm/L salinity, while older individuals grew most rapidly at 22 to 26°C and about 15 gm/L salinity (Kinne 1960, Kinne and Kinne 1962a, b). Body shape varied among fish incubated at different combinations of salinity and temperature (Sweet and Kinne 1964). Temperature effects on size at hatch at constant (35 gm/L) salinity were interpreted to reflect temperature and possible salinity optima for utilization of yolk by developing embryos (Blaxter 1969).

Desert pupfish from the Salton Sea hatch at 0.4-0.5 cm total length and may double in length within the first 8 weeks of life. Depending primarily upon temperature, size ranges from 1.5 to 2.8 cm at 24 weeks of age, and lengths of 4.5 to 5.0 cm are attained in the laboratory by the end of the first growing season (Kinne 1960). Maximum length [to 7.5 cm (Moyle 1976)] may be attained by the second summer. Quitobaquito pupfish in June averaged 29.6 mm at age 1, 40.2 mm at age 2, and 48 mm at age 3 (Kynard and Garret 1979).

Life span in the wild appears highly variable; from less than a year for some populations (Minckley 1973), two years for others (Moyle 1976), and up to three years for Quitobaquito pupfish (Kynard and Garrett 1979). Predation by aquatic insects, piscivorous birds, and mammals was noted by Cole and Whiteside (1965) in Quitobaquito Spring and likely is a source of mortality elsewhere (see Walker 1961).

Foods and Feeding Habits. Larval pupfish in the laboratory begin feeding on tiny invertebrates within a few hours to a day after hatching (Crear and Haydock 1971) and presumably do so in the wild as well. As they grow, wild fish become opportunistic omnivores, consuming whatever variety of algae, plants, suitably-sized invertebrates, and detritus is available (Cox 1966 and 1972, Naiman 1979). Adult foods include ostracods, copepods, and other crustaceans and insects, pile worms, molluscs, and bits of aquatic macrophytes torn from available tissues. Detritus or algae are often predominant in their diets. Pupfish at Quitobaquito Spring have been reported to eat their own eggs and young (Cox 1972), and it has been suggested (Loiselle 1980) that males differentially consume eggs within their territories that were fertilized by other males. Pit digging, the active excavation of soft bottoms in search of foods, is a pupfish behavior described in detail by Minckley and Arnold (1969); these pits are defended when occupied. Foraging is typically a daytime activity, and fish may move in response to daily warming from shallower water during morning to feed in deeper places later in the day.

Co-occurring Native Fishes. The harshest habitats historically occupied by desert pupfish had temperatures, salinities, and dissolved oxygen concentrations so extreme that other fishes were excluded. Elsewhere in cienegas, springs, and small streams, the Sonoran topminnow (Poeciliopsis occidentalis) was a common co-habitant; however, it is unknown how the two species interacted. Topminnows and pupfish also inhabited the margins of larger rivers, where shallow depths, high temperatures, or other factors excluded adults of most species. Other fishes in desert pupfish habitats included Gila chub (Gila intermedia), speckled dace (Rhinichthys osculus) and the desert sucker (Pantosteus clarki), but these typically inhabited deeper waters and presumably had little interaction with pupfish. Longfin dace (Agosia chrysogaster), Sonora sucker (Catostomus insignis), and roundtail chub (Gila robusta) were commonly found in mainstream and deeper portions of mid-sized streams occupied peripherally by pupfish. Bonytail (Gila elegans), razorback sucker (Xyrauchen texanus), Colorado squawfish (Ptychocheilus lucius), and woundfin (Plagopterus argentissimus) occupied the mainstream of larger rivers. It is doubtful there was opportunity for these species, except as larvae or early juveniles, to interact with pupfish. Longfin dace was the only native fish with potential to have co-occurred with pupfish at Quitobaquito Spring (Minckley 1973).

Reasons for Decline

There are many reasons for declines of desert pupfish populations. They include habitat loss (dewatering of springs, some headwaters, and lower portions of major streams and marshlands), habitat modification (stream impoundment, channelization, diversion, and regulation of discharge, plus domestic livestock grazing and other watershed uses such as timber harvest, mining, and road construction), pollution, and interactions with non-native species (competition for food and space, and predation) (Matsui 1981, Minckley 1985, Service 1986, Miller and Fuiman 1987).

Many historic pupfish localities have been dried by groundwater pumping (affecting both spring and stream discharges), channel erosion or arroyo formation (resulting in drainage of marshlands, creation of sheer banks, and loss of lateral habitat), and water impoundment and diversion (reducing or eliminating stream flows and natural flow regimes) (Hastings and Turner 1965, Fradkin 1981, Rea 1983, Hendrickson and Minckley 1985). Impoundment also creates upstream habitat unsuitable for pupfish because of increased depth and which, because of its lentic character, is more conducive to occupation by non-native fishes. Poor grazing practices by domestic livestock may reduce terrestrial vegetative cover, enhance watershed erosion, exacerbate problems of arroyo cutting, and increase sediment loads and turbidity in receiving waters. Habitats may be further impacted by trampling where cattle feed or drink in or adjacent to water.

Fishes now occupying former desert pupfish habitat include many non-native species (see Miller 1961, Minckley 1973, 1979a and b, Moyle 1976, Marsh and Minckley 1987). These fishes pose the greatest threat to extant desert pupfish populations (Minckley and Deacon 1968, Deacon and Minckley 1974, Schoenherr 1981 and 1988, Meffe 1985, Miller and Fuiman 1987). Pupfish do not fare well in the presence of non-native fishes and incursions by exotics have typically resulted in decline or extirpation of pupfish. Non-native fishes that occupy habitats also used by pupfish [e.g., adult western mosquitofish (Gambusia affinis), sailfin molly (Poecilia latipinna), largemouth bass (Micropterus salmoides), and juvenile cichlids (Oreochromis ssp. and Tilapia ssp.)] have proven most destructive to populations of native species. Primary mechanisms of replacement include predation and aggression (mosquitofish and largemouth bass) and behavioral activities that interfere with reproduction (mollies and cichlids) (Matsui 1981, Schoenherr 1988).

Interactions with introduced mosquitofish were noted early as contributory to the decline of pupfish in the Salton Sea (Evermann 1930, Jennings 1985). Pupfish populations declined further when sailfin molly and African cichlids became abundant (Schoenherr 1979, 1985, and 1988, Black 1980a and b, Matsui 1981). In the Salton Sink, pupfish survive as remnant populations in tributary streams, a few shoreline pools, and irrigation drains where actual or potential invasion by non-native fishes (i.e., centrarchids, cichlids, ictalurids, and poeciliids), threaten their survival.

The Quitobaquito pupfish was threatened by establishment of golden shiner (Notemigonus crysoleucus) following unauthorized stocking in 1968 or 1969 (Minckley 1973). Eradication of the shiner and re-establishment of the pupfish were costly in time, money, and effort. In addition, an August 5, 1993, memorandum from the Superintendent of Organ Pipe National Monument notified the Service that an unconfirmed species of catfish was discovered in Quitobaquito Spring (written communication, H. Smith, Organ Pipe National Monument). The specimen was later identified as a black bullhead (Amieurus melas) (W.L. Minckley, ASU, pers. comm).

Pupfish populations in Mexico have been impacted by proliferation in recent years of non-native fishes (May 1976, McMahon and Miller 1985, Miller and Fuiman 1987, Hendrickson and Varela-Romero 1989). African cichlids, mosquitofish, sailfin molly, red shiner (Cyprinella lutrensis), carp (Cyprinus carpio), and channel catfish (Ictalurus punctatus) are now widespread on the Colorado River Delta. In Rio Sonoyta, Sonora, former and present pupfish habitats are variously infested with mosquitofish and black bullhead (Amieurus melas).

Non-native bullfrog (Rana catesbeiana) may also prove problematic in the management of desert pupfish. This species was introduced to California early in the 1900s (Storrer 1922) and rapidly became established over a wide geographic range in the West, where it has extirpated or displaced several native amphibians (Clarkson and deVos 1986). The bullfrog is an opportunistic omnivore with a diet throughout its range that includes fish (Frost 1935, Cohen and Howard 1958, Brooks 1964, McCoy 1967, Clarkson and deVos 1986). Its potential for impact on desert pupfish was demonstrated in an artificial pond at Arizona State University, where a population of desert pupfish numbering in the thousands was nearly eliminated by fewer than 20 adult bullfrogs over a period of approximately a year. Natural and re-established populations of desert pupfish may thus be at risk where bullfrogs become established, and their removal may be required to assure viability of the native fish.

Drift from aerial application of pesticides, in proximity to pupfish populations, has contributed to the decline of Quitobaquito pupfish (Kynard 1981, Miller and Fuiman 1987). Aerial pesticide application is a common practice near other natural populations (e.g., Rio Sonoyta, Mexico; lower San Felipe Creek, California and a small portion of the upper creek) which may be similarly impacted.

Elevated concentrations of mercury have been detected in tissue samples from a cichlid fish (Tilapia mossambica) and Asian clam (Corbicula fluminea) collected in the vicinity of the Cerro Prieto geothermal field in Mexico (Gutierrez-Galindo et al. 1988). Although measured levels (maximum in fish of 0.14 micrograms per gram dry weight) were below that considered hazardous to human health, potential acute or chronic effects on aquatic life, including some portion of desert pupfish life cycle, have not been determined.

There is also concern that introduced saltcedar (Tamarisk) adjacent to pupfish habitat may cause a lack of water at critical times (Bolster 1990, R. Bransfield pers. comm.). Evapotranspiration by luxuriant growths of this plant may especially impact smaller habitats where water supply is limited.

II. RECOVERY

Objective

The objective of this recovery action plan is to describe actions necessary to eliminate threats to extant populations and successfully establish additional populations of desert pupfish in secure habitats within probable historic range. Once these actions are successfully completed to fulfill the specific criteria delineated below, downlisting of the Colorado River subspecies of desert pupfish (Cyprinodon macularius macularius) from endangered to threatened status will be considered. Because of insoluble threats and limited habitat, delisting of this subspecies is not considered feasible in the foreseeable future.

Neither down- nor delisting of Quitobaquito pupfish (C. m. eremus) is expected because of its limited range, continuing threats to its survival, and lack of historic range in which the subspecies can be recovered. However, this plan provides specific recovery actions determined necessary to ensure survival of this subspecies.

Downlisting Criteria

Desert pupfish (Cyprinodon macularius macularius) will be considered for downlisting when:

(1) Naturally occurring populations in the United States and Mexico are secure. These include five metapopulations at 12 known locations:
   (a) Salton Sink (San Felipe Creek/San Sebastian Marsh, upper Salt Creek, and shoreline pools and irrigation drains of Salton Sea, California);
   (b) Rio Sonoyta, Sonora;
   (c) El Doctor (3 localities) and Santa Clara Slough (2 localities), Sonora;
   (d) Laguna Salada, Baja California; and
   (e) Cerro Prieto (2 localities), Baja California, Mexico;

(2) Populations of desert pupfish are re-established and secure within probable historic range according to specifications detailed in task 2 of this plan;

(3) A protocol for exchange of genetic material among re-established populations is developed and implemented to ensure maintenance of natural levels of allelic genetic diversity; and

(4) Population and genetic monitoring plans as outlined below in the stepdown of this plan are devised and implemented to routinely assess status of all populations.

Security is herein defined as formal protection of habitat and water rights by methods such as land and water rights acquisition, legislation, or management agreement, and maintenance of a genetically pure, self-sustaining, stable or increasing (viable) population. Until additional information becomes available, a viable population (Lacy 1987, Ryman and Utter 1987, Soulé 1987, Templeton 1990) will include not fewer than 500 overwintering adults or existing numbers, whichever is greater, in a normal sex ratio with in-situ reproduction and recruitment sufficient to maintain that number.

In the United States, formal protection of water and land will be considered to occur when one of the following criteria is met.

(1) Water rights and habitat associated with each naturally occurring population are in the legal possession of an agency, or organization, or entity whose goals include protection and recovery of endangered species, which possess adequate statutory authority to protect those populations against other land and water uses which may adversely affect desert pupfish, which has adequate regulations in place to enforce such authority, and which has demonstrated over a period of not less than 10 years adequate capability to protect and manage a viable population of desert pupfish.

(2) A legally-binding, long-term (>25 years) agreement is in place between the land and water rights owner(s) and an agency, organization, or entity such as described above, which provides sufficient legal rights to the agency or organization to manage a viable population of desert pupfish. The efficacy of this agreement should be demonstrated over a period greater than (if not equal to) 10 years.

In Mexico, formal protection of land and water will be considered to occur when security comparable to that defined for the United States is achieved.

Locally adjacent desert pupfish populations are considered separate only if a discrete catastrophic event (e.g., invasion by exotic fishes, habitat destruction, etc.) is likely to impact only one population. Unless demonstrated otherwise on a case-by-case basis, the presence of non-native fishes is considered a threat to desert pupfish population viability.

Once this plan is finalized and approved, downlisting of C. m. macularius is expected to take 15 years. Total recovery (delisting) is not expected in the foreseeable future.

Narrative Outline for Recovery Actions Addressing Threats

Factors considered above continue to threaten existence of desert pupfish populations. Increasing human populations continue to deplete available water resources and impact habitats used by desert pupfish. Although major water development projects in the United States have largely been completed, impoundment, stream diversion and groundwater pumping can be expected to continue and increase in the foreseeable future, both in this country and in Mexico. Habitat alteration and loss resulting from past land management practices continue to occur as damaged watersheds struggle to stabilize. Ongoing dispersed land uses will continue to disrupt that stabilization process with potential adverse effects on aquatic ecosystems. Localized agriculture, mining, recreation, and other activities will thus continue to threaten individual desert pupfish populations. Water pollution resulting from drift of agricultural pesticides may impact populations in both countries as agricultural development expands in Mexico and portions of California. Finally, non-native organisms constitute continuing threats to desert pupfish populations throughout their range because introduced species may have the capability to extirpate pupfish and may also be impractical to eradicate or control.

Desert pupfish recovery will require efforts of private and government agencies and organizations in Arizona, California, Sonora, and Baja California. These include, but are not limited to, the Service Regions 1 and 2, Forest Service Region 3, NPS, Bureau of Land Management (BLM), Centro Ecológico de Sonora (CES), Secretaria de Agricultura y Recursos Hidráulicas (SARH), Secretaría de Desarrollo Social (SEDESOL), AGFD, CADFG, Arizona State Land Department, California State Lands Commission, National Audubon Society, and The Nature Conservancy (TNC). Recovery efforts will be effected by subsets of the above participants, as dictated by political boundaries and management authority. The program herein addresses threats to the species and recovery tasks that are necessary to recover the Colorado River form of the desert pupfish throughout its native range, and maintain Quitobaquito and Rio Sonoyta forms. Management plans developed subsequent to this plan will detail actions specific to each state or population.

Recovery actions in the United States emphasize relatively small habitats and establishment of refugium populations, whereas those in Mexico will be most concerned with protecting marshlands and larger areas occupied by desert pupfish and other native species. However, successful implementation of this recovery plan in both countries is required for recovery of the species.

Progress toward recovery of the desert pupfish has been initiated by numerous agencies and organizations. For example, management plans, programs, or activities that include desert pupfish or target specific populations have been prepared or undertaken by AGFD, Arizona State Lands Department, California Department of Parks and Recreation, CADFG, California State Lands Commission, CES, The Living Desert, TNC, BLM, Service, NPS, and others. Several management plans developed for specific populations identify tasks necessary for their security. Full implementation of tasks described in these and additional plans is necessary to accomplish downlisting criteria defined here.

A hierarchical approach to re-establishment is developed for desert pupfish (task 2, below). The need to maintain the integrity of discrete, naturally-occurring stocks while also recognizing a requirement for exchange of genetic material is vital for recovery. This hierarchical approach accommodates (1) protection of naturally occurring populations, (2) replication of each distinct naturally occurring population with re-established populations in the best available sites, (3) opportunity to conduct genetic exchange within re-established populations, and (4) flexibility in protection of the desert pupfish by maximizing recovery success potential while minimizing probability of catastrophic population loss through tiered population management.

Because extant wild populations of desert pupfish are the most valuable remaining reservoir of original genetic material, their security is the most important consideration. From these, a second tier of populations will be established in the wild in the best available natural habitats, and among which individuals can be exchanged to maintain genetic variability. A third tier of populations would be established in natural or "quasi-natural" refugia. While these third tier habitats might be considered inferior or marginal relative to tier-two habitats, they must nonetheless be suitable for long-term maintenance of desert pupfish. Genetic exchange should occur both among third-tier populations and from second- to third-tier populations but not the reverse (see task 2, below). As new information becomes available, specific exchange protocols will be developed and implemented to enable desert pupfish evolution to occur as naturally as possible.

TASK 1. PROTECT NATURAL POPULATIONS OF DESERT PUPFISH

1.1 Identify Land Ownership of Extant Populations and Natural Habitats

Naturally occurring, wild populations of desert pupfish persist at Quitobaquito Springs, Arizona; two Salton Sink localities (plus shoreline pools and irrigation drains) in California; several localities in Rio Sonoyta, Sonora; and the Colorado River Delta, Sonora and Baja California. Specific private and U.S. or Mexican local, State, or Federal landowners must be accurately identified for all extant pupfish populations. The population at Quitobaquito Spring lies entirely within boundaries of Organ Pipe Cactus National Monument and is thus under control of the U.S. Government. Land within and adjacent to pupfish habitats in California is in a mosaic of private and Federal ownerships. Mexican pupfish habitats are primarily in State or private ownership. Most of the property along Rio Sonoyta and lower Colorado River Delta is under local ejido ownership, while pupfish habitat at Cerro Prieto is privately controlled.

1.2 Acquire Habitats Occupied by Natural Populations of Desert Pupfish.

Desert pupfish and their habitats cannot be protected until land and water rights ownerships are in the hands of entities that will ensure protection of the species and its environs. Special consideration must be paid to acquisition of properties or legal agreements in Sonora and Baja California, Mexico, where substantial pupfish habitat remains unprotected. Appropriate mechanisms must be used to acquire any lands in private ownership where such protection is not expected to be forthcoming. Most pupfish habitats in the United States are already under Federal ownership, or ownership by private parties whose conservation goals include perpetuation of desert pupfish. However, these populations and their habitats are not necessarily secure.

Assurance of an adequate water supply through time must be accomplished on a case-by-case basis. The source of water (e.g., aquifer, local watershed, stream channel, etc.) must first be specifically and accurately determined. In instances where water management adversely affects pupfish habitat (e.g., groundwater mining resulting in water level reduction) appropriate mechanisms must curtail the offending water use. Where long-term impacts to pupfish habitat can be predicted, a plan must be prepared and implemented to ensure an adequate water supply. This could be accomplished by a variety of mechanisms, including water rights acquisition, legal protection of instream flows, land and water use agreements, and improved water and/or land-use practices. Specific mechanisms will be determined on a case-by-case basis for each habitat.

1.3 Secure Natural Populations and Their Habitats.

Once land and water ownership or management title has been acquired, several tasks must be accomplished before desert pupfish in any particular habitat can be considered secure. These include promulgation of regulations which will provide sufficient long-term protection and management (e.g., specific designation as Areas of Critical Environmental Concern, Research Natural Areas, etc.), assurance of water of sufficient quantity and quality, protection against habitat degradation, control or removal of deleterious non-native animals and vegetation (if present), prevention of invasion by non-native fishes, and modification of land management practices deleteriously affecting aquatic habitats. Implementation of specific tasks required to achieve population and habitat security must be directed by individual management plans for each site.

Impacts of activities such as livestock grazing or watering, mining, timber harvest, phreatophyte control, recreation, agricultural or residential

development, etc., must also be determined for each pupfish habitat. Appropriate management plans must be formulated for each site or group of sites and implemented to reduce or eliminate impacts so populations are secure. Populations will be considered secure only when the plan is in force and being implemented properly. The goal is to ensure adequate water and habitat to secure pupfish populations meeting criteria specified above.

Unless information becomes available to the contrary, desert pupfish populations cannot be considered secure in habitats occupied by non-native fishes. Thus, habitats presently occupied by desert pupfish and detrimental non-native fishes must be considered, on a case-by-case basis, for reclamation to remove the non-native(s). Habitats in need of renovation should be ranked in consideration of the following criteria:

(a) Natural populations should be considered the first priority for recovery (as opposed to re-established populations),
(b) Immediacy of the threat of extirpation due to presence of non-native fishes,
(c) Status of populations of the same genetic composition,
(d) Ease of reclamation,
(e) Probability of success,
(f) Security against re-infestation by non-native fishes, and
(g) Other general and site-specific factors

Each operation must be supported by the Service, responsible resource agency(ies), the Desert Fishes Recovery Team, and other affected parties. Each operation should be supported by sufficient personnel, equipment, funding, and expertise to maximize chances for success. Inadequate planning, insufficient support, and lack of follow through are major contributors to past reclamation failures (see, e.g., Marsh and Minckley 1990), and those projects without such support must not be initiated until adequate support is available.

Securing desert pupfish populations also requires protecting the habitat against contamination/re-contamination by non-native fishes. Such assurance must be accomplished on a case-by-case basis, depending upon the specific characteristics of each habitat. Provisions might include construction of barriers to preclude natural invasion from confluent waters, removal of offending fishes from confluent or potentially confluent habitats (e.g., livestock watering tanks), imposition of regulations locally prohibiting possession of non-native fishes, and modifying habitat to exclude non-natives. Where habitat reclamation is required, it is imperative to ensure against reinvasion by non-native fishes before renovation is conducted. Public education about desert pupfish and its plight have obvious benefits.

Non-native bullfrogs may also prove problematic in the management of desert pupfish. The diet of bullfrogs includes fish, and its potential impact on pupfish has been documented. Both natural and re-established populations of desert pupfish may thus be at risk where bullfrogs become established. Control or removal of bullfrogs may be required to assure viability of the native fish.

In addition to threats from non-native species, the desert pupfish also faces threats to genetic integrity from contamination by other species or subspecies of pupfish stocked outside of their historic range. Populations of questionable genetic purity may be present in Arizona in Bog Hole Tank (Coronado National Forest, Santa Cruz County), Finley Tank (Audubon Society Research Ranch near Elgin, Santa Cruz County), Arizona-Sonora Desert Museum (Tucson, Pima County), and Tohono Chul Park (Tucson). These populations are all outside of the historic range of the species and threaten recovery of downstream populations. These sites should be renovated to remove the existing populations.

Other habitat management activities may also be required and must be considered on a case-by-case basis. For example, aquatic and/or terrestrial vegetation control may be required to maintain suitable desert pupfish habitat.

A key feature of desert pupfish conservation in Mexico (CES 1990) is the acquisition and expansion of presently-protected areas to include important habitats along Rio Sonoyta and the lower Colorado River Delta. The Reserva del la Biosfera El Pinacate (Pinacate Reserve) could be expanded to incorporate pupfish habitats in Rio Sonoyta. Similar opportunities exist for protection of desert pupfish and their habitats in the lower Colorado River Delta, where a natural area is protected for conservation of totoaba [Cynoscion macdonaldi (Perciformes: Sciaenidae)].

TASK 2. RE-ESTABLISH DESERT PUPFISH POPULATIONS

This plan incorporates a 3-tier plan for protection, re-establishment, and recovery of desert pupfish. Extant natural populations will be designated tier 1, which represent the original genotypes, are recognized as the most valuable resource, and will receive the highest level of protection.

Populations designated tier 2 are replicates of remaining, naturally occurring stocks. Tier 2 will be composed of re-established populations in the most natural (i.e., historic condition) identifiable habitats within probable historic range. Preference will be given to those habitats which are most likely to persist in perpetuity without human intervention. If sufficient sites meeting that criteria are not available, then tier 2 populations will be placed into habitats which are expected to require the least human intervention for maintenance.

A second suite of re-established populations (tier 3) will be in the most-natural habitats remaining after fulfillment of tier 2 requirements (see below). Habitat availability may make it necessary to establish some or all tier 3 populations in "quasi-natural" (i.e., human-modified to imitate historic conditions) sites. Individual tier 3 populations may be lost during the course of recovery management, but the total number specified below is to be maintained continuously. Tier 3 populations will theoretically function to optimize the balance between in- and outbreeding depression. Practically, they insure against loss of existing genetic variation and provide a source of future management opportunities.

Genetic exchange is to be accommodated between tier 2 populations derived from a single natural (tier 1) source, from tier 2 source populations to their tier 3 derivatives (but not the reverse), and between tier 3 populations derived from a single tier 2 source (but not between tier 3 populations from different sources). Continued cooperation with Mexico should allow future acquisition of desert pupfish broodstock. Addition of individuals from existing natural populations (Cienega de Santa Clara, El Doctor) will alleviate problems associated with in- and outbreeding depression which may occur in refugia populations.

Re-established populations in Arizona will be located in the lower and middle Gila (including the Hassayampa and Agua Fria), San Pedro, Santa Cruz, and Salt (including Verde) river drainages. Suitable sites in Mexican portions of the Santa Cruz and San Pedro river drainages should also be considered. Specific sites must be determined by appropriate participating entities, consistent with criteria for potential success of transplanted desert pupfish populations detailed below.

Populations of Cyprinodon macularius macularius are to be re-established according to specifications presented in Table 3.

Table 3. Re-establishment specifications for Cyprinodon macularius macularius populations.

Area	Natural Populations Tier 1	Re-established Populations Tier 2	Tier 3
Arizona	0	10	45
California	3	9 (3 reps. of each natural)	27 (9 reps. of each natural)
Colorado Delta	3	9 (3 reps. of each natural)	27 (9 reps. of each natural)
Rio Sonoyta	1	--- 3 of either tier 2 or 3 ---	

Specifications:

Tier 2 populations will receive a high degree of protection and will be long-term populations. A tier 2 population will be considered to be successfully established and count toward recovery if it has survived for 10 years and has required only minor management to persist. Minor management may include:

habitat-
1) minor vegetation removal
2) fencing
3) drawing off excess water for wildlife and livestock

populations-
4) population monitoring
5) management for other native species
6) pupfish transfers for genetic maintenance

Major management actions which would preclude a population from being considered successful would include:

habitat-
1) new or modified water supply
2) dredging
3) major vegetation removal
4) habitat (re)construction
5) exotic fish introduction or control

populations-
1) restocking pupfish
2) supplemental stockings of pupfish (for reasons other than genetic protocol)

Tier 3 populations may experience major management activities. Management will not preclude counting populations as contributing towards recovery. The specified total number of populations must be achieved and continuously maintained for 10 years.

Preliminary site determination should be based upon potential habitat suitability for long-term success of a population. Provision of security regarding land ownership, water supply, anti-degradation, and non-native fishes should be addressed secondarily as necessary. The San Pedro River (BLM Riparian National Conservation Area, Cochise County, Arizona) should be considered a priority re-establishment site [as already recommended by Minckley (1987) for desert pupfish plus other extirpated native fishes], because it has high potential and is the type locality for the species. A thorough survey of the upper San Pedro River system, Mexico, should be conducted to determine whether or not a native lineage of desert pupfish remains in that system. If discovered, the population would be the preferred source for downstream re-establishment in the San Pedro river system. Other priority sites should be determined after assessment of potential localities in Arizona, California, and Mexico.

To the extent practicable, efforts should be made to re-establish pupfish into a diversity of habitat types reflective of those occupied historically (e.g., spring, cienaga-marshland, stream, and river margin). Pupfish stocks within each region (Rio Sonoyta, Colorado River Delta, Salton Sea) should be distributed among habitat types, rather than concentrating stocks into a single habitat type.

More than 100 transfers of the Colorado River subspecies of desert pupfish have occurred in Arizona, California, Mexico, and elsewhere, and Quitobaquito pupfish has been stocked or transferred to nearly 30 other locales (Bagley et al. 1991, Brown and Abarca 1992, AGFD files). Although many stockings have failed, at least 30 non-aquarium populations of desert pupfish remain (including several of questionable purity, which must be destroyed). Of 20 populations whose failure was documented in 1989, 8 were due to habitat desiccation, 2 were destroyed by invading exotic fishes, 1 was renovated, and 9 failed for unknown reasons (AGFD files). Although desert pupfish are remarkably tolerant of harsh environmental conditions, there appear to be unknown habitat characteristics that negatively influence pupfish survival. Comparisons among and between habitats that failed for unknown reasons and those remaining could provide valuable information and guidance in selecting transplant sites with the highest probability for long-term success. Any such assessment must be accompanied by careful study of habitats occupied by natural desert pupfish populations. These data should provide a more complete understanding of specific criteria necessary for perpetuation of the species (see task 6, below).

This plan recognizes that an adequate number of unaltered, natural habitats suitable for re-establishment of desert pupfish populations may not exist. In such case, re-construction of suitable habitat meeting necessary criteria should be used to assure that the target number of populations are established.

TASK 3. ESTABLISH A REFUGIUM POPULATION OF QUITOBAQUITO PUPFISH

At least one secure population of the Quitobaquito form must be established in a refugium. This refugium should be located in the vicinity of the species natural range (i.e., Organ Pipe Cactus National Monument) to minimize potential for accidental or unintentional contamination of populations of other subspecies. The habitat must be spatially separated from Quitobaquito Spring such that any natural or human-induced catastrophe would be unlikely to impact both populations. Transplant stocks must be obtained directly from Quitobaquito Spring and comprised of not fewer than 500 fish with an approximate 1:1 sex ratio. As with transplant populations of the Colorado River form, this refugium population must be self-sustaining within a natural or quasi-natural habitat and capable of persistence without human intervention.

An evaluation of previous transplant success attempts should also be made to guide selection of the refugium site.

TASK 4. DEVELOP PROTOCOLS FOR EXCHANGE OF GENETIC MATERIAL AMONG DESERT PUPFISH POPULATIONS

Recent research has demonstrated that several refugium populations of desert pupfish differ little from their parental natural populations (Turner 1984), suggesting that transplanted populations can be a biologically valid component of management and conservation. However, other studies with captive populations of closely related species indicated there is loss of some rare alleles found in natural populations (Edds and Echelle 1989). This indicates that maintaining the genetic integrity of transplanted populations requires adherence to specific management recommendations (see also Echelle 1988 and 1991).

Initial studies by Turner (1983) compared samples from pupfish populations at six localities and detected allozyme differences among stocks from Salton Sea, Cienega de Santa Clara, and Quitobaquito Spring. The overall level of differentiation was low and in the range of within-population comparisons in other teleosts. These data must be expanded to include populations from Rio Sonoyta, additional localities on the lower Colorado River Delta, and individual populations in California and include analysis of mitochondrial DNA. Resultant information must be used to determine levels of differentiation among all known natural populations of desert pupfish and guide development of a protocol for exchange of genetic material among re-established populations. Applicable recommendations to establish such a protocol have been suggested (Echelle 1988 and 1991, Edds and Echelle 1989 and references therein).

Development of this protocol will involve using quantitative modelling techniques to determine the frequency and number of individuals to be exchanged between populations and to ensure that each desert pupfish stock maintains its genetic integrity. This integrity should be maintained so the populations' genetic diversity is allowed to follow a natural, independent evolutionary path. Some genetic changes may have already occurred in desert pupfish as a result of human induced or other factors.

TASK 5. MONITOR AND MAINTAIN NATURAL, RE-ESTABLISHED, AND REFUGIUM POPULATIONS

Two levels of population monitoring are necessary to assess population status, detect trends, and evaluate success of desert pupfish recovery. The first is twice-annual assessment of population and habitat condition, and the second is periodic (5-year interval) examination of population genetics. Monitoring schedules may be modified after populations have established and their security is assured.

Population monitoring should be conducted before spawning commences in spring and again in late summer-early autumn. All populations, natural, re-established, and refugium, must be examined. The spring sampling would provide an index of adult abundance after over-winter mortality, and the late summer-autumn sampling would allow assessment of reproductive success and probable recruitment. As practicable, all populations should be monitored within the same general timeframe so that seasonal effects on population dynamics do not confound interpretation of data. Qualitative estimates of adult numbers may be accomplished by either surface or underwater inspection. Where circumstances warrant (e.g., spatially large or complex habitats where competent visual estimates of population size are not possible) population estimates by quantitative methods such as mark-recapture may be necessary. Monitoring protocols should be standardized (e.g., methods, equipment, length of sampling, number of observers, etc.) within, and to the extent practicable, among sites.

Habitat assessments and population estimates should be conducted coincidentally, under site-specific protocols mutually established by the Service and other responsible management agencies. Methods must be sufficient to detect changes in habitat quality and the status of native and non-native fishes. Requisite data may vary among locales but will include location, technique, temperature, water depth, clarity, flow, surface area, diversity and abundance of aquatic vascular plants and algae, weather, and condition of banks, substrate, and riparian areas. Representative habitat conditions at each site should be photo-documented at fixed locations. Changes in habitat other than those reliably ascribed to seasonal variation must be assessed for potential impact to resident pupfish. Data acquired during routine monitoring will be integrated with studies to determine factors affecting persistence of desert pupfish populations (Task 6). All data collected during population and habitat monitoring will be submitted to a Service designated, central repository/clearing house for distribution and permanent archiving.

Genetic monitoring of populations should be accomplished at 5-year intervals using fish collected during population/habitat assessments. Screening of the appropriate number of diagnostic loci should be performed to determine the rate and nature of change in genetic composition, if any, and to provide additional modelling data as necessary. Samples of approximately 50 pupfish (25 males and 25 females) should be collected from each population, fully and accurately labeled, fresh-frozen, and stored in a supercold freezer until analyzed. Substantial short-term changes would not normally be expected to occur within natural populations, and lack of change can be interpreted as indication that populations are genetically stable. Where changes occur, their implications must be expediently and thoroughly assessed by qualified persons so that necessary adjustments to recovery protocols can be planned and implemented. It is anticipated that this recovery plan will undergo revision as new information becomes available.

TASK 6. DETERMINE FACTORS AFFECTING POPULATION PERSISTENCE

Many attempts to prevent the demise and to establish new desert pupfish populations have failed. Although factors such as habitat size and stability, water quality, minimum population size, and non-native species have been suggested as being important influences, there has been little attention given to quantifying causal relationships and designing programs to maintain populations and maximize population establishment success. Success rates may be improved by quantifying habitat and life history characteristics and applying basic principles of conservation biology. With this information, populations may be established and managed by incorporating a thorough understanding of population and genetic demographics and habitat requirements into consideration of requirements to secure populations. The research efforts described in this section are considered valuable adjuncts but secondary in implementation priority to recovery tasks 1-5 above. Information derived from this research is nonetheless expected to prove essential to desert pupfish recovery.

Life history and habitat preference information is required also to establish criteria for selecting refugia on merits of their ability to provide population security. An understanding of life history and habitat preference is required to determine the viability and status of native populations, to develop delisting criteria, and rehabilitate habitats so they may be better suited to desert pupfish than to non-natives.

6.1 Develop Habitat Criteria

The size of desert pupfish populations is influenced by habitat size and quality. Habitat preference and additional physico-chemical tolerance information is required to determine size and quality of habitat necessary to support secure populations, both in natural and re-establishment sites.

Habitat parameters that may be important include water depth, water quality and quantity, annual temperature regime, substrate, cover, aquatic vegetation, and current velocity. These studies need to examine requirements for reproduction, juvenile rearing, and feeding. Habitat preferenda of common non-native species occurring in desert pupfish habitats must also be determined. This may in the future make it possible to create habitat suitable for pupfish but poorly suited to occupation by introduced species. Being able to manage habitats in this manner should decrease the incidence of non-native species becoming established in desert pupfish habitats.

6.2 Determine Biological Criteria

The influences that habitat quality and biological factors have on population size and persistence are difficult to segregate because population viability is a function of interactions between abiotic and biotic factors. It is important that such factors be examined to identify tasks for quantification of minimum viable population size, description of a biologically secure population, and preparation of delisting criteria.

Control of non-native aquatic species is a primary requirement for recovery of the desert pupfish throughout its range. This control will be difficult because non-native species are widespread and persist in a wide variety of environments; they will be difficult to eliminate from desert pupfish habitats. Quantification of the effects of these species on desert pupfish will provide information that will assist in managing native and refugium habitats so the influence of these species on desert pupfish is minimized or eliminated.

In order to determine the effects of non-native species on desert pupfish, it is necessary to understand the life history and habitat requirements of all species in the assemblage. Once understood, it will be possible to determine areas of niche overlap and segregation and identify which non-native species impact desert pupfish. Integration of these data and knowledge of habitat preferenda for desert pupfish will permit implementation of management actions to enhance pupfish but discourage or eliminate non-native species.

6.3 Acquire Desert Pupfish Life History Information

Detailed life history information is required to determine characteristics of desert pupfish population dynamics. It is important that parameters such as the mean and variance of population increase, effective population size etc., required to develop life tables be determined. These studies must also evaluate the effects of demographic, genetic, environmental, and catastrophic events to determine the probability of extinction within, for example, the next century and millennium. This will permit quantification of requirements to maintain viable populations in small habitats that may be influenced by factors such as catastrophic events and introductions of non-native species.

TASK 7. INFORMATION AND EDUCATION

An information and education program is needed to inform the public, resource managers, and others of the desert pupfish and its plight. This program could include videotape and slide presentations, brochures and pamphlets, seminars, training sessions, and other information-exchange meetings; these should be available in both English and Spanish.

The purpose of education is two-fold. First, it provides an opportunity for the general public to become aware of and informed about, the pupfish and its plight, and about the ecosystem-level implications of species extinction. Strong support for rare species conservation can be derived from a knowledgeable public. For example, a multi-media campaign launched in behalf of the Devils Hole pupfish (Cyprinodon diabolis) not only benefitted this

imperiled species but also had profound influence on passage of the Endangered Species Act (Deacon and Williams 1991). A public constituency who understands and appreciates that perpetuation of endangered species requires protection of environments upon which the species depend for survival, and upon which people ultimately depend, is an invaluable ally for recovery.

Second, there are individuals within the resource management community who require training in endangered species conservation and in their legal obligations under the Endangered Species Act. These individuals may represent any level of several involved State or Federal agencies, plus the academic and private sectors. Needs of these individuals should be addressed through workshops, training seminars, and participation in public information and education programs.

Literature Cited

Arizona Game and Fish Department. 1988. Threatened native wildlife in Arizona. Arizona Game and Fish Department Publication. Phoenix. 32 pages.

Arnold, E.W.T. 1972. Behavioral ecology of two pupfish (Cyprinodontidae, Genus Cyprinodon) from Northern Mexico. Doctoral Dissertation, Arizona State University, Tempe.

Bagley, B.E., D.A. Hendrickson, F.J. Abarca, and S.D. Hart. 1991. Status of the Sonoran topminnow (Poeciliopsis occidentalis) and desert pupfish (Cyprinodon macularius) in Arizona. Arizona Game and Fish Department - A Special Report on Project E5-2, Job 9.

Baird, S.F. and C. Girard. 1853. Descriptions of new species of fishes collected by Mr. John H. Clark, on the U.S. and Mexican Boundary Survey, under Lt. Col. Jas. D. Graham. Proceedings of the Academy of Natural Sciences of Philadelphia 6: 387-390.

Barlow, G.W. 1958a. High salinity mortality of desert pupfish Cyprinodon macularius. Copeia 1958: 231-232.

Barlow, G.W. 1958b. Daily movements of desert pupfish, Cyprinodon macularius, in shore pools of the Salton Sea, California. Ecology 39:580-587.

Barlow, G.W. 1961. Social behavior of the desert pupfish, Cyprinodon macularius, in the field and in the aquarium. American Midland Naturalist 65: 330-359.

Black, G.F. 1980a. The current status and future management of the desert pupfish, Cyprinodon macularius, within California. Proceedings of the Desert Fishes Council XI: 47-48.

Black, G.F. 1980b. 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 80-81, Sacramento, California.

Blaxter, J.H.S. 1969. Development: Eggs and larvae. Pages 177-252 in W.S. Hoar and D.J. Randall (editors), Fish Physiology, Volume 3. Academic Press, New York.

Bolster, B.C. 1990. Five year status report for desert pupfish, Cyprinodon macularius macularius. California Department of Fish and Game, Inland Fisheries Division, Endangered Species Project, Rancho Cordova, California.

Brooks, G.R., Jr. 1964. An analysis of the food habits of the bullfrog, Rana catesbeiana, by body size, sex, month, and habitat. Virginia Journal of Science (new series) 15: 173-186.

Brown, M. and F.J. Abarca. 1992. An update status report of the Sonoran topminnow (Poeciliopsis occidentalis) and desert pupfish (Cyprinodon macularius eremus) in Arizona. 39 pages.

Bryan, K. 1925. The Papago country, Arizona. U.S. Geological Survey Water Supply Paper 499: 1-436.

California Department of Fish and Game. 1980. At the crossroads. A report on California's endangered and rare fish and wildlife. California Department of Fish and Game, Sacramento. 147 pages.

Centro Ecológico de Sonora. 1990. Plan de conservación del pupo del desierto (Cyprinodon macularius), en Sonora y Baja California, Mexico. Centro Ecológico de Sonora, Área de Ecología Acuática, Hermosillo.

Clarkson, R.W. and J.C. DeVos, Jr. 1986. The bullfrog, Rana catesbeiana Shaw, in the lower Colorado River, Arizona-California. Copeia (1986): 42-49.

Cohen, N.W. and W.E. Howard. 1958. Bullfrog food and growth at the San Joaquin Experimental Range, California. Copeia (1958): 223-225.

Cole, G.A. 1963. The American Southwest and Middle America. Pages 393-434 in D.G. Frey (editor), Limnology in North America. University of Wisconsin Press, Madison.

Cole, G.A. and M.C. Whiteside. 1965. An ecological reconnaissance of Quitobaquito Spring, Arizona. Journal of the Arizona Academy of Science 3: 159-163.

Coleman, G.A. 1929. A biological survey of the Salton Sea. California Fish and Game 15: 218-227.

Constanz, G.D. 1981. Life history patterns of desert fishes. Pages 237-290 in R.J. Naiman and D.L. Soltz (editors), Fishes in North American Deserts. John Wiley & Sons, Incorporated, New York.

Courtois, L.A. and S. Hino. 1979. Egg deposition of the desert pupfish, Cyprinodon macularius, in relation to several physical parameters. California Fish and Game 65: 100-105.

Cowles, R.B. 1934. Notes on the ecology and breeding habits of the desert minnow, Cyprinodon macularius Baird and Girard. Copeia 1934: 40-42.

Cox, T.J. 1966. A behavioral and ecological study of the desert pupfish (Cyprinodon macularius) in Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona. Dissertation, University of Arizona, Tucson.

Cox, T.J. 1972. The food habits of desert pupfish (Cyprinodon macularius) in the Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona. Journal of the Arizona-Nevada Academy of Science 7: 25-27.

Crear, D. and I. Haydock 1971. Laboratory rearing of desert pupfish, Cyprinodon macularius. Fishery Bulletin 69: 151-156.

Deacon, J.E. and W.L. Minckley. 1974. Desert fishes. Pages 385-488 in G.W. Brown, Jr (editor), Desert Biology, Volume II. Academic Press, New York.

Deacon, J.E. and C.D. Williams. 1991. Ash Meadows and the legacy of the Devils Hole pupfish. Pages 69-87 in W.L. Minckley and J.E. Deacon (editors). Battle against extinction: Native fish management in the American West. University of Arizona Press, Tucson.

Echelle, A.A. 1988. Review of genic diversity and conservation genetics in fishes of U.S. Fish and Wildlife Service Region II, with a suggested program of conservation genetics. Report, U.S. Fish and Wildlife Service, Albuquerque, New Mexico. Oklahoma State University, Stillwater.

Echelle, A.A. 1991. Conservation genetics and genic diversity in threatened fishes of western North America. Pages 141-153 in W.L. Minckley and J.E. Deacon (editors). Battle against extinction: Native fish management in the American West. University of Arizona Press, Tucson.

Echelle, A.A. and T.E. Dowling. 1992. Mitochondrial DNA variation and evolution of the Death Valley pupfishes (*CYPRINODON*, Cyprinodontidae). Evolution 46: 193-206.

Echelle, A.A. and A.F. Echelle. 1993. An allozyme perspective on mitochondrial DNA variation and evolution of the Death Valley pupfishes (Cyprinodontidae: Cyprinodon). Copeia 2:275-287.

Edds, D.R. and A.A. Echelle. 1989. Genetic comparisons of hatchery and natural stocks of small endangered fishes: Leon Springs pupfish, Comanche Springs pupfish, and Pecos gambusia. Transactions of the American Fisheries Society 118: 441-446.

Eigenmann, C.H. and R.S. Eigenmann. 1888. Cyprinodon californiensis Girard. Western American Science 5: 3-4.

Evermann, B.W. 1916. Fishes of the Salton Sea. Copeia 1916: 61-63.

Evermann, B.W. 1930. Report of the director of the museum and of the aquarium for the year 1929. In H.W. Clark (editor), Proceedings of the California Academy of Sciences, Vol. XVIII, No. 18, 542-586.

Fisher, S.G. 1989. Hydrologic and limnologic features of Quitobaquito pond and springs, Organ Pipe Cactus National Monument. University of Arizona Cooperative National Park Resources Studies Unit Technical Report Number 22 (Quitobaquito Science Series Number 8), Tucson, Arizona. 33 pages.

Fradkin, P.L. 1981. A River No More: the Colorado River and the West. University of Arizona Press, Tucson.

Frost, W.W. 1935. The food of Rana catesbeiana Shaw. Copeia (1935): 15-18.

Garman, S. 1895. The cyprinodonts. Memoirs of the Museum of Comparative Zoology 19: 1-179.

Gilbert, C.H. and N.B. Scofield. 1898. Notes on a collection of fishes from the Colorado Basin in Arizona. Proceedings of the U.S. National Museum 20: 487-499.

Girard, C. 1859. Ichthyological notices. XLI-LIX. Proceedings of the Academy of Natural Sciences of Philadelphia 11: 157-161.

Gutierrez-Galinado, E.A., G.F. Munoz, and A.A. Flores. 1988. Mercury in freshwater fish and clams from the Cerro Prieto geothermal field of Baja California, Mexico. Bulletin of Environmental Contamination and Toxicology 41: 201-207.

Hastings, J.R. and R.M. Turner. 1965. The changing mile: an ecological study of vegetation change with time in the lower mile of an arid and semiarid region. University of Tucson Press, Tucson. 317 pages.

Hendrickson, D.A. and W.L. Minckley. 1985. Cienegas -- vanishing climax communities of the American southwest. Desert Plants 6(1984): 131-175.

Hendrickson, D.A. and A. Varela-Romero. 1989. Conservation status of desert pupfish, Cyprinodon macularius, in Mexico and Arizona. Copeia 1989(2): 478-483.

Hubbs, C.L., W.I. Follett, and L.J. Dempster. 1979. List of the fishes of California. Occasional Papers of the California Academy of Sciences 133: 1-51.

Hubbs, C. and R.R. Miller. 1948. The zoological evidence: correlation between fish distribution and hydrographic history in the desert basins of western United States. Bulletin of the University of Utah 30: 17-166.

IUCN (International Union for the Conservation of Nature and Natural Resources). 1990. 1990 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland and Cambridge, U.K. 228 pages.

Jaeger, E.C. 1938. The California deserts. A visitor's handbook. Stanford University Press, Palo Alto, California.

Jennings, M.R. 1985. Behavioral interactions between desert pupfish (Cyprinodon macularius) and mosquitofish (Gambusia affinis) in systems open to egress. Dissertation, University of Arizona, Tucson. 53 pages.

Johnson, R.R., B.T. Brown, and S. Goldwasser. 1983. Avian use of Quitobaquito Springs oasis, Organ Pipe Cactus National Monument, Arizona. Cooperative National Park Service Research Studies Unit, Arizona. Technical Report 13: 1-16.

Jordan, D.S. 1924. A topminnow (Cyprinodon browni) from an artesian well in California. Proceedings of the Academy of Natural Sciences of Philadelphia 76: 23-24.

Jordan, D.S. and R.E. Richardson. 1907. Description of a new species of killifish, Lucania browni, from a hot spring in Lower California. Proceedings of the U.S. National Museum 4: 1-18.

Kinne, O. 1960. Growth, food intake, and food conversion in a euryplastic fish exposed to different temperatures and salinities. Physiological Zoology 33: 288-317.

Kinne, O. and E.M. Kinne. 1962a. Rates of development in embryos of a cyprinodont fish exposed to different temperature-salinity-oxygen combinations. Canadian Journal of Zoology 40: 231-253.

Kinne, O. and E.M. Kinne. 1962b. Effects of salinity and oxygen on developmental rates in a cyprinodont fish. Nature (London) 193: 1097-1098.

Kodric-Brown, A. 1981. Variable breeding systems in pupfishes (genus Cyprinodon): adaptations to changing environments. Pages 205-235 in R.J. Naiman and D.L. Soltz (editors), Fishes in North American Deserts. John Wiley & Sons, Incorporated, New York.

Kornfield, I.L. and E. Nevo. 1976. Likely pre-Suez occurrence of a Red Sea fish, Aphanius dispar, in the Mediterranean. Nature 264: 289-291.

Kynard, B.E. 1981. Study of Quitobaquito Pupfish - Systematics and preservation. Report, National Park Service, Organ Pipe Cactus National Monument, Arizona. University of Arizona, Tucson. 16 pages.

Kynard, B.E. and R. Garrett. 1979. Reproductive ecology of the Quitobaquito pupfish from Organ Pipe Cactus National Monument, Arizona. Pages 625-629 in R.M. Linn (editor), Proceedings of the First Conference on Scientific Research in National Parks. Transactions and Proceedings Series Number 5, Washington, DC.

Lacy, R.C. 1987. Loss of genetic diversity from managed populations: interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology 1: 143-158.

Loiselle, P.V. 1980. Spawn recognition by male Cyprinodon macularius californiensis. Proceedings of the Desert Fishes Council XI(1979): 46. (abstract).

Loiselle, P.V. 1982. Male spawning-partner preference in an arena-breeding teleost Cyprinodon macularius californiensis Girard (Atherinomorpha: Cyprinodontidae). The American Naturalist 120: 721-732.

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.

Lowe C.H. and W.G. Heath. 1969. Behavioral and physiological responses to temperature in the desert pupfish, Cyprinodon macularius. Physiological Zoology 42: 53-59.

Marsh, P.C. and W.L. Minckley. 1987. Aquatic resources of the Yuma Division, lower Colorado River. U.S. Bureau of Reclamation, Lower Colorado Region Contract Number 2-07-30-X0214. Arizona State University, Tempe. 300 pages.

Marsh, P.C. and W.L. Minckley. 1990. Management of endangered Sonoran topminnow at Bylas Springs, Arizona: description, critique, and recommendations. Great Basin Naturalist 50: 265-272.

Matsui, M. 1981. The effects of introduced teleost species on the social behavior of Cyprinodon macularius californiensis. Unpublished Thesis, Occidental College, Los Angeles, California. 61 pages.

May, L.A. 1976. Fauna de Vertebrados de la región del Gran Desierto, Sonora, Mexico. Ann. Inst. Biol. Universidad Nacional Autónoma de Mexico, Serie Zoologíe 47: 143-182.

McCoy, C.J. 1967. Diet of bullfrogs (Rana catesbeiana) in central Oklahoma farm ponds. Proceedings of the Oklahoma Academy of Science 48: 44-45.

McMahon, T.E. 1984. The role of emigration in the dynamics and regulation of populations of the desert pupfish (Cyprinodon macularius). Dissertation, University of Arizona, Tucson.

McMahon, T.E. and R.R. Miller. 1985. Status of the fishes of the Rio Sonoyta basin, Arizona and Mexico. Proceedings of the Desert Fishes Council XIV(1982): 237-245.

McMahon, T.E. and J.C. Tash. 1988. Experimental analysis of the roles of emigration in population regulation of desert pupfish. Ecology 69: 1871-1883.

Meffe, G.K. 1985. Predation and species replacement in American Southwestern stream fishes: a case study. Southwestern Naturalist 30: 173-187.

Miller, R.R. 1943. The status of Cyprinodon macularius and Cyprinodon nevadensis, two desert fishes of western North America. Occasional Papers of the Museum of Zoology, University of Michigan 473: 1-25.

Miller, R.R. 1961. Man and the changing fish fauna of the American southwest. Papers of the Michigan Academy of Science, Arts and Letters 46: 365-404.

Miller, R.R. 1968. Records of some native freshwater fishes transplanted into various waters of California, Baja California, and Nevada. California Fish and Game 54(3):170-179.

Miller, R.R. 1979. Freshwater fishes. Red Data Book, Volume 4. Pisces. Revised Edition. International Union for Conservation of Nature and Natural Resources. Morges, Switzerland, 1977.

Miller, R.R. 1981. Coevolution of deserts and pupfishes (genus Cyprinodon) in the American southwest. Pages 39-94 in R.J. Naiman and D.L. Soltz (editors), Fishes in North American Deserts. John Wiley & Sons, Incorporated, New York.

Miller, R.R., The University of Michigan. (Letter to Field Supervisor, Fish and Wildlife Service on the draft recovery plan for the desert pupfish) February 16, 1993.

Miller, R.R. and L.A. Fuiman. 1987. Description and conservation status of Cyprinodon macularius eremus, a new subspecies of pupfish from Organ Pipe Cactus National Monument, Arizona. Copeia 1987(3): 593-609.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department, Phoenix. 293 pages.

Minckley, W.L. 1979a. Aquatic habitats and fishes of the lower Colorado River, southwestern United States. U.S. Bureau of Reclamation, Lower Colorado Region, Contract Number 14-06-300-2529. Arizona State University, Tempe. 478 pages.

Minckley, W.L. 1979b. Resource inventory for the Gila River complex, eastern Arizona. U.S. Bureau of Land Management, Safford District Office, Contract Number YA-512-CT6-2166. Arizona State University, Tempe. 570 pages.

Minckley, W.L. 1980. Cyprinodon macularius Baird and Girard. Desert pupfish. Page 497 in D.S. Lee, C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. (editors). Atlas of North American freshwater fishes. North Carolina Museum of Natural History, Raleigh.

Minckley, W.L. 1985. Native fishes and natural aquatic habitats in U.S. Fish and Wildlife Service Region II west of the Continental Divide. Report, U.S. Fish and Wildlife Service, Albuquerque, New Mexico. Arizona State University, Tempe. 158 pages.

Minckley, W.L. 1987. Fishes and aquatic habitats of the upper San Pedro River system, Arizona and Sonora. Report, U.S. Bureau of Land Management, Denver, Colorado. Arizona State University, Tempe. 81 pages.

Minckley, W.L. and E.T. Arnold. 1969. "Pit digging," a behavioral feeding adaptation in pupfishes (Genus Cyprinodon). Journal of the Arizona Academy of Science 4: 254-257.

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

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley and Los Angeles. 405 pages.

Naiman, R.J. 1979. Preliminary food studies of Cyprinodon macularius and Cyprinodon nevadensis (Cyprinodontidae). Southwestern Naturalist 24: 538-541.

National Park Service. 1992. Annual summary of activities, Quitobaquito desert pupfish (Cyprinodon macularius eremus). Organ Pipe Cactus National Monument, Arizona. 10 pages.

Nichol, K., L. Sabrina, and C. Boehm. 1991. A distribution survey of desert pupfish (Cyprinodon macularius) around the Salton Sea, California. Prepared for California Department of Fish and Game, Inland Fisheries Division.

Rea, A. 1983. Once a River: Bird Life and Habitat Changes on the Middle Gila. University of Arizona Press, Tucson.

Ryman, N. and F. Utter (editors). 1987. Population Genetics & Fishery Management. University of Washington Press, Seattle.

Schoenherr, A.A. 1979. Niche separation within a population of freshwater fishes in an irrigation drain near the Salton Sea, California. Bulletin of the Southern California Academy of Science 78: 46-55.

Schoenherr, A.A. 1981. The role of competition in the replacement of native fishes by introduced species. Pages 173-203 in R.J. Naiman and D.L. Soltz (editors), Fishes in North American Deserts. John Wiley & Sons, Incorporated, New York.

Schoenherr, A.A. 1985. Replacement of Cyprinodon macularius by Tilapia zilli in an irrigation drain near the Salton Sea. Proceedings of the Desert Fishes Council XIII(1981): 65-66 (abstract).

Schoenherr, A.A. 1988. A review of the life history and status of the desert pupfish, Cyprinodon macularius. Bulletin of the Southern California Academy of Science 87: 104-134.

Schoenherr, A.A and C.R. Feldmeth. 1991. Thermal tolerances for relict populations of desert pupfish, Cyprinodon macularius. Proceedings of the Desert Fishes Council XXIII (1991):49-54 (abstract).

Secretaría de Desarrollo Urbano y Ecología. 1991. Acuerdo por el que se establecen los criterios ecológicos CT-CERN-001-91 que determinan las especies raras, amenazadas, en peligro de extinción o sujetas a protección especial y sus endemismos de la flora y la fauna terrestres y acuáticas en la Republica Mexicana. Gaceta Ecológica. 15:2-27.

Smith, H. Organ Pipe National Monument. (Memorandum to Field Supervisor, Fish and Wildlife Service) August 5, 1993.

Soulé, M.E. (editor). 1987. Viable Populations for Conservation. Cambridge University Press, New York. 189 pages.

Storrer, T.I. 1922. The eastern bullfrog in California. California Fish and Game 8: 219-224.

Sweet, J.G. and O. Kinne. 1964. The effects of various temperature-salinity combinations on the body form of newly hatched Cyprinodon macularius (Teleostei). Helgolaender Wissenschaftliche Meeresunter-suchungen 11: 49-69.

Templeton, A.R. 1990. The role of genetics in captive breeding and reintroduction for species conservation. Endangered Species Update 8(1): 14-18.

Thompson, W.F. 1920. Investigation of the Salton Sea. California Fish and Game 6: 83-84.

Thompson, W.F. and H.C. Bryant. 1920. The mullet fisheries of the Salton Sea. California Fish and Game 6: 60-63.

Turner, B.J. 1983. Genic variation and differentiation of remnant natural populations of the desert pupfish, Cyprinodon macularius. Evolution 37: 690-700.

Turner, B.J. 1984. Evolutionary genetics of artificial refugium populations of an endangered species, the desert pupfish. Copeia 1989: 364-369.

U.S. Fish and Wildlife Service. 1986. Endangered and threatened wildlife and plants; determination of endangered status and critical habitat for the desert pupfish. Federal Register 51: 10842-10851.

Walker, B.W. 1961. The ecology of the Salton Sea, California, in relation to the sportfishery. California Department of Fish and Game Fish Bulletin Number 113: 1-203.

Glossary of Terminology

CAPTIVE -- populations outside of historic range and/or in aquaria, pools, ponds or chambers, where water must be supplied to historically unwatered habitats.

CIENEGA -- mid-elevation (1,000-2,000 m) wetlands characterized by permanently saturated, highly organic, reducing soils, and a depauperate flora dominated by low sedges highly adapted to such soils (Hendrickson and Minckley 1985).

EJIDO -- communal farm.

LENTIC -- relating to still waters, as in ponds.

NATIVE -- a species within its historic range.

NATURAL -- relatively free of human or human-induced impact; in a condition approximating that which existed prior to manipulation by technologic humans.

NATURAL POPULATIONS -- those remaining populations occupying historic habitats and which were not known to have been placed in those habitats by humans.

NON-NATIVE (EXOTIC) -- species introduced outside their native range.

PANMIXIA -- random mating within a breeding population.

QUASI-NATURAL -- constructed or modified for the specific purpose of imitating a natural habitat.

RE-ESTABLISHED -- reintroduced populations, within historic range, where documentation of earlier presence at that specific site may not exist.

SECURE -- protected from human or human-induced impacts; further defined for desert pupfish as formal protection of habitat and water rights by methods such as land and water rights acquisition, legislation, or management agreement, and maintenance of a genetically pure viable population.

TELEOSTS -- any group of fishes with a bony rather than a cartilaginous skeleton.

VIABLE POPULATION -- capable of maintaining itself over the long term without human manipulation; in the case of desert pupfish, until additional information becomes available a viable population will include not fewer than 500 overwintering adults, or existing numbers, whichever is greater, in a normal sex ratio and with in-situ reproduction and recruitment sufficient to maintain that number.

III. IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000'S)					COMMENTS
				SERVICE		OTHER	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	
				REG.	PROG.							
1	1.1	Identify ownership of natural habitats	1	2*,1	ES,RE		1,1	0	0	0	0	
						AGFD	1	0	0	0	0	
						CADFG	1	0	0	0	0	
						CES	1	0	0	0	0	
						BLM	1	0	0	0	0	
1	1.2	Acquire natural habitats	15	2*,1	ES,RE,RW		1,2,2	1,2,2	1,2,2	1,2,2	0,1,1	
						AGFD	0	5	5	5	3	
						CADFG	5	5	5	5	0	Not including acquisition costs
						CES	+	+	+	+	+	
						BLM	5	10	5	5	5	
						~~TNC~~	~~0~~	~~0~~	~~5~~	0	0	
1	1.3	Secure natural populations and habitats	15	2*,1	ES,RW,LE		~~1,0,0~~	~~2,2,1~~	~~2,2,1~~	~~1~~	1	
						AGFD	~~1~~	~~5~~	~~5~~	~~5~~	5	
						CADFG	~~1~~	~~5~~	~~5~~	~~5~~	5	
						CES	~~+~~	~~+~~	~~+~~	~~+~~	+	
						BLM	~~1~~	~~5~~	~~5~~	~~0~~	5	
						NPS	~~1~~	~~5~~	~~0~~	~~5~~	0	
1	4.0	Genetic exchange protocol	5	2*,1	ES		10	10	10	10	10	
						AGFD	5	5	5	5	5	
						CADFG	5	5	5	5	5	
						CES	+	+	+	+	+	
1	5.0	Monitor and maintain populations	on-going	2*,1	ES		8	23	8	10	10	
						AGFD						
						CADFG	**	**	**	**	**	
						CES						
						BLM						
						NPS						
						FS						
2	2.0	Re-establish populations	15	2*,1	ES,FR		20	20	20	20	20	
						AGFD						
						CADFG	**	**	**	**	**	
						CES						
						BLM						
						TNC						
						NPS						
						FS						

* - Lead region
** - Due to undetermined ownership of potential re-establishment sites, costs cannot be assigned.
\+ - Due to economic differences and administrative re-configuration of respective Mexican agencies, we are unable to provide estimates for Mexico's responsibility.

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000'S)					COMMENTS
				SERVICE		OTHER	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	
				REG.	PROG.							
2	3.0	Establish Quitobaquito refugia	15	2*	ES		2	2	1	1	1	
						AGFD	2	2	1	1	1	
						NPS	6	6	3	3	3	
2	6.1	Develop habitat criteria	5	2*,1	ES		5	5	5	5	1	
						AGFD	0	4	4	4	0	
							0	4	4	4	0	
						CADFG	+	+	+	+	+	
						CES	0	4	4	4	0	
						BLM	0	1	2	2	0	
						FS						
2	6.2	Determine biological criteria	5	2*,1	ES		5	5	5	5	5	
						AGFD	5	5	5	5	5	
							5	5	5	5	5	
						CADFG	+	+	+	+	+	
						CES	5	5	5	5	5	
						BLM						
3	6.3	Acquire life history information	15	2*,1	ES		0	2	2	2	2	
						AGFD	2	5	5	5	5	
							2	5	5	5	5	
						CADFG	+	+	+	+	+	
						CES	2	5	5	5	5	
						BLM						
3	7.0	Information and education	on-going	2*,1	ES		0	0	1	1	1	
					PAO		2	1	1	1	1	
						AGFD	1	1	1	1	1	
							1	1	1	1	1	
						CADFG	+	+	+	+	+	
						CES	1	1	1	1	1	
						BLM	1	1	1	1	1	
						FS	1	1	1	1	1	
						NPS						
						TOTAL	122	184	161	154	126	747

* - Lead region
\+ - Due to economic differences and administrative re-configuration of respective Mexican agencies, we are unable to provide estimates for Mexico's responsibility.

Definitions and Acronyms

Priorities in column one of the following implementation schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. **Priority 2** - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

3. **Priority 3** - All other actions necessary to meet the recovery objective.

Key to Acronyms used in Implementation Schedule

AGFD - Arizona Game and Fish Department
BLM - Bureau of Land Management
CADFG - California Department of Fish and Game
CES - Centro Ecológico de Sonora
FS - Forest Service
NPS - National Park Service
TNC - The Nature Conservancy

FR - Fisheries Resources
ES - Ecological Services
LE - Law Enforcement
PAO - Public Affairs Office
RE - Realty
RW - Refuges and Wildlife

IV. APPENDIX

APPENDIX. Known transplantations of desert pupfish, Cyprindon macularius; arrangement by (1) subspecies, (2) recipient State (AZ, CA, Sonora, other), and (3) year. Distributions to museums, laboratories, and other destinations for specimen verification, curation, biochemical or genetic studies, etc., are included for completeness. Abbreviations as follows: Dexter NFH = U.S. Fish and Wildlife Service National Fish Hatchery, Dexter, New Mexico; ASU = Arizona State University, Tempe, Arizona; AGFD = Arizona Game and Fish Department; BLM = U.S. Bureau of Land Management; CADFG = California Department of Fish and Game; reintro = reintroduction within historic range in attempt to establish new populations, towards species recovery, or to repopulate following habitat renovation; intro = stocking outside of native range. (Information complied June 1991; updated with AGFD information June 1992 and CADFG 1993.)

Desert (lower Colorado River) pupfish, Cyprindon m. macularius

Origin	Destination	Purpose/ Date	status	Authority(ies)
		ARIZONA		
Mexico, Sonora, Santa Clara Slough	AZ, Maricopa Co, private pond,	1976	broodstock extant	Minckley & Brooks 1985
Santa Clara Slough	AZ, Maricopa Co, ASU pond, Tempe	1976	refugium extirpated	AGFD files
AZ, Maricopa Co, private pond, Tempe (W.L. Minckley)	AZ, Pinal Co, Boyce Thompson Arboretum pond	1977	broodstock extirpated	Minckley & Brooks 1985;
Boyce Thompson Arboretum pond	AZ, Maricopa Co, AGFD ponds, Phoenix	1977	broodstock extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, Hidden Water Spr	1977	reintro extirpated	Minckley & Brooks 1985; AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, "Pupfish" Spr	1977	broodstock extirpated	Minckley & Brooks 1985
Private aquarium	AZ, Maricopa Co, Little Hells Gate	1977	reintro extirpated	AGFD files
Mexico, Sonora Rio Sonoyta	AZ, Pima Co, Univ Arizona, Tucson	1977	research extirpated	Kynard 1981
Mexico, Sonora El Doctor	AZ, Pima Co, Univ Arizona, Tucson	1977	research extirpated	Kynard 1981
Mexico, Sonora Santa Clara Slough	AZ, Pima Co, Univ Arizona, Tucson	1977	research extirpated	Kynard 1981
Mexico, Baja "Pozo Caliente"	AZ, Pima Co, Univ Arizona, Tucson	1977	research extirpated	Kynard 1981

Boyce Thompson Arboretum pond	AZ, Pinal Co, Queen Creek	1978	reintro unknown	AGFD files
AZ, Maricopa Co, AGFD ponds, Phoenix	Boyce Thompson Arboretum pond	1979	broodstock extirpated	AGFD files
Boyce Thompson Arboretum pond	Boyce Thompson Arboretum pond	1980	broodstock extirpated	AGFD files
unknown	AZ, Yuma Co, Little White Tanks (Castle Dome Mtns)	1982	reintro unknown	AGFD files
Boyce Thompson Arboretum pond	AZ, Cochise Co, Boston Water Catchment	1982	extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Yavapai Co, Tres Alamos Falls Spr	1982	intro extirpated	Kepner, in litt.; AGFD files
Boyce Thompson Arboretum pond	AZ, Cochise Co, Boston Water Catchment	1982	reintro extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Cochise Co, Kino Spr	1982	reintro extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Yavapai Co, Peeples Canyon	1982	intro extirpated	Kepner, in litt.
Boyce Thompson Arboretum pond	AZ, Yavapai Co, Peeples Canyon Spr	1982	intro extirpated	Kepner, in litt., AGFD files
Boyce Thompson Arboretum pond	AZ, Pinal Co, Mesquite Spr	1983	reintro extirpated	Kepner, in litt., AGFD files
Boyce Thompson Arboretum pond	AZ, Graham Co, Howard Well tank	1983	reintro unknown	Kepner, in litt., AGFD 1992
Boyce Thompson Arboretum pond	AZ, Maricopa Co, Deer Valley HS pond, Glendale	1983	display extant	Kepner, in litt., Miller & Fuiman 1987 AGFD files
Boyce Thompson Arboretum pond	AZ, Graham Co, BLM aquarium, Safford	1983	display extirpated	AGFD files
Dexter NFH	ASU pond	1983	refugium extirpated	Service files, Miller & Fuiman 1987
Santa Clara Slough	Boyce Thompson Arboretum pond	1983	broodstock established	AGFD files

Santa Clara Slough	Dexter NFH	1983	broodstock established	Service files, Miller & Fuiman 1987
Dexter NFH	ASU pond	1984	broodstock extirpated	Service files
Dexter NFH	Boyce Thompson Arboretum pond via AGFD	1984	broodstock established	Service files
AZ, Maricopa Co, Deer Valley HS pond, Glendale	AZ, Yavapai Co, Peeples Valley	1985	intro extirpated	AGFD files
AZ, Maricopa Co, Deer Valley HS pond, Glendale	AZ, Maricopa Co, AZ Museum Sci & Tech aquarium, Phoenix	1985	display extirpated	AGFD files
AZ, Maricopa Co, Deer Valley HS pond, Glendale	Boyce Thompson Arboretum pond	1985	broodstock established	AGFD files
Dexter NFH	Boyce Thompson Arboretum pond	1985	broodstock established	Service files; Miller & Fuiman 1987 AGFD files
AZ, Maricopa Co, Deer Valley HS pond, Glendale	AZ, Pima Co, Flowing Wells JHS pond	1986	display extant	AGFD files
AZ, Maricopa Co, Deer Valley HS pond, Glendale	AZ, Pima Co, Flowing Wells JHS pond	1986	display extant	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, Phoenix Zoo pond	1986	display extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, Phoenix Zoo pond	1986	display extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, AGFD aquarium, Mesa	1987	display extant	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, Roper Lake State Park aquarium, Safford	1987	display extant	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, Roper Lake State Park lower HQ pond, Safford	1987	display extirpated	AGFD files
AZ, Maricopa Co, Deer Valley HS pond, Glendale	AZ, Navajo Co, private aquarium, Pinetop (R. Clarkson)	1987	display extant	AGFD files

Boyce Thompson Arboretum pond	AZ, Maricopa Co, private aquarium, Phoenix (M. Gilbert)	1987	display extant	AGFD files
AZ, Maricopa Co, Deer Valley HS Glendale	AZ, Maricopa Co, Deer Valley HS Glendale	1987	display extant	AGFD files
Dexter NFH	AZ, Maricopa Co, Desert Botanical Garden pond, Phoenix	1987	display extant	AGFD files
Dexter NFH	AZ, Mohave Co, BLM aquarium, Kingman	1987	display extirpated	Service files
AZ, Maricopa Co, private aquarium Phoenix (M. Gilbert)	AZ, Maricopa Co, AZ Museum Sci & Tech, Phoenix	1987	display extirpated	AGFD files
AZ, Graham Co, Howard Well	AZ, Graham Co, BLM aquarium, Safford	1988	display extirpated	AGFD files
Boyce Thompson Arboretum pond	ASU pond	1988	refugium extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, private pond, Tempe (W.L. Minckley)	1988	broodstock established	AGFD files
Dexter NFH	AZ, Mohave Co, BLM aquarium, Kingman	1988	display extirpated	AGFD files Service files
Dexter NFH	AZ, Cochise Co, Buffalo Corral pond Spring	1988	reintro extirpated	Service files AGFD files
Dexter NFH	AZ, La Paz Co, Yerba Manza (=Grapevine) Spr	1988	intro extirpated	AGFD files
Dexter NFH	AZ, Yavapai Co, Peeples Canyon	1988	display extirpated	Service files, Kepner, in Litt.
private aquarium	AZ, Maricopa Co, private aquarium, Phoenix (L. Kepner)	1988	display extant	AGFD files
unknown	AZ, Pima Co, Private aquarium, Tucson (D. Straub)	1989	display extirpated	AGFD files

AZ, Maricopa Co, AGFD, Phoenix	AZ, Maricopa Co, private aquarium, Phoenix (R. Van Haverbeke)	1989	display extant	AGFD files
Boyce Thompson Arboretum pond	AZ, Pima Co, Buehman Canyon	1989	reintro unknown	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, private aquarium, Phoenix (B. Bagley)	1989	display extirpated	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, private aquarium, Phoenix (M. Childs)	1989	display extant	AGFD files
Boyce Thompson Arboretum pond	AZ, Maricopa Co, private aquarium, Tempe (T. Velasco))	1989	display extirpated	AGFD files
AZ, Maricopa Co, private aquarium, Tempe (T. Velasco)	AZ, Maricopa Co, AGFD aquarium, Phoenix	1989	display extirpated	AGFD files
Dexter NFH	AZ, Maricopa Co, Hassayampa River Preserve aquarium	1989	display extant	Service files
Dexter NFH	AZ, Maricopa Co, Palm Lake HQ Headspring	1989	reintro established	Service files AGFD files
Dexter NFH	AZ, Maricopa Co, AZ Museum Sci & Tech aquarium, Phoenix	1989	display extant	AGFD files Service files
Dexter NFH	AZ, Maricopa Co, AGFD aquarium, Phoenix	1989	display extant	Service files
Dexter NFH	AZ, Maricopa Co, private pond, Glendale (R. Engle-Wilson)	1989	display extant	AGFD files
Dexter NFH	AZ, Graham Co, Roper Lake State Park HQ upper pond, Safford	1989	display extirpated	AGFD files
Dexter NFH	AZ, Pima Co, AZ Historical Society pond, Tucson	1989	display extant	Service files
Private aquarium	AZ, Maricopa Co, private aquarium, Tempe (K. Young)	1989	display extirpated	AGFD files

Private aquarium	AZ, Maricopa Co, private aquarium, Phoenix (R. Babb)	1990	display extirpated	AGFD files
Dexter NFH	AZ, Maricopa Co, private aquarium, Phoenix (R. Babb)	1990	display extant	AGFD files
Dexter NFH	AZ, Graham Co, Cold Springs	1990	reintro extant	AGFD files
Deer Valley HS	AZ, Maricopa Co, Grand Canyon University aquarium	1990	display extant	AGFD files
Flowing Wells Jr High School, Tucson	AZ, Graham Co, Cold Springs	1990	reintro extant	AGFD files
	CALIFORNIA			
Salton Sea	CA, Riverside Co, Dos Palmas	1939	intro extirpated?	Miller 1968
CA, Riverside Co Date Palm Beach Salton Sea	CA, Inyo Co, Little Lake, Owens Valley	1940	intro extirpated?	Miller 1968
Salton Sea	CA, San Diego Co, Palm Canyon, Anza-Borrego State Park	1970	refugium extirpated	Black 1980b, Miller & Fuiman 1987, Bolster 1990
Salton Sea	CA, San Diego Co, Palm Canyon, Anza-Borrego State Park	1972	refugium extirpated	Bolster 1990
CA, San Diego Co, Palm Canyon, Anza-Borrego State Park	CA, Riverside Co, Living Desert Reserve, Palm Desert	1972	refugium established	Black 1980b Miller & Fuiman 1987, Bolster 1990
Salton Sea	CA, Imperial Co, Arrowhead Spring	1975	refugium extirpated	Black 1980b, CADFG files
Salton Sea	CA, Riverside Co, Oasis Spring Ecological Reserve	1977	refugium established	Miller & Fuiman 1987, Bolster 1990
CA, San Diego Co, Palm Canyon, Anza-Borrego State Park	CA, San Diego Co, Palm Spring Pond Anza-Borrego Desert State Park	1978	refugium established	Black 1980b Bolster 1990
Salton Sea and Palm Canyon	CA, San Diego Co, Visitor Center, Anza-Borrego Desert State Park	1979	refugium established	Black 1990b, Bolster 1990

Salton Sea	CA, Riverside Co, Oasis Spring Ecological Reserve	1979	refugium established	Bolster 1990, CADFG files
San Felipe Creek	CA, San Diego Co, Palm Canyon Anza-Borrego Desert State Park	1981	refugium established	Bolster 1990, CADFG files
Palm Canyon	CA, San Diego Co, Palm Spring, Anza-Borrego Desert State Park	1981	refugium extant	Bolster 1990, CADFG files
Salt Creek	CA, San Diego Co, Hubbs Sea World	1981	research extirpated	CADFG files
Palm Canyon	CA, San Diego Co, Borrego Springs HS	1981	display extirpated	CADFG files
Salton Sea ? xxxx	CA, Butte Co, Butte County Mosquito Abatement District pond	1982	refugium extirpated	Miller & Fuiman 1987, Bolster 1990, CADFG files
Salton Sea	CA, Riverside Co, Salton sea State Recreation Area HQ	1982	refugium established	Bolster 1990, CADFG files
Butte Co, Mosquito Abatement District pond	CA, San Francisco Co, Steinhart Aquarium	1982	display unknown	CADFG files
Steinhart Aquarium	CA, Humbolt Co, Humbolt State University	1983	display unknown	CADFG files
San Felipe Creek via Palm Canyon	CA, Riverside Co, Living Desert, Palm Desert	1985	refugium established	Bolster 1990, CADFG files
Salt Creek	CA, Riverside Co, Simone/ McCallum Pond, Thousand Palms Oasis, Coachella Valley Preserve	1987	refugium established	Bolster 1990
San Felipe Creek	CA, Riverside Co, Living Desert, Palm Desert	1987	refugium established	Bolster 1990
Salt Creek	CA, Riverside Co, Visitor Center, Thousand Palms Oasis via	1989	refugium established	Bolster 1990

	Simone/McCallum Pond			
Salt Creek	CA, Riverside Co, Rancho Dos Palmas via Simone/ McCallum Pond	1990	refugium established	CADFG files
		SONORA		
Boyce Thompson Arboretum pond	Mexico, Sonora, Centro Ecologico de Sonora pond, Hermosillo	1986	display extirpated	AGFD files
Mexico, Sonora, Rio Sonoyta	Mexico, Sonora, Centro Ecologico de Sonora pond, Hermosillo	1986	refugium established	Hendrickson & Varela-Romero 1989; L. Juarez R., pers. comm.
Cienega de Santa Clara	Mexico, Sonora, Centro Ecologico de Sonora pond, Hermosillo	1986	refugium extirpated	Hendrickson & Varela-Romero 1989
		OTHER		
Boyce Thompson Arboretum pond	CO, Univ Colorado, Boulder	1986	research extirpated	AGFD files
Dexter NFH	MA, New England Aquarium, Boston	1988	display extant	Service files
Dexter NFH	NM, Eastern New Mexico State Univ, Portales	1983	research museum	Service files
Dexter NFH	NM, FWS aquarium Albuquerque	1988	display extant	Service files
Dexter NFH	OK, Oklahoma State Univ, Stillwater	1985	research extirpated	Service files

Quitobaquito pupfish, Cyprinodon macularius eremus

Origin	Destination	Date	Purpose/ status	Authority(ies)
		ARIZONA		
AZ, Pima Co, Quitobaquito Spr	AZ, Pima Co, Gachado Tank	ca 1940	intro extirpated	Kynard 1981
Quitobaquito Spr	AZ, Maricopa Co, Salt River	ca 1958	intro extirpated	Minckley & Brooks 1985
Quitobaquito Spr	AZ, Pima Co, Blanketship Ranch tank	1960	intro extirpated	AGFD files
Quitobaquito Spr	AZ, Pima Co, Arizona-Sonora Desert Museum, Tucson	ca 1964	display unknown	Kynard 1979
Quitobaquito Spr	Quitobaquito Spr	1970	reintro established	AGFD files
Quitobaquito Spr	Quitobaquito Spr	1970	reintro established	AGFD files
Quitobaquito Spr	AZ, Yavapai Co, AGFD Page Sprs Hatchery	1970	refugium extirpated	Minckley & Brooks 1985
Quitobaquito Spr	ASU pond	1970?	refugium extirpated	Minckley 1973, Miller & Fuiman 1987
Quitobaquito Spr	AZ, Pima Co, Bonita Well	60s-70s?	refugium extirpated	AGFD files
Quitobaquito Spr	AZ, Pima Co, Williams (Rincon) Spr	1960s	refugium extirpated	Minckley & Brooks 1985, Miller & Fuiman 1987
Quitobaquito Spr	AZ, Pima Co, Univ AZ, Tucson	1976	research extirpated	Kynard 1979, 1981
AZ, Pima Co, Univ Arizona, Tucson	AZ, Pima Co, Gachado Tank 1/	1976	refugium extirpated	Kynard 1979, 1981
AZ, Pima Co, Univ Arizona, Tucson	AZ, Santa Cruz Co, Bog Hole 1/	1977	intro established	Minckley & Brooks
Quitobaquito Spr	AZ, Pima Co, Univ AZ, Tucson	1977	research extirpated	Kynard 1981
AZ, Pima Co, Univ Arizona, others?	AZ, Pima Co, Arizona-Sonora Desert Museum, Tucson 1/	1978	display extirpated	Kynard 1979, Miller & Fuiman 1987
AZ, Pima Co, Univ Arizona, others?	AZ, Pima Co, Arizona-Sonora Desert Museum, Tucson 1/	1978	display extirpated	Kynard 1979, Miller & Fuiman 1987

AZ, Pima Co, Univ Arizona, Tucson	AZ, Pima Co, Arizona Historical Society pond, Tucson 1/	1978	display extirpated	Kynard 1979, AGFD files
AZ, Pima Co, Univ Arizona, Tucson	AZ, Pima Co, Finley Tank 1/	1978	refugium established	Kynard 1979, Minckley & Brooks 1985
Quitobaquito Spr	AZ, Pima Co, Bates Well	1978	refugium extirpated	Kynard 1979, Minckley & Brooks 1985, Miller & Fuiman 1987
Quitobaquito Spr	AZ, Pima Co, Arizona-Sonora Desert Museum	1981	display extant	AGFD files
AZ, Santa Cruz Co, Finley Tank	AZ, Cochise Co, Kino Spr 1/	1982	intro extirpated	AGFD files
AZ, Santa Cruz Co, Finley Tank	AZ, Cochise Co, Kino Spr 1/	1983	intro extirpated	AGFD files
AZ, Cochise Co, Kino Spr	AZ, Cochise Co, Buffalo Corral Pond Spring 1/	1984	intro extirpated	AGFD files
AZ Pima Co, Arizona-Sonora Desert Museum	AZ, Pima Co, Tohono Chul Park 1/	1987	display extant	AGFD files
AZ, Maricopa Co, AGFD aquarium, Phoenix	ASU Aquaria	1989	refugium extant	AGFD files
Quitobaquito Spr	AZ, Maricopa Co, AGFD aquarium, Phoenix	1989	display extirpated	AGFD files Service files
Quitobaquito Spr	AZ, Yavapai Co, AGFD Bubbling Pond Hatchery	1989	refugium extirpated	Service files
		OTHER		
Quitobaquito Spr	CO, Univ Colorado, Boulder	1989	research extirpated	AGFD files
Quitobaquito Spr	VA, Univ Virginia, Roanoke	1980	research unknown	AGFD files

1/ Quitobaquito pupfish held and distributed by University of Arizona may have become mixed with other Cyprinodon subspecies or species; stocks distributed to the Arizona Historical Museum and stocked into Bog Hole and Finley Tank (both outside the historical range of Quitobaquito pupfish) and other locations are thus of questionable genetic purity (Hendrickson and Varela-Romero 1989) and should be destroyed and replaced with appropriate stock.

V. ATTACHMENT

DESERT PUPFISH RECOVERY PLAN
COMMENT RESPONSES

Two separate sets of comments were evaluated on the desert pupfish recovery plan. On December 17, 1991, technical review was solicited from biologists and individuals with expertise in the biology, habitat, and management of desert pupfish. Technical review drafts were sent to 29 individuals. A total of 7 letters of comments were received.

On January 29, 1993, a Federal Register notice was published announcing the availability of the draft recovery plan for public comment. In addition, public notices were published in the Arizona Daily Star (Tucson, Arizona) on February 11, 1993, Imperial Valley Press (El Centro, California) on February 12, 1993, and Yuma Daily Sun (Yuma, Arizona), on February 12, 1993. Copies of the draft plan were direct mailed to 105 parties. Copies of the draft plan were sent to 23 additional parties upon request. The public comment period closed on March 30, 1993. A total of 18 letters were received during the public review process.

The responses from both groups were treated the same; comments were evaluated in three ways: 1) editorial comments, corrections of factual errors, etc., which were incorporated directly into the text; 2) comments concerning the recovery plan context which required a written response (although similar comments were grouped together and only answered once); and 3) comments which were beyond the scope of this document which could not be readily incorporated. All letters of comment follow.

LETTERS RECEIVED ON THE TECHNICAL DRAFT

RESPONSES TO LETTERS RECEIVED ON THE TECHNICAL DRAFT

Al Bammann, Bureau of Land Management
Letter dated January 2, 1992
Many of the comments were incorporated as suggested. Below are the Service's response to some of the more detailed questions or comments in the letter or written in the margins of an attached marked-up copy.

Cover letter comment, Page 1, second paragraph Executive Summary comments about protecting aquatic habitats are not realistic.
Response The Service recognizes the difficulties in protecting and recovering a species which is threatened by such a diverse array of serious problems. We understand that natural catastrophic events may cause losses of desert pupfish individuals and populations. However, we believe that we can, through management, curtail human caused losses of desert pupfish and improve its status to the point at which the species once again has the natural resilience to withstand natural catastrophic events. We do not believe that the desert pupfish has reached the point at which extinction is inevitable and management useless.

Cover letter comment, Page 1, second paragraph, first sentence The concept of "species historic range" is not useful with pupfish since we do not have complete species records.
Response Gaps in information exist in most species historic range. This recovery plan does not restrict the historical range of desert pupfish to only those sites with documented records of the species. The plan's description of the historical range is based on the probability that pupfish were present in a given area based on the actual records together with habitat factors, connecting waterways, and other elements.

Comment in cover letter "...the insistence of maintaining the species within the historic range is a bad idea... climate has always been changing and the rate of change may be increasing due to human activity."
Response Service policy precludes the introduction of listed species into areas outside of historical range. This policy is in keeping with predominant biological thought, which recognizes the ecological problems that often arise from introduction of non-native species into the habitat of native species. The potential for global climatic change to render all or most of the desert pupfish historic unsuitable for the species is beyond the scope of this plan.

Cover letter comment, Page 1, end of second paragraph Genetic exchange between populations may be problematic. It would be wise to carefully consider the impact of moving individuals from one set of environmental conditions into a different area.
Response One of the recovery goals is to establish a protocol for exchange of genetic material among re-established populations to ensure maintenance of natural levels of allelic genetic diversity. The present, highly fragmented nature of the desert pupfish populations prevents natural genetic interchange. The existing information on the species does not support a hypothesis that desert pupfish populations naturally are totally genetically isolated.

Cover letter comment, Page 1, last sentence and on to next page
Management within these environmental conditions will result in continual loss of populations.
Response This plan recognizes that populations of desert pupfish may historically have undergone considerable flux. The tiered approach adopted by this plan is an attempt to allow management to mimic the natural fluctuations within the constraints imposed by the diminished quantity and quality of habitat.

Cover letter comment, Page 2, first full paragraph Disagrees with the practical aspect of overlapping designations and protective layers. Will FWS

need to establish a special administrative designation on a refuge acquired for a T/E species or is ESA sufficient?
Response The Service believes that designation of Areas of Critical Environmental Concern or other special use designation provides additional protection for desert pupfish habitats through identification of appropriate uses of the area and restriction of competing land uses. National Wildlife Refuges are by definition special use designations. However, additional planning regulations or special use designations may be appropriate to identify and restrict adverse land uses on refuges, particularly on those refuges not originally acquired for endangered species purposes.

Cover letter comment, page 2, second full paragraph
Expressed concern over site specific management plan. The Draft Plan should be modified to require a management plan for each site prior to reintroduction.
Response The development of management plans are under the authority of the specific land managers. The finalization of a recovery plan for the desert pupfish should enable agencies to identify goals and recovery tasks required which could be incorporated in management plans.

Cover letter comment, page 2, third full paragraph
The failure of this Region to utilize the Experimental-Nonessential provisions of the ESA will make it difficult for multiple-use land management agencies to take part in the recovery of desert pupfish...
Response The Service has the authority to designated populations to be nonessential "experimental" in accordance with Section 10(j) of the Endangered Species Act. During the 1980's a program to utilize this authority for the desert pupfish was investigated, in conjunction with the Bureau of Land Management, Arizona Game and Fish Department (AGFD), and other entities. However, in the end, the Service decided to put on hold any designation of populations of desert pupfish as nonessential experimental. Because of the precarious status of the species, we believe that current recovery efforts should be focused on the establishment and maintenance of viable self-sustaining populations in critical recovery areas that are fully protected. Current recovery goals focus on establishing replicates of remaining, naturally occurring stocks. In the future improving population trends may require re-evaluation of how nonessential experimental populations fit into the overall conservation program for the desert pupfish.

Comments written in the margin , Page 1 Why is Salton Sea - a lake resulting from a broken canal and supported by agricultural runoff- considered a natural site? Seems artificial to me.
Response The Salton Sea and the Laguna Salada are endorheic basins of the lower Colorado River that undergo periodic filling during high water events. These periods of surface water alternate with periods of complete loss of ponded water. Desert pupfish are found within, and considered to be naturally occurring inhabitants of both basins. The Salton Sea has, within the last 100 years, been unnaturally filled and maintained by human activities. This fact does not negate the natural occurrence of the desert pupfish in the sea itself and the streams and springs tributary to the sea.

Comment written on Page 8, see reference on Page 9 Does the El Doctor population include the Lucania browni from the hot spring in N. E. Baja?
Response Lucania browni is now a synonym of Cyprinodon macularius macularius. The population described from northeastern Baja California was located on the eastern edge of the Laguna Salada not at El Doctor, which is on the east side of the Colorado Delta in Sonora, Mexico.

Comment written on Page 14, see reference on Page 15
Since longfin dace and pupfish have been isolated at Quitobaquito, why has only pupfish subspeciated? Why is it only one of the two species we are trying to maintain? Is it the number of populations of dace that makes it

secure, not the security of any population?
Response Taxonomic experts on desert pupfish agree that the Quitobaquito population is a distinct subspecies. No longfin dace currently occur at Quitobaquito Spring; therefore, questions regarding taxonomy of longfin dace which may or may not have occurred there are unanswerable.

Comment written on margin Page 28, see reference Page 30 Bullfrog control may have to be conducted annually.
Response Many management activities may need to be modified on a case by case basis.

Comment written on Page 29, see reference Page 31 Absolutely unrealistic to expect populations to exist in perpetuity without human intervention due to environmental changes and natural catastrophe.
Response The Service recognizes that human disturbance and habitat modification has had significant influence on threatened and endangered species and ecosystems. For the purposes of this document, preference will be given to those populations in habitats which are most likely to persist in perpetuity without human intervention.

Comment written on Page 30, see reference Page 31 Should consult with genetics experts on the plan's recommendations for genetic exchange between tier 1, 2 and 3 populations. The recommended one-way gene flows may result in problems.
Response Genetic experts have been and will continue to be consulted. Genetic exchange was limited to one direction to avoid accidental and irreversible contamination of natural populations with genetic material from other natural populations.

Comment written on Page 40, see reference Page 43 Suggested that control of some native species such as cattails may be needed, in addition to the non-native aquatic species.
Response Control of cattails is an issue of desert pupfish habitat management, but at this time it is not a "primary requirement for recovery of the desert pupfish throughout its range."

Glenn Black, California Department of Fish and Game
Letter dated January 27, 1992
Most of suggestions incorporated as suggested. Some discussion is addressed below.

Page 1, second paragraph Information provided in the 1981 thesis by M. Matsui has been added to the document.

Page 1, third paragraph Document modified to include Evermann 1930 and delete Evermann 1916.

Page 2, first full paragraph Suggests that only San Felipe Creek be considered tier 1, with San Sebastian Marsh being considered as part of the San Felipe Creek population.
Response Language modified to indicate that San Felipe Creek and San Sebastian Marsh are actually one site.

Page 2, second full paragraph Recommends that tier 2 and 3 populations be established in a phased manner that allows for essential genetic, life history and habitat preference/requirement information to be acquired for representative populations prior to establishing all of the recommenced number of populations. Suggests that within a ten year period, only one-third of the populations be established.
Response A very good suggestion, the task duration listed in the Implementation Schedule are estimates.

Brian Bagley, Flagstaff, Arizona
Letter dated February 8, 1992
General Comment Recommends that the Appendix be updated since the information is over two years old. Recent stockings and site failures should be assessed.
Response Appendix has been modified with information provided by AGFD.

Thomas Dowling, Arizona State University, Depart. of Zoology, Tempe, Arizona
Letter dated February 9, 1992
General comments, most of which did not require a response.
Comment Concern over sample size for genetic monitoring.
Response Between the technical draft and the final the sample size has been increased from 20 (10 males and 10 females) to 50 pupfish (25 males and 25 females).

Harold Smith, National Park Service, Organ Pipe Cactus National Monument (ORPI), Ajo, Arizona
Memorandum dated February 10, 1992
Question #1 How can we prevent introduction of exotics at Quitobaquito?
Response The problem of controlling introduction of exotic species at Quitobaquito Spring has numerous elements unusual to that site. The recovery plan recommendations are not tailored to specific sites and many of the measures recommended are not feasible at Quitobaquito Spring. Recommendations specific to Quitobaquito Spring will need to be sought through site specific management planning.

Question #2 Could longfin dace (Agosia chrysogaster) be compatible with pupfish at Quitobaquito?
Response Longfin dace have historically occurred with the Rio Sonoyta form of pupfish. However, no historic records from Quitobaquito Spring exist. Compatibility between longfin dace and Quitobaquito pupfish would require further investigation.

Question #3 Is it desirable or necessary to do twice annual monitoring at Quitobaquito?
Response Close monitoring is needed because replicate populations of Quitobaquito Spring stock do not exist. The two sampling periods would serve two separate functions. The spring sampling would provide an index of adult abundance after over-winter mortality, and the late summer-autumn sampling would allow assessment of reproductive success and probable recruitment. Twice yearly monitoring is very desirable; however, sampling once per year is more desirable than no sampling at all.

Question #4 Would interpretive signs or displays, in both Spanish and English, be helpful? Death Valley National Monument has a small aquarium in the Visitor Center as part of their display.
Response Interpretive signs or displays at Quitobaquito Spring would certainly be helpful. Because of its location on the U.S./Mexico border, it would be desirable for those displays to be in both Spanish and English. The expertise of the National Park Service, who accommodates millions of visitors a year is important in formulating any such displays. The pupfish on display at Death Valley National Monument are most likely one of the species native to that area and not Cyprinodon macularius. Take of an endangered species for display or educational purposes is not allowed under the Endangered Species Act. However, aquarium populations of C. m. eremus may be valuable as short term refugia populations.

Question #5 Why do genetically impure stocks have to be destroyed? Can they not be used in displays?
Response Extant wild populations of desert pupfish represent the original genetic stock of the species and are, therefore, irreplaceable. The protection of these individuals is critical to the continued existence of this species. Populations which are of questionable genetic purity, can never be guaranteed as isolated and may, therefore, threaten recovery of other populations.

Question #6 Where would a refugium at ORPI be located and what kind of maintenance would be required?
Response The specifics for establishment of a refugium population of Quitobaquito pupfish are not yet determined. Close coordination with the ORPI Resource Management staff and other Federal and State entities will be required.

Question #7 How can we protect the springs at Quitobaquito from the effects of groundwater pumping in Mexico?
Response As with the question of exclusion of non-native species, protective management must be tailored to fit the unique circumstances at Quitobaquito Spring. Amelioration of the adverse effects of groundwater pumping in Mexico is a very difficult problem that will require the close cooperation of several U.S. and Mexican agencies.

Question #8 Are Rio Sonoyta habitats affected by the discharge of pollutants in the town of Sonoyta?
Response The Service has no information on the affects of discharge of pollutants in the town of Sonoyta. Threat to desert pupfish in Rio Sonoyta area include dewatering, exotic fishes, and habitat alterations. Pesticide contamination may also be a problem.

Question #9 How would we monitor more intensively the habitat at Quitobaquito? Is photo monitoring necessary?
Response The existing monitoring program of the Organ Pipe Cactus National Monument (ORPI) may be sufficiently intensive. Photo monitoring is an expensive but highly productive habitat monitoring technique. The Service welcomes the opportunity to coordinate with ORPI to identify any possible ways to improve the existing monitoring system.

Francisco Abarca, AGFD, Phoenix, Arizona
Letter dated February 18, 1992
Most of the comments were editorial and included as suggested. The update on the status of some of the transplanted populations of desert pupfish was also very useful.

Comment The AGFD role as the contracting agency for this plan should be acknowledged.
Response The Service appreciates AGFD assistance in preparation of this plan and has acknowledged this on the title page.

LETTERS RECEIVED ON THE PUBLIC DRAFT

RESPONSES TO LETTERS RECEIVED ON THE PUBLIC DRAFT

Mark Jorgensen, State of California, Department of Parks and Recreation - Anza Borrego Desert State Park, Borrego Springs, California
Letter dated February 7, 1993
General letter No specific comments, no response needed.

Robert Rush Miller, The University of Michigan, Ann Arbor, Michigan
Letter dated February 16, 1993

Most of the comments were editorial and were incorporated as suggested.

Additional Comment Important addition of a record of Cyprinodon macularius from Puerto Penasco, Sonora, Mexico, on the Gulf of California, collected by E.W. Kirschbaum in 1960.
Response Map and text have been modified to include this record.

Harold Smith, National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona
Memorandum dated February 27, 1993
Comment #1 Organ Pipe Cactus National Monument is in Pima County, not Santa Cruz County.
Response Document corrected.

Comment #2 Requested additional details on the establishment of a refugium population of the Quitobaquito pupfish.
Response Establishing a site is a recovery objective; identification of the site is a means by which the task is accomplished. The specifics for establishment of a refugium population of Quitobaquito pupfish will be determined as part of recovery plan implementation. Close coordination with the ORPI Resource Management staff and other Federal and State entities will be vital to this effort. The refugium population of Quitobaquito pupfish established at AGFD Bubbling Ponds/Page Springs Hatchery no longer exists. It was discontinued due to hatchery renovation.

June Mire, American Fisheries Society, California-Nevada Chapter, Berkeley, California
Letter dated March 13, 1993
Most of the recommendations were general or grammatical and were incorporated as suggested. Some of the comments are discussed below.

Page 1, second paragraph The Recovery Plan does not address possible variation in reproductive season among populations.
Response The recovery plan does discuss the extended breeding season (early spring into winter whenever water temperature exceeds about 20°C). Growth rates also vary depending on temperature. In addition, more information on life history of the species should be gathered during the monitoring program.

Page 1, third paragraph How many individuals constitute a population?
Response Any number of desert pupfish in a geographically segregated area constitute a population for the purposes of this plan. Until additional information becomes available, a viable population is considered not fewer than 500 overwintering adults in a normal sex ratio with in-situ reproduction and recruitment sufficient to maintain that number.

Page 1, fourth paragraph The term "ethologists" should be used in place of

"behaviorists."
Response The Service prefers to use the term "behaviorists" for its commonly understood meaning. A large portion of the users of this plan are not academics or biologists and may not understand the term "ethologists." The difference between the two terms is at a level that we believe is not important to the meaning here.

Page 1, last paragraph The discussion of allozyme variation is too vague and the relevance of the comparison of mean heterozygosity values of C. macularius and Aphanius to management decisions is unclear.
Response This portion of the recovery plan is a summary of known information about the species. Some of the information may not have direct relevance to management decisions except as an increased understanding of the species. The summary information is purposefully brief. For further information on the allozyme information provided, we refer you to the literature cited in the plan.

Page 2, first paragraph The recommendation that several populations of questionable genetic purity should be destroyed is buried (in the document). It belongs in a later section on recommendations.
Response We did not intend to hide the comment that populations of questionable genetic purity should be destroyed. We agree that management recommendations, such as this, should be placed in the "Narrative Outline" containing recommendations for management and have made appropriate changes to the plan.

Page 2, second paragraph The mixture of past and present tense in this paragraph is a little awkward. I think the discussion of habitats should be clearly delineated between past and present, with reference to the historical time frame denoted by the past tense.
Response We believe the time frame of the discussion of habitat requirements of the desert pupfish is clear.

Page 2, third paragraph The reference to consort pairs given as Barlow (1961) is incorrect. Consort pairs were described in Kodric-Brown (1981).
Response Correction has been incorporated.

Page 2, fourth paragraph The term "incubation" which implies modulation of temperature, is not accurate for pupfish. Their eggs merely develop without incubation.
Response The term incubation does not necessarily imply modulation of temperature.

Page 2, last paragraph Is the source of mercury known?
Response According to the report by Gutierrez-Galinado, Munoz, and Flores (1988) referenced in the recovery plan, the Cerro Prieto geothermal field is the major source of mercury. However, some clams collected "far way" from Cerro Prieto had even higher levels of mercury than the fish samples within the geothermal field.

Allen Schoenherr, Fullerton College, Fullerton, California
Letter dated March 19, 1993
A few general comments were included in the margins of a marked-up copy of the draft recovery plan. Many comments incorporated as suggested.

General Comment Request for more specifics on protecting the California populations.
Response The recovery plan sets up a framework for formulation of more specific management measures at individual desert pupfish populations. We believe the recovery plan recognizes the precarious status of the California natural populations of desert pupfish and provides general measures for their

protection and recovery. We look forward to working with Dr. Schoenherr to develop site specific management for these populations.

General Comment Dr. Schoenherr provided information on a proposal that would transport trash by train from Los Angeles to a former open pit mine in Riverside County, California. The Salt Creek population occurs a few hundred meters downstream from a railroad crossing.
Response The Service issued a biological opinion (opinion) on September 10, 1992 to the Bureau of Land Management regarding the effects of the proposed Eagle Mountain Landfill Project on the desert tortoise and desert pupfish. The Bureau of Land Management manages the land on which the landfill would occur. The opinion, which concludes formal consultation under section 7 of the Endangered Species Act, found that the proposed project would not jeopardize the survival of either species. The potential for toxic spills off the railway trestle into desert pupfish habitat was evaluated. Reasonable and prudent measures and their implementing terms and conditions to minimize take of desert pupfish as a result of the proposed project included a contingency plan in the event of train derailment or fuel spill, inspection of fuel and lubricant tanks prior to passage over the Salt Creek trestle, enhancement of trestle structure to contain spills, education of landfill associated employees regarding desert pupfish protection, use of a qualified biologist during maintenance and emergency activities, mitigation measures for trestle or railway maintenance activities, prohibition of maintenance or repair activities during the fall when pupfish are most vulnerable, restrictions on location of storage and staging areas, incorporation of desert pupfish habitat restoration measures into emergency response plans, and restocking the desert pupfish population in case of loss.

Michael Wargo, Coachella Valley Mosquito Abatement District, Thermal, California
Letter dated March 25, 1993
Comment General discussion on the feasibility of using desert pupfish for mosquito, midge, and other insect control in the golf course and country club lakes and ponds in the Coachella Valley and other areas of the Southwest.
Response Pupfish do not fare well in the presence of non-native fishes, including mosquitofish which the Coachella District currently uses for mosquito control. Non-native fishes (e.g., adult mosquitofish) that occupy shallow habitats also used by pupfish have proven most destructive, typically resulting in the decline or extirpation of the pupfish. Immediate recovery goals in this recovery plan include securing genetically pure, self-sustaining, stable populations of desert pupfish. Mosquito control may potentially be accomplished while fulfilling that goal but is of secondary importance.

The actual three tier sites are not yet established and certainly could include some areas managed by the Coachella Valley Mosquito Abatement District. The elimination of mosquitofish and other non-native fishes would be a minimum requirement for consideration of pupfish introduction. In addition, habitat parameters that may be important include water depth, water quality and quantity, annual temperature regime, substrate, cover, aquatic vegetation, and current velocity.

Marcia Radke, Fish and Wildlife Service, Salton Sea National Wildlife Refuge, Calipatria, California
Letter dated March 13, 1993
Page 1, second paragraph The recovery plan should undergo editing to include pupfish occurrence within 72% of the surveyed drains around the Salton Sea (reference in a 1991 report by the California Department of Fish and Game).

Response The document "A Distribution Survey of Desert Pupfish Around the Salton Sea, California" by California Fish and Game is useful to the Service for monitoring trends in the species in that area. The document has been modified to acknowledge the presence of desert pupfish in the irrigation drains.

Page 1, third paragraph Discussion on the idea of utilizing pupfish for the biological control for mosquitos.
Response See response to letter from Coachella Mosquito District.

Page 1, paragraphs four though seven, and Page 2 paragraphs one and four Acknowledge non-natural areas e.g. irrigation drains.
Response The document was modified to acknowledge irrigation drains in several places.

Page 2, first paragraph Include a discussion of triploid diploid grass carp used for aquatic weed control within drains by the Imperial Irrigation District.
Response Grass carp (Ctenopharyngodon idella) are used in some irrigation district drains in the Salton Sea basin for aquatic weed control and may adversely affect desert pupfish habitats.

Page 2, paragraph 2 Include more discussion on contaminant issues facing the Salton Sea area under threats facing pupfish recovery.
Response Information on contaminant issues affecting the pupfish around the Salton Sea is limited. Additional information should be gathered under the monitoring program.

Page 2, paragraph 3 Plans for pupfish habitat should also ensure adequate water quality.
Response Under task number one in the recovery plan, subsection 1.3 is titled "Secure Natural Populations and Their Habitats". This calls for promulgation of regulations which will provide sufficient long-term protection and management (e.g., specific designation as Areas of Critical Environmental Concern, Research Natural Areas, etc.), assurance of water of sufficient quantity and quality, protection against habitat degradation, control or removal of deleterious non-native animals and modification of land management practices deleteriously affecting aquatic habitats.

Duane Shroufe, AGFD, Phoenix, Arizona
Letter dated March 23, 1993
Most of the comments were incorporated as suggested. Some comments discussed below.
Comment 1 Document modified to clarify the number of subspecies and expand on recovery objectives.

Comment 2 Document modified to state that the desert pupfish is listed as endangered in Mexico.

Comment 3 Document modified to add Bagley et al. 1991, and Brown and Abarca 1992 as citations.

Comment 4 Document modified to indicate that the transplant was from Dexter National Fish Hatchery but originated from Cienega de Santa Clara.

Comment 5 Document modified to indicate that least eight Colorado River form desert pupfish populations are known to exist as of March 1993 and five are unknown. Information is not available for California and Mexico.

Comment 6 Since 1992, SEDUE has been called SEDESOL.
Response Document has been corrected.

Comment 7 The Recovery Plan addresses the need for the re-establishment of pupfish in a diversity of habitat types reflective of historical sites. Locations of the stocks have not yet been determined.

Comment 8 Addition reads: "Continued cooperation with Mexico should allow future acquisition of desert pupfish broodstock. Addition of individuals from existing natural populations (Cienega de Santa Clara, El Doctor) will alleviate problems associated with in- and outbreeding depression which may occur in refugia populations."

Comment 9 Document modified to add Bagley et al. 1991 and Brown and Abarca 1992 as citations.

Comment 10 The Recovery Plan acknowledges that water quality may be an important habitat criteria about which more information is needed. The Yuma desalinization plant is not specifically mentioned because its future is not certain at this time.

Comment 11 Arizona Game and Fish Department is abbreviated AGFD.

Comment 12 Population status information updated to reflect information from AGFD.

Comment 13 The Brown and Abarca (1992) report states on page 12 that "In 1990, desert pupfish at Bog Hole (site #130) were not found. The site was revisited in 1991 and again failed to yield any pupfish. Despite these results, we still believe there may be pupfish present at Bog Hole." The Service does not have sufficient evidence to indicate that the desert pupfish at Bog Hole are possibly extinct.

Paul C. Marsh, Arizona State University, Center for Environmental Studies, Tempe, Arizona
Letter dated March 24, 1993
Most of the comments were editorial and were incorporated as suggested. Some comments discussed below.

Page 1, second paragraph Document corrected as suggested.

Page 1, third paragraph Document modified as suggested.

Page 1, fourth paragraph The recovery criteria addresses extant natural populations.

Page 1, fifth paragraph IUCN reference added as suggested.

Page 1, sixth paragraph California Department of Fish and Game is abbreviated CADFG throughout the document.

Page 1, seventh, eighth, and ninth paragraphs Document modified as suggested.

Page 1, tenth paragraph Extirpated and most captive stocks of desert pupfish have been put back in the appendix although we acknowledge the information is incomplete.

Page 1, eleventh paragraph Text has been updated to include Bagley et al. (1992) and other trip reports.

Page 1, last paragraph Modified as suggested.

Page 2, first paragraph See comment to Page 1, tenth paragraph.

Page 2, second paragraph Plug in transplant records in Miller (1968).
Response The 1939 and 1949 transplants into the Salton Sea Basin are acknowledged in the Appendix.

Page 2, third paragraph Reference to Table 2 deleted since it does not address Rio Sonoyta forms or recently extirpated forms.

Page 2, fourth paragraph Incorporated as suggested.

Page 2, fifth paragraph Matsui (1981) has been added to the literature cited.

Page 2, sixth, seventh, eighth, tenth, eleventh, and twelfth paragraphs
Incorporated as suggested.

Page 2, ninth paragraph Recovery objectives for the Rio Sonoyta forms of desert pupfish are not known at this time. Downlisting of the Quitobaquito forms are not expected due to continuing threats to its survival, and lack of historic range in which the subspecies can be recovered. The downlisting of the Colorado River form of pupfish is specific to this subspecies. However, the recovery plan states that downlisting is expected to take 15 years. As additional information becomes available, that time frame may change, particularly if information on the other two subspecies change perspective for the species.

Page 2, paragraph 13 I do not agree at all with even "minor" management of tier 2 populations (other than monitoring and genetic maintenance), because the term is inexact and subject to differing interpretation... This section must be changed to indicate that tier 2 populations can be counted toward recovery only if they have persisted for 10 years without human intervention.

Response It is the Service's belief that some management (e.g. fencing, management for other native species) should be allowed.

Page 2, paragraph 14 Pupfish transfers are listed in the appendix.

Page 2, last paragraph Document modified as suggested.

Chief, Division of Fish and Wildlife Management Assistance, Fish and Wildlife Service, Washington, D.C.
Memorandum dated March 29, 1993
Most of the comments were editorial and were incorporated as suggested. Some comments discussed below.

Page 2, first paragraph Incorporated suggestion to add words to the glossary.

Page 2, second paragraph Questions why pollution from aerial pesticides are not addressed under Recovery Tasks.
Response Aerial pesticides are not specifically addressed under the recovery tasks. However, under item 1.2 "Acquire Habitats Occupied by Natural Populations of Desert Pupfish", the document acknowledges that water management practices which adversely affects pupfish habitat must be

curtailed. Specific mechanisms will be determined on a case-by-case basis for each habitat.

Page 2, third paragraph Reference is made here to desert pupfish colonizing the Salton Sink as the consequence of a "diversion of the Colorado River." Yet throughout the remainder of the document, you refer to pupfish in the Salton Sink as naturally occurring populations. This needs to be clarified.
Response The desert pupfish has historically occurred in springs, seeps and slow-moving streams in the Salton Sink basin. After the Salton Sink was flooded in the early 1900s by diversion of the Colorado River, desert pupfish colonized the area now known as the Salton Sea. The Salton Sea has, within the last 100 years, been unnaturally filled and maintained by human activities. This fact does not negate the natural occurrence of the desert pupfish in the sea itself and the streams and springs tributary to the sea. Desert pupfish are found within and considered to be naturally occurring inhabitants of both basins.

Page 2, fourth paragraph It appears that you are saying that a large population of C. m. macularius inhabits Quitobaquito Spring...
Document clarified to indicate reference to C. m. eremus.

Page 2, fifth paragraph We are troubled with the suggestion that several populations of "questionable genetic purity" be destroyed.
Response Extant wild populations of desert pupfish represent the original genetic stock of the species and are, therefore, irreplaceable. The protection of these individuals is critical to the continued existence of this species. Populations which are of questionable genetic purity, can never be guaranteed as isolated and may, therefore, threaten recovery of other populations.

Page 2, sixth paragraph Is it really necessary to carrying out the Recovery Plan to include such extensive details on the spawning behavior of the species.
Response This information is provided as background. A large portion of the readers of this plan are not academics or biologists and may be interested in the general information.

Page 2, last paragraph The reference to "other mortality factors" has been deleted from the recovery plan.

Page 3, first paragraph Title modified to read co-occurring native fishes, as suggested.

Page 3, second paragraph Cited interactions with non-indigenous species include only competition and predation. Are hybridization and pathogen transfer not evident or suspected?
Response Information on hybridization or pathogen transfer is not available.

Page 3, third paragraph The terms non-native and exotic are used synonymously as acknowledged in the glossary.

Page 3, fifth paragraph It seems that an effort should be made, regardless of the likelihood of its successful achievement, to at least define what would need to occur to enable delisting.
Response Delisting is not seen as feasible in the foreseeable future. Once this plan is finalized and approved, downlisting of the Colorado River form of desert pupfish is expected to take a minimum of 15 years. Neither down- nor delisting of Quitobaquito pupfish is expected.

Page 3, sixth paragraph What is the basis for the number 500 (for the number of overwintering adults)? What is the normal sex ratio for this species?
Response The number 500 individuals is based on the citations in the

document and review by the Desert Fishes Recovery Team. The sex ratio should be approximately 1:1 or whatever is sufficient to maintain the 500 individuals.

Page 3, seventh paragraph Document modified to delete anthropomorphic traits to watersheds.

Page 3, eighth paragraph What is the basis for the target numbers under tiers 2 and 3?
Response The numbers are designed to re-establish pupfish into a diversity of habitat types reflective of those occupied historically. The tiered approach with the numbers specified in this plan should allow management to mimic the natural fluctuations within the constraints imposed by the diminished quantity and quality of habitat.

Page 3, ninth paragraph In other recovery plans for species restricted to a single site, it is recognized that the species may be unique precisely because of the particular characteristics of that environment. The establishment of a second population is specifically discouraged except as a last resort. How does this differ in the case of Quitobaquito pupfish?
Response The second population of Quitobaquito pupfish is meant to serve as a refugium and should be in the vicinity of Quitobaquito Springs.

Page 4, first paragraph One concern we have with the protocol development is alluded to in the final sentence of this section in referring to possible pre-existing anthropogenic influences. How will this affect the selection of your baselines (controls) for genetic comparisons?
Response The genetic integrity of the desert pupfish should be maintained so the populations' genetic diversity is allowed to follow a natural, independent evolutionary path.

Page 4, second paragraph Again, what is the basis for the numbers? Why 50 pupfish and why 25 of each sex?
Response The sample size was determined by a combination of literature reviews and consultation with members of the Desert Fishes Recovery team and other fisheries authorities. Sample sizes should be approximately 50. Additional information may modify that figure during implementation.

Page 4, last paragraph We strongly support the intent to use "information and education" programs to help promote a successful recovery of the species. Again, however, we would encourage you to consider using the previously cited pupfish "of questionable genetic purity" for the public displays instead of destroying them and then depending on pupfish otherwise useful to recovery.
Response This is a very complex situation. Can populations ever be guaranteed as isolated? Extant wild populations of desert pupfish represent the original genetic stock of the species and are, therefore, irreplaceable. The Service believes that the protection of these individuals is paramount to the continued existence of this species.

Bill Rinne, Bureau of Reclamation, Boulder City, Nevada
Memorandum dated March 30, 1993
No specific comments; no responses needed.

Mason Bolitho, Arizona Department of Water Resources, Phoenix, Arizona
Letter dated March 30, 1993
Offers services on obtaining information on the acquisition of water rights and legal protection of instream flows.

Conrad G. Keyes, Jr. International Boundary and Water Commission (USIBWC), El Paso, Texas
Letter dated March 31, 1993
The USIBWC provided background information on the Treaty of February 3, 1944, for "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande." Some discussion is included below.

Page 1, third paragraph The USIBWC is concerned about the extraterritorial application of the desert pupfish recovery plan... the United States, at this time, is not prepared to enter into negotiations for a United States and Mexico ground-water treaty.
Response Although the plan discusses the potential for the control of ground water, specific mechanisms will be determined on a case-by-case basis at a later time, and in fact may not be possible. Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Objectives will be attained and any necessary funds made available, subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

Page 2, second full paragraph The USIBWC would be favorable to the Service utilizing sites in Mexico if it can be done without governmental involvement, that is if non-governmental organizations can purchase lands and available water rights to protect habitat. Can the Service consult with the USIBWC on site specific recovery plans?
Response It will be important to have the perspective of the USIBWC. The Service will definitely consult with the USIBWC on ground water management and other such issues.

Page 2, last paragraph The USIBWC is currently consulting with the Department of State on the issues raised by the desert pupfish recovery plan and has respectfully request that no action be taken until that consultation is completed.
Response Implementation of the recovery plan has not yet begun.

Acting Field Supervisor, Fish and Wildlife Service, Carlsbad, California
Memorandum dated July 19, 1993
Most of the recommendations were grammatical and were incorporated as suggested. Some comments which are discussed below.

Page 1, last paragraph, continuing to next page The population of desert pupfish within the Salton Sea raises several issues which may need addressing in the Plan. Based on the results of recent surveys, desert pupfish likely occupy more than a few shoreline pools. With this apparent increase in desert pupfish population numbers it seems plausible that the movement of genetic material between the Salt Creek population and the San Felipe Creek population currently exists. Planned water conservation measures, if implemented, will affect the aquatic ecosystem of the Salton Sea and shorten the amount of remaining time that introduced fishes can persist due to increases in salinity. This loss of introduced fishes will likely benefit the desert pupfish but may cause harm through the loss of suppression of large predatory fish.
Response The document has been modified to reflect the expansion of desert pupfish beyond "a few shoreline pools" into the irrigation drains around the Salton Sea. If genetic information is being transferred between the Salt Creek and San Felipe Creek populations, that information should be verified during implementation of the genetic monitoring program. The effect of water development projects, e.g. impoundment, stream diversion and groundwater pumping, can be expected to continue and increase in the foreseeable future.

The recovery plan discusses the need for long-term protection and management (e.g., specific designation as Areas of Critical Environmental Concern, Research Natural Areas, etc.), assurance of water of sufficient quantity and quality, protection against habitat degradation, control or removal of deleterious non-native animals and vegetation (if present), prevention of invasion by non-native fishes, and modification of land management practices deleteriously affecting aquatic habitats. Implementation of specific tasks required to achieve population and habitat security must be directed by individual management plans for each site.

Page 2, first paragraph The Salton Sea issue is further complicated by the presence of a variety of contaminants (e.g. selenium, DDT, and metabolites of DDT). Information needs to be developed concerning the affects of these substances on the desert pupfish and should be identified as action within the Plan.
Response Task number 6 addresses the factors affecting population persistence. The document acknowledges that many attempts to prevent the demise or establish new desert pupfish populations have failed. Although factors such as habitat size and stability, water quality, minimum population size, and non-native species have been suggested as being important influences, there has been limited attention given to quantifying causal relationships and designing programs to maintain populations and maximize population establishment success. The exact parameters are not yet established and certainly can include contaminants.

Page 2, seventh paragraph Having a legally binding, long-term (>25 years) agreement would not seem to meet the "perpetual" standard.
Response Twenty five years from finalization of this plan would take us to the year 2018. Once this plan is finalized and approved, downlisting of Cyprinodon macularius macularius is expected to take a minimum of 15 years. Total recovery (delisting) is not expected in the foreseeable future. Delisting of this subspecies is not considered feasible in the foreseeable future. Neither down- nor delisting of Quitobaquito pupfish (Cyprinodon macularius eremus) is expected. Given the long-term recovery objectives, this recovery plan will require periodic review, including the appropriateness and the effectiveness of the 25 year agreement.

Page 2, ninth paragraph Document modified to add SEDUE and CES to the Glossary of Terminology.
Response CES has been added to the "Key to Acronyms used in Implementation Schedule". Secretaría de Desarrollo Social (SEDESOL) has replaced SEDUE and is mentioned in the text.

Instituto Nacional De Ecologia. Direcction General De Aprovechamiento, Mexico **Letter dated May 12, 1993** (translated by Cande Sánchez Barfuss, The Nature Conservancy, Phoenix, Arizona)
Most of the letter was general and did not request modification to the document. Some comments are discussed below. The page and paragraph numbers refer to the translated version of the letter.

Page 1, fourth paragraph Concern expressed over the need to have a more in depth study of the distribution and abundance of the non-described subspecies in the Sonoyta River in Sonora and Cyprinodon macularius eremus in Sonora and Lower California.
Response Task number five in the recovery plan calls for monitoring and maintaining all natural, re-established, and refugium populations in the U.S. and Mexico. As practicable, all populations should be monitored within the same general time frame so that seasonal effects on population dynamics do not confound interpretation of data. Monitoring protocols should be standardized (e.g., methods, equipment, length of sampling, number of observers, etc.)

within, and to the extent practicable, among sites. Such an endeavor will require considerable coordination between the Fish and Wildlife Service, Centro Ecológico de Sonora, Secretaria de Agricultura y Recursos Hidráulicas, California Department of Fish and Game, AGFD, and others.

Page 1, fifth paragraph Concern expressed over the genetic purity of the populations distributed outside the historic range and the potential threat to the recovery of the species.
Response Maintaining the genetic integrity of the various subspecies and providing for genetic exchange among populations within a subspecies is a priority of the recovery plan. The Service believes that in order to maintain genetic integrity, populations of questionable purity must be destroyed.

Boyd Gibbons, California Department of Fish and Game, Sacramento, California
Letter dated August 12, 1993
Most of the suggested changes were editorial and were incorporated as suggested. Some comments are discussed below.

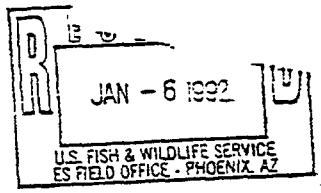
Page 1, sixth paragraph Aerial application of pesticides and direct runoff from agricultural fields may also affect pupfish populations in the drains.
Response The Service does not have any references on the effect of agricultural uses on the drains. With the pupfish population expanding into the irrigation drains, additional information will need to be gathered on water diversion, water quality, and other factors.

Page 1, last paragraph Define "major" and "minor" vegetation removal.
Response Major vegetation removal could be accompanied by dredging or habitat reconstruction. Minor vegetation removal should not.

Page 2, second paragraph While we support the recommended level of population and habitat condition monitoring, recent staffing levels and other constraints may only allow annual surveys.
Response The reference in the recovery plan to twice annual monitoring is what is determined to be necessary to assess population status, and habitat condition. The two sampling periods would serve two separate functions. The spring sampling would provide an index of adult abundance after over-winter mortality, and the late summer-autumn sampling would allow assessment of reproductive success and probable recruitment. Twice yearly monitoring is very desirable; however, sampling once per year is more desirable than no sampling at all.

Page 2, paragraph Oasis Spring Ecological Reserve: This consists of an artesian well and two earthen ponds. Each pond overflows into a short stream, approximately 0.25 mi and 1.0 mi long, respectively.
Response Thank you for the clarification on the Oasis Spring Ecological Reserve.

Mr. Sam Spiller, Field Supervisor
U.S. Fish and Wildlife Service
3616 W. Thomas Road, Suite 6
Phoenix, Arizona 85019



Dear Mr. Spiller: January 2, 1992

I receivied and reviewed the Technical Draft Desert Pupfish Recovey Action Plan written by Paul Marsh and Donald Sada. While the document is basically adaquate it contains some conceptual problems that will plague us as we go forward with implementation. For over a decade I have tried to facilitate the reintroduction of desert pupfish but have made little progress due to both the communication problems between the agencies and the public, as well as the lack of understanding of the desert ecosystem that this fish requires. Correction of these problems will have some small impact on portions of the biological aspect of T/E species management but will result in easing the actual process of recovery.

The Executive Summary makes several statements about protecting the aquatic habitats that the pupfish will inhabit that are not realistic. 1. Each individual site is vulnerable to human or natural catastopic events. Non-native fishes, fires, floods, predators, diseases or vandalism threaten each one. There is no way to achieve the actual protection the Summary says will be necessary for any individual population. 2. The concept of "species historic range" is not useful with desert pupfish. Historic ranges involve at least 3 factors, a) suitable habitat, b) physical connection, and c) records by a competent observer. With large conspicuous mammals there are obvious gaps in records, with small fishes there are more gaps than observations. Furthermore, the best water sources were developed first; many in the 1880's. Additionally, livestock numbers in southern Arizona many have been at the all-time high in the 1890s. Many populations were undoubtedly lost before they were observed (complete species records are still not present for native fishes in Arizona according to the loach minnow and spikedace recovery plans). Where there was continuous suitable habitat there likely were pupfish and placing a restriction of where some collector happened to sample upon the species is not adviseable. 3. Lastly, the insistance of maintaining the species within the historic range is a bad idea on the long term since we know the climate has always been changing and the rate of change may be increasing due to human activity. This problem continues into the issue of genetic exchange between populations. It would be wise to carefully concider the impact of moving individuals from one set of environmental conditions into a different area. Individuals adapted or adapting to Sonoran Desert rainfall patterns may cause problems if introduced to a Mojave Desert population. Evolution has not ceased, it is continuing and we should permit natural selection of individuals for site specific environmental conditions rather than automatically managing for frequent genetic exchange.

Page 5. The paragraph at the top is an excellent discussion of the environmental conditions that the pupfish will have to survive

within. The managing agenies will be working within this framework and populations will be continuously lost.

Page 26. I disagree with the need for site specific regulations to protect habitats, such as ACEC designations. The ESA provides far more protection than an administrative designation such as ACEC; also the land management agencies will have problems with the additional paperwork; and will see an inconsistance if the FWS doesn't establish Critical Habitat. Will FWS require a special administrative designation on its wildlife refuge for pupfish populations?

There is a need for a site specific management plan for each population, but the BLM, FWS and AGFD develop them already in the reintroduction agreement. The reintroduction plan should detail issues such as water rights, on-site management, and control of any deleterious animal or plant (such as cattails) regardless if it's native or not. It will be the number of populations of pupfish that will protect it from extinction, not guarentees on a piece of paper. The current policy of detailing future management in the EA prior to the release of T/E species seems to be a good practice; after the fish are in the water it is very difficult to correct misunderstandings. The Draft Plan should be modified to require a management plan for each site prior to reintroduction.

Page 31. All populations will "wink in and out" including our tier 1 stocks. This document, on page 5, explains why. The solution is not to develop huge plans but to have a lot of populations as insurance. An example is the Dude Fire which resulted in the loss of some fish populations. The common species are safe not because they live in safe habitat but because they are in many locations and the loss of several doesn't jeoprodize the species. Dispite everybodys best efforts we continue to lose fish populations and no amount of planning will prevent it. We need to have many populations not a few presumed secure ones. Even fish hatcheries get shipment of bad fish food, have parasite or disease outbreaks, and power failures.

Page 32. The recent hydrologic report on the San Pedro River needs to be reviewed. Dry rivers are poor fish habitat. The San Pedro River should be studied as a potential reintroduction site, it might not be suitable anymore due to several environmental problems and the statement that it "must be concidered a priority re-establishment site" is premature. The current FWS policy of not utilizing the experimental non-essential status works against the reintroduction of listed species by delaying the process until the sites are allocated to other uses or are lost due to the lack of public issues.

As previously stated, my concerns are primarily on conceptual issues and implementation problems. Aquatic species are very vulnerable in the desert because everything in the watershed affects them and society wants to move the water some place else. This plan is fine in so far as the biology goes but is not realistic anymore. The land management agencies have many laws they must implement, not just the ESA. Quality sites are being allocated to other uses because there are no fish in them. Regardless of their legal status the agency will act to protect the

resources because the public supports that type of thing; but there is no support for protecting a site that might get pupfish sometime in the future.

Once fish are in the water there is no protection against natural catastrophy or vandalism regardless of the agencies name or special designation on paper. What counts is selecting good sites, establishing a consistant monitoring program, and having a site specific management plan in place so that problems can be corrected quickly. We will be in a management mode forever, regardless of what we would like in our glossary of terms on page 55. The best sites will require less management. It will be only a matter of degree. I am aware of the massive management at Quitobaquito and at the Salton Sea, for example. Warren and Anderson, 1987, documented the impacts of livestock grazing at Quitobaquito and since then there has been control of native vegetation, digging of water ways and cleaning out of sediment.

Regardless of the tier, or the paper protection, there must be provisions for regular management to remove salt cedar, kill bullfrogs, dredge sand and gravel and to reintroduce the fish when they wink out again. Due to the world-wide impacts from modern technology and our desire to hold aquatic systems in their present conditions or a desired condition, we will have to conduct management to offset human impacts or natural processes such as erosion and plant succession. This Draft Plan infers that sites will remain static and individual populations of pupfish will be safe and stable if we carefully select our locations; and that is not possible.

The failure of this Region to utilize the Experimental-Nonessential provisions of the ESA will make it difficult for multiple-use land management agencies to take part in the recovery of desert pupfish. There are too many conflicting laws that Congress has passed directing land management for complete, technical compliance with all provisions of the ESA. In my professional career I've heard of many fully protected species and populations that have been lost, but I can't think of any Experimental-Nonessential population that an agency decided it didn't want anymore and had the animals removed. In my experience, agencies are just as concerned about protecting populations of rare flora and fauna regardless of their official status...the public is not making the distinction, either. Because there will always be the need to manage sites, and because the public lands will always have minor conflicting uses occurring it will be extreamly difficult for multiple-use agencies to buy into this plan as it is written. I expect there will be a move to put implementation of the ESA into the same category with other single use activities, such as mining and livestock grazing, and require a full Environmental Impact Statement prior to reintroductions if there isn't some flexibility (such as provided with the Experimental-Nonessential provisions).

Other comments are included in the text. Thank you for the opportunity for me to comment on this Draft Plan.

Sincerely;

Albert Rasmussen

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, Governor

DEPARTMENT OF FISH AND GAME
330 Golden Shore, Suite 50
Long Beach, CA 90802
(310) 590-4807

January 27, 1992

Mr. Sam Spiller
U.S. Fish and Wildlife Service
3616 W. Thomas, Suite 6
Phoenix, AZ 85019

Dear Mr. Spiller:

Thank you for the opportunity to provide you with my comments on the Draft Desert Pupfish Recovery Plan. I believe the implementation of this plan will be instrumental in the recovery of this species. The following are my suggestions for changes and/or additions to the current draft:

I suggest that the recovery plan should make reference under the "Life History" Section (Pg. 8) and the "Reasons for Decline" Section (Pgs. 14 & 15) to a thesis by Margaret Matsui (1981) entitled "The effects of introduced teleost species on the social behavior of Cyprinodon macularius californiensis". I believe this thesis provides an important reference for the interference by several non-native fish species with the spawning behavior of the desert pupfish. I have enclosed a copy of the thesis for your review.

The first sentence of the second paragraph on Page 15 of the draft states that "Interactions with introduced mosquitofish were noted early as contributory to the decline of pupfish in the Salton Sea (Evermann 1916, see also Jennings 1985)". This sentence is not supported by Evermann's 1916 report - his report only mentions one specific spring (Figtree John) where he collected them and makes no reference to their abundance in the Sea itself. Mosquitofish were not mentioned as being present in the Sea or in springs by the author. This same author does report (Calif. Academy Sciences, Vol XVIII, No. 18, Pg. 553) in 1930 that desert pupfish in the irrigation ditches "had been mostly or altogether replaced by the mosquitofish" but that "a good number were found in the highly saline waters of the Salton Sea". It is not known what observation or report the latter reference is comparing desert pupfish and mosquitofish abundance. Coleman (1929 reference included) says that both desert pupfish and mosquitofish were "in sufficient abundance in the Sea to form the food of a considerable population of sportfish since they are

found all along the shoreline". Additionally, Barlow (1961) refers to having observed schools of juvenile pupfish numbering upwards of 10,000 individuals - this observation was made for the shoreline pools at the Sea.

On Pg. 19, under Recovery, (b) Salton Sink there are four tier 1 locations listed - two of these are San Felipe Creek and San Sebastian Marsh. I do not understand the rationale for separating the two since San Sebastian Marsh is an area within San Felipe Creek that in many years has a direct connection to the remainder of San Felipe Creek. I suggest that only San Felipe Creek be considered as a location for tier 1.

I suggest that tier 2 and tier 3 populations be established in a phased manner that allows for essential genetic, life history and habitat preference/requirement information to be acquired for representative populations prior to establishing all of the recommended number of populations. Otherwise, it will be very costly to monitor established populations as well as do the biological studies that are needed. Therefore, I suggest that maybe only one-third of the populations be established within a 10-year period and along with them would go the appropriate funding for the studies.

This completes my comments on the draft. Thanks again for the opportunity to review it and express my opinion.

Sincerely,

Glenn Black

Glenn Black
California Department of Fish and Game

cc: Betsy Bolster
Kim Nicol

Attachments

Dear Sally:

Feb 8, 1992

I commented on the Pupfish Recovery Plan draft a year ago. I sent my comments directly to Paul and they were either incorporated or discarded as absurd. Thus, I see no need to repeat them. However, I would like to use this piece of yellow paper to state the obvious. The draft Plan was written over a year ago and much of the information is over two years old. The Appendix needs to be updated on recent stockings + site failures in conjunction with the text. Since this Plan will be guiding the recovery for pupfish for the next several years, I feel that it is essential for it to be accurate and up to date.

Thank you for the opportunity to comment,

Brian Bagley

Arizona State University

Department of Zoology
Tempe, Arizona 85287-1501
602/965-3571

9 February 1992

United States Department of Interior
Fish and Wildlife Service
Ecological Services
3616 W. Thomas, Suite 6
Phoenix, AZ 85019

Dear Mr. Spiller:

Enclosed is my copy of the draft review of the desert pupfish recovery plan authored by Dr. Paul C. Marsh. The report is very well-written and I have few comments on content, except for corrections of typographical errors and comments penciled in the margin. The only things I can add regard some minor points concerning the genetics of pupfishes. First, I will provide Paul with a copy of manuscript on mitochondrial DNA in pupfishes (by Dr. A. A. Echelle and myself). He will be able to incorporate any information from that manuscript into his draft. The second point regards sample sizes for monitoring genetic characteristics of desert pupfish populations. It is likely the only differences between populations will be in allele frequencies, requiring larger sample sizes (ca. 50 - 100) than those outlined in the document (ca. 20). The status of this species may make such large sample sizes difficult to obtain; however, accurate assessment of allelic and genotypic frequencies cannot be achieved without appropriate sampling. Therefore, it may be necessary to work out some intermediate level which will allow assessment of genetic features without damaging the recovery effort.

I hope that my review has assisted you in your efforts. If there is anything else you require, you can reach me at my office (602-965-1626). Good luck in achieving your goals.

Sincerely,

Thomas E. Dowling

United States Department of the Interior

NATIONAL PARK SERVICE
ORGAN PIPE CACTUS NATIONAL MONUMENT
ROUTE 1, BOX 100
AJO, ARIZONA 85321

IN REPLY REFER TO:

N22

February 10, 1992

Memorandum

To: Field Supervisor, Ecological Services, U.S.F.W.S.

From: Superintendent, Organ Pipe Cactus National Monument

Subject: Technical Review of the Draft Desert Pupfish Recovery Plan

Thank you for providing us the opportunity to review the draft of the Desert Pupfish Recovery Plan. Enclosed you will find a list of our comments, questions, and concerns. If clarification is needed with regard to these comments, please do not hesitate to contact Jim Barnett, Chief of Resources Management, or myself, at (602) 387-6849. Thank you.

Sincerely,

Harold J. Smith
Superintendent

"TECHNICAL DRAFT DESERT PUPFISH RECOVERY PLAN"

COMMENTS

1. Pg. 28, Para. 2, Sent. 1. How can we prevent introduction of exotics at Quitobaquito.

2. Pg. 14, Para. 1, Sent. 2. Could longfin dace (Agosia chrysogaster) be compatible with pupfish at Quitobaquito?

3. Pg. 36, Para. 2, Sent. 1. Is it desirable or necessary to do twice annual monitoring at Quitobaquito?

4. Pg. 41, Para. 2, Sent. 2. Would interpretive signs or displays, in both Spanish and English, be helpful? Death Valley National Monument has a small aquarium in the Visitor Center as part of their display.

5. Pg. 7, Para. 2, Sent. 2. Why do genetically impure stocks have to be destroyed? Can they not be used in displays?

6. Pg. 33, Para. 3, Sent. 1. Where would a refugium at ORPI be located and what kind of maintenance would be required?

7. Pg. 26, Para. 1, Sent. 2. How can we protect the springs at Quitobaquito from the effects of groundwater pumping in Mexico?

8. Pg. 29, Para. 2, Sent. 1. Are Rio Sonoyta habitats affected by the discharge of pollutants in the town of Sonoyta?

9. Pg. 37, Para. 1, Sent. 3/4. How would we monitor more intensively the habitat at Quitobaquito? Is photo monitoring necessary?

THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

2221 West Greenway Road, Phoenix, Arizona 85023-4312 (602) 942-3000

Governor
Fife Symington

Commissioners:
Phillip W. Ashcroft, Eagar, Chairman
Gordon K. Whiting, Klondyke
Larry Taylor, Yuma
Elizabeth T. Woodin, Tucson
Thomas G. Woods, Jr., Phoenix

Director
Duane L. Shroufe

Deputy Director
Thomas W. Spalding

February 18, 1992

Sally Stefferud
U.S. Fish and Wildlife Service
Ecological Services
3616 W. Thomas, Suite 6
Phoenix, Arizona 85019

Dear Sally:

As per your request, I have reviewed the last version of the draft Desert Pupfish Recovery Plan, and I would like to provide some comments.

1. The plan shows consistency in format, content and style, and previous comments provided by members of the Desert Fishes Recovery team have been incorporated.

2. Paul Marsh and Donald W. Sada were contracted by Arizona Game and Fish Department, under a Section 6 project, to prepare the mentioned draft Recovery Plan. The cover letter of the draft must reflect this action.

3. Recovery criteria, recovery objective, habitat requirements and limiting factors are not included in the executive summary, as consistent with other recovery plans.

4. Update of the status of some of the transplanted populations of desert pupfish is as follows:
   a) Howard Well: this site was visited in February 1991 and only small numbers of pupfish were found. No topminnow were found. Bullfrogs were present.

   b) Deer Valley High School: ca. 300 desert pupfish were stocked in April 1991 and they are doing well.

   c) Boyce Thompson Arboretum: pupfish were doing well by March 1991.

   d) Roper Lake State Park: this site was visited in January 1991, but no pupfish were found.

   e) Desert Botanical Garden: small numbers of pupfish were observed during the March 1991 monitoring.

f) Buehman Canyon: no pupfish were captured during the February 1991 monitoring. Fish were recently scoured by floods at time of monitoring.

g) Cold Spring Seep: None of the two ponds contained pupfish during the February 1991 monitoring. Abundant topminnow was observed at one of the ponds.

If you have any questions on my comments, do not hesitate to contact me at 789-3508.

Sincerely,

Francisco Abarca

Francisco Abarca
Native Fish Program Manager

FJA:fa

United States Departme

FISH AND WILDLIFE
Post Office Box 1306
Albuquerque, N.M. 87103

In Reply Refer To:
Region 2/FWE/SE

MAR 25 1992

MEMORANDUM

To: Field Supervisor, Ecological Services, FWS, Phoenix, Arizona

From: Assistant Regional Director, Fish and Wildlife Enhancement

Subject: Cyprinodon macularius Recovery Plan

We have completed our review of the recovery plan (technical draft version) for Cyprinodon macularius. Our comments/recommendations, etc., are either provided on the margins of the plan or as attachments. We now look forward to receiving a clear copy ready for public review and comment.

Attachments

STATE OF CALIFORNIA — RESOURCES AGENCY PETE WILSON, Governor

DEPARTMENT OF PARKS AND RECREATION

Anza-Borrego Desert State Park
Post Office Box 299
Borrego Springs, California 92004

February 7, 1993

Gilbert D. Metz, Field Supervisor
United States Fish and Wildlife Service
Arizona Ecological Services Field Office
3616 West Thomas Road, Suite 6
Phoenix, Arizona 85019

Mr. Metz:

We apprciate the opportunity to review the draft recovery plan for the desert pupfish, (Cyprinodon macularius).

Your staff has done a thorough job of compiling all the current literature on desert pupfish and has come up with a realistic recovery plan. We would like to continue to support the recovery efforts of the desert pupfish in any way we can. Presently three refugia exist in the park, with opportinities for more if necessary in the future.

The staff at Anza-Borrego is working closely with Kim Nichol of the California Department of Fish and Game to maintain and monitor the park's refugia. Continued funding for her maintenance efforts will be necessary to assure a successful recovery program.

If our staff can be of assistance in any way, please feel you can count on us. Good luck with the recovery plan.

Sincerely,

Mark C. Jorgensen

Mark C. Jorgensen
Naturalist
Anza-Borrego

Attn. Sally Shetland

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR
FISH AND WILDLIFE SERVICE

FEB 19 1993

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In Reply Refer To:
FWS/AES/TE

Memorandum

To: Assistant Regional Director, Region 2 (ES)

From: Chief, Division of Endangered Species

Subject: Review of the Desert Pupfish Draft Recovery Plan

The Division of Endangered Species appreciates the opportunity to review the draft recovery plan for the desert pupfish (Cyprinodon macularius). The draft plan appears consistent with current guidance and policy for the development of recovery documents. No specific technical or biological comments are offered at this time. The Division looks forward to receipt of the final plan and its successful implementation for this native fish species. If you have any questions concerning this review, please contact staff biologist Vicki Finn at 703-358-2171.

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THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN, U.S.A. 48109-1079

MUSEUM OF ZOOLOGY

PHONE: (313) 764-0476
FAX: (313) 763-4080

February 16, 1993

Field Supervisor
U.S. Fish and Wildlife Service
3616 W. Thomas Road, Suite 6
Phoenix, Arizona 85019

Dear Sir:

I have read the draft for the Desert Pupfish Cyprinodon macularius, a fish I have worked with for some 50 years. It's an excellent document, and I highly commend Paul Marsh and Don Sada for a thououghly researched and well written account. My few comments are entered in red.

There is one additional record for this species that I discovered at the California Academy of Sciences in 1991. It's from Puerto Penasco, Sonora, Mexico, on the Gulf of California (6 juv.-ad.), collected by E. W. Kirschbaum in 1960 (CAS 40724), identified at CAS as only "Cyprinodon". This is not too far from the mouth of the Rio Sonoyta which is known to reach the Gulf in years of heavy rainfall.

I am glad to see that the northern state of the Baja California peninsula is correctly called Baja California (not Baja California Norte as many Mexicans insist on calling it: that name - the modifier "Norte" - was dropped by the federal government years ago). The correct name of the southern state remains as Baja California Sur.

It was a pleasure to review this fine account.

Sincerely yours,

Robert R. Miller
Professor Emeritus of Biology
and Curator of Fishes

jsg/RRM

FEB 22 1993

United States Department of the Interior

NATIONAL PARK SERVICE
ORGAN PIPE CACTUS NATIONAL MONUMENT
ROUTE 1, BOX 100
AJO, ARIZONA 85321

IN REPLY REFER TO:

N1621

February 27, 1993

Memorandum

To: Gilbert D. Metz, Acting Field Supervisor, US Fish & Wildlife Service, Arizona Ecological Services Field Office

From: Superintendent, Organ Pipe Cactus National Monument

Subject: Draft Recovery Plan for the Desert Pupfish (*Cyprinodon macularius*)

Enclosed please find comments on the subject draft recovery plan for the Organ Pipe Cactus National Monument. Thank you for the opportunity to review the document and we look forward to assisting with future recovery and protection of this species. If there are any questions please contact Jim Barnett, Chief of Resources Management, at 387-7662 ext. 7110. Thank you.

Harold J. Smith

encl.

DRAFT

DESERT PUPFISH (*Cyprinodon macularius*)

RECOVERY PLAN

Comments:

USDI, National Park Service
Organ Pipe Cactus National Monument
Rt. 1, Box 100
Ajo, AZ 85321

1) Pg. 2, para. 1: Organ Pipe Cactus National Monument is in Pima County not Santa Cruz County.

2) Pgs. 31-32. We would like additional details on the establishment of a refugium population of the Quitobaquito Pupfish. Currently one refugium is maintained by the Arizona Game and Fish Department (fish removed from Quitobaquito Pond in 1989). The plan indicates that the refugium should be located "in the vicinity of the species natural range (i.e. Organ Pipe Cactus National Monument)." At this time there are no suitable refugium sites in the Monument. We recommend that US Fish & Wildlife Service, Arizona Game & Fish and the National Park Service work towards the identification of a refugium site before the completion of this plan.

CALIFORNIA-NEVADA CHAPTER

American Fisheries Society

ORGANIZED 1870 | INCORPORATED 1910

June B. Mire
Dept. Integrative Biology
University of California
Berkeley, CA 94720
(510) 643-5318

March 13, 1993

Field Supervisor
U. S. Fish and Wildlife Service
3616 W. Thomas Rd., Suite 6
Phoenix, AZ 85019

Re: Comments on the draft recovery plan for Ivanpodon maculanius

I was impressed by the thorough and conservative nature of this draft recovery plan, and feel like it is a good start. Specific comments referenced by page numbers follow. My copy did not include tables referred to in the text, so I cannot comment their format or clarity.

One particular concern I have is that the plan does not address possible variation in reproductive season among populations. My work with the closely-related Owens pupfish, C. radiosus, revealed as much as a three month difference in the onset of spawning in populations just a few miles apart. Interaction of temperature and photoperiod are probably responsible for this difference, but the causes and consequences of different spawning seasons have not been fully investigated. Knowledge of the timing and duration of the spawning season for each population is critical to management decisions involving vegetation control, transplant activities, and population censuses.

Another concern is one common to pupfish recovery plans. How many individuals constitute a "population" as defined by the recovery criteria? This is a difficult question that was not adequately addressed in this draft plan.

Specific Comments:

Draft Page (DP) 1; Paragraph (P) 1:
Change "behaviorists" to "ethologists." The former term has a specific meaning that is inaccurate in this context.

DP 2; P 1:
The discussion of allozyme variation is too vague to be useful. Explain the relevance of the mean heterozygosity values of I. maculanius being comparable to Aphanius, and how this affects management decisions.

DP 7; P 3:

The recommendation that several populations of questionable genetic purity should be destroyed is buried in this section. It belongs in a later section on recommendations.

DP 9; P 1:

The mixture of past and present tense in this paragraph is a little awkward. I think the discussion of habitats should be more clearly delineated between past and present, with reference to the historical time frame denoted by the past tense.

D 10; first full P:

The reference to consort pairs given as Barlow (1961) is incorrect. Consort pairs were described in Kodric-Brown (1981).

D 11; first partial P:

The term "incubation," which implies modulation of temperature, is not accurate for pupfish. Their eggs merely develop without incubation.

D 16: P 3:

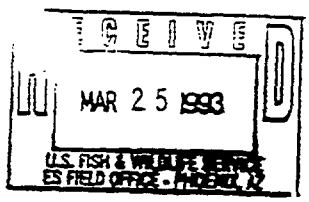
Is the source of mercury known?

NORTH ORANGE COUNTY COMMUNITY

FULLERTON COLLEGE

NATURAL SCIENCES

19 March 1993



Field Supervisor
U. S. Fish and Wildlife Service
3616 West Thomas Road, Suite 6
Phoenix, AZ 85019

Dear Sir:

I have finished reading the review draft of the recovery plan for the Desert Pupfish, *Cyprinodon macularius*. I have commented directly on the manuscript.

Back in 1977 a group of us got together to begin the long tedious process of getting this little fish listed. Perhaps you can imagine how gratifying it is to finally see the wheels in motion for an actual recovery plan. I found the document to be extremely well done. It is thorough, insightful, and well researched. Paul Marsh and Don Sada are to be commended.

If I have a major recommendation for improvement, it is that protective measures for the remaining natural populations should be spelled out more precisely, particularly for the California populations. Mexican populations are obviously beyond our control. In the United States, the Quitobaquito population seems relatively secure, but the precarious status of the California populations is understated.

The San Felipe Creek population is the most secure of the three California populations but it suffers from a lack of quiet water. The stream course lies in a sandy wash that is subjected to repeated flooding. While the population seems always to recover from flooding, its numbers suffer a severe decline nearly every year in late summer during flood season.

Regarding fish in shoreline pools, as of early 1991 there was serious concern that pupfish had been extirpated from the Salton Sea. A survey conducted by the California Department of Fish and Game during spring of that year revealed a remarkable resurgence of pupfish populations in shoreline pools and adjacent irrigation drains. It may be that the extended period of extremely cold weather during the winter of 1990-91 eliminated *Tilapia zilli* from those habitats. Without interference, perhaps in association with the "March miracle," a period of heavy rain and runoff, the pupfish populations were able to recover. Whatever were the circumstances

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321 East Chapman Avenue, Fullerton, California 92632-2095 (714) 992-7000 • FAX (714) 447-4097

favoring recovery, the conditions responsible for the initial decline have not been rectified. In addition, the Salton Sea at the present time is experiencing an unprecedented amount of water pollution.

The population in upper Salt Creek is even more threatened. Based on my quarterly surveys, carried out for three years, I estimate the total population to be small, numbering in the 100s. The population is impacted with non-native species, including potential competitors and predators. A source of non-native fishes occurs upstream at a fish farm and Dos Palmas Oasis. Furthermore, the population lies a few hundred meters downstream from a railroad crossing that formerly carried the ore trains from the Eagle Mountain iron mine. Recently, the Riverside County Board of Supervisors approved, in concept, a trash train that would carry trash from Los Angeles to the former open pit mine. While freight cars would be covered, and modifications may be made to the railroad trestle, it is presumed that the tracks could carry four trainloads a day for a hundred years. It seems to me that there is a significant chance a some sort of accident occurring during that time that could conceivably impact the fish population. What about a diesel spill, for example? In the EIS I read, the only allowance for the pupfish population was that they would be restocked if an accident occurred.

So, I have no quarrel with the adequacy or direction of the recovery plan. It is a fine document. However, as it reads now a poorly informed reader could be led to believe that natural populations in California are relatively secure, which couldn't be farther from the truth.

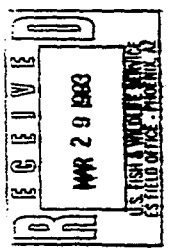
Sincerely,

Allan Schoenherr

Allan A. Schoenherr
Professor of Ecology

Coachella Valley Mosquito Abatement District

83-733 Avenue 55 - Thermal, CA 92274-9491 - (619) 398-0119 - FAX (619) 398-5238



March 25, 1993

Sam Spiller, Field Supervisor
U.S. Fish and Wildlife Service
3616 W. Thomas Road, Suite 6
Phoenix, AZ 85019

RE: Desert Pupfish, Cyprinodon macularius, Recovery Plan

Dear Mr. Spiller:

Thank you for the opportunity to review the recovery plan and to express my idea to utilize desert pupfish for mosquito control. I feel this idea has strong possibilities for everyone's benefit.

Our District would like to make a suggestion to assist in the Recovery Plan of the Desert Pupfish. I believe this fish could be effectively used for control of mosquitoes, midges and other insects in the golf course and country club lakes and ponds in the Coachella Valley and other areas of the Southwest.

Information from various sources such as university thesis and dissertations and papers in Proceedings of Desert Fishes Council indicate the pupfish feeds on aquatic organisms throughout the water column while the mosquitofish, Gambusia affinis, tend to feed primarily in open water and at the surface. It makes sense to utilize a native fish that is also a better predator.

The Coachella Valley has about 85 golf courses with another 25 courses planned for construction within the next 10 years. Each golf course and country club has many lakes and ponds. Through agreements with these golf courses and country clubs, it may be possible to greatly the number of "quasi-natural" refugia (third tier, page 22). Many people living in these protected communities are sensitive to environmental issues such as endangered species.

Our District currently uses mosquitofish in these locations to control mosquitoes. We try to use biological control organisms first, bio-rational compounds such as Bti and other chemicals last. If there is a way to utilize pupfish for mosquito control, we are interested in working cooperatively with state and federal authorities. It would benefit the pupfish by broadening their distribution, increase their populations and their number of refugia. With teamwork, all involved agencies could benefit while improving the situation for the pupfish.

A vector is any insect or other arthropod, rodent or other animal of public health significance capable of causing human discomfort, injury, or capable of harboring or transmitting the causative agent of human disease.

Our District could rear these fish at our facility for future release or use in the habitat described above. If you determine this idea to be worth further discussion, I would be happy to talk with you or your staff. I realize a response to this idea cannot happen overnight. Let's explore the pros and cons to see if we can make it work.

Enclosed are two letters for your review. Please contact me with any questions or comments.

Sincerely,

Michael J. Wargo

Michael J. Wargo
District Manager

Enclosures

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Salton Sea National Wildlife Refuge
P.O. Box 120
Calipatria, CA 92233-0120

March 13, 1993

Field Supervisor
U.S. Fish and Wildlife Service
3616 W. Thomas Road, Suite 6
Phoenix, AZ 85019

Dear Sir/Madam:

Thank-you for the opportunity to comment on the draft Desert Pupfish Recovery Plan. Following are specific suggestions toward improving the draft.

Desert pupfish (Cyprinodon macularius macularius) occur not only in three natural populations in California, but also occur in several irrigation drains leading to the Salton Sea. Therefore, the draft recovery plan should undergo editing to include pupfish occurrence within 72% of surveyed drains around the Salton Sea. A copy of "A Distribution Survey of Desert Pupfish Around the Salton Sea, California" by California Dept. of Fish and Game has been included for your information.

Our office has met with technicians from the Coachella Valley Mosquito Abatement District (CVMAD), and are intrigued with the idea of using desert pupfish for mosquito control in Coachella Valley lakes and ponds. Pupfish, being more adapted to local environmental conditions, may be an ideal biological control for mosquitos, however, there is reluctance to persue the issue because of the fish's endangered species status. In addition, there could be problems in maintaining genetic purity of the fish, but please consider this idea for the draft recovery plan. A copy of our letter to CVMAD is included for your information.

2

Executive Summary	Include under Current Species Status populations of the Colorado form which occur in non-natural areas, i.e. within irrigation drains.
Introduction, 2nd paragraph	Again, include populations of desert pupfish which occur within irrigation drains which lead to the Salton Sea.
Page 6, 2nd paragraph	The Salton Sea, tributary streams, and irrigation drains still support desert pupfish populations.
Page 8, 1st paragraph	Include non-natural populations of desert pupfish which occur in irrigation drains.

3

4

Page 15, 2nd paragraph	Again, pupfish occur not only as remnant populations in tributary streams and shoreline pools, but also within irrigation drains. Include discussion of competitor fish species which occur at the Salton Sea and its drains. Include a discussion of triploid grass carp used for aquatic weed control within drains by the Imperial Irrigation District.
Page 20, 1st paragraph	Include more discussion on contaminant issues facing the Salton Sea area (i.e. selenium, boron, salinity) under threats facing pupfish recovery.
Page 24, 1st paragraph	Plans for pupfish habitat should also ensure adequate water quality (see above).
Page 53	Again, include irrigation drains under Salton Sink.

Please contact me at (619) 348-5278 if you require further information.

Sincerely,

Marcia F. Radke

Marcia F. Radke
Wildlife Biologist

THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

2221 West Greenway Road, Phoenix, Arizona 85023-4399 (602) 942-3000

Commissioners:
Gordon K. Whiting, Central, Chairman
Larry Taylor, Yuma
Elizabeth T. Woodin, Tucson
Arthur Porter, Phoenix
Norm Johnson, Saperstein

Director
Duane L. Shroufe

Deputy Director
Thomas W. Spalding

March 23, 1993

Mr. Sam Spiller, Field Supervisor
Fish and Wildlife Service
Ecological Services
3616 West Thomas Road, Suite 6
Phoenix, Arizona 85019

Dear Sam:

Thank you for the opportunity to review and comment on the "Desert pupfish, *Cyprinodon macularius*, Recovery Plan." We find the document well written, organized and provides guidance for the management and conservation of the species. A major achievement of the plan is that it addresses threats and recovery tasks in both, United States and Mexico. The Department's review comments are enclosed, and editorial comments are simply noted in the margins of the enclosed draft.

If you or your staff have any questions or comments, please contact Dennis Kubly at 789-3516.

Sincerely,

Duane L. Shroufe
Director

DLS:

Enclosures

ARIZONA GAME AND FISH DEPARTMENT
DESERT PUPFISH RECOVERY PLAN REVIEW

1. **Executive Summary:** A. Actions Needed: Action 5 Determine life history and habitat requirements of the three subspecies. The first sentence within the Current Species Status section states that the species is composed of two subspecies.
B. Recovery Objective: Indicate that delisting of the Colorado River form is not considered feasible in the foreseeable future.

2. **Page 1, Paragraph 2:** Add to the last sentence the following: "The Mexican government has also listed the species as endangered (Secretaría de Desarrollo Urbano y Ecología [SEDUE] 1981)." A copy of the reference is attached to this comments. The document should be cited as follows:

   Secretaría de Desarrollo Urbano y Ecología. 1991. Acuerdo por el que se establecen los criterios ecológicos CT-CERN-001-91 que determinan las especies raras, amenazadas, en peligro de extinción o sujetas a protección especial y sus endemismos de la flora y la fauna terrestres y acuáticas en la República Mexicana. Gaceta Ecológica. 15:2-27.

3. **Page 6, Paragraph 4:** Replace "AZGFD files" with Bagley et al. (1991) and Brown and Abarca (1992) as better citations of information.

4. **Page 7, Paragraph 1:** The sentence: "However, the subspecies has been transplanted from Santa Clara Slough, Mexico, to a number of locations within the state" should read "However, the subspecies has been transplanted from Dexter National Fish Hatchery (Santa Clara Slough origin), to a number of locations within the state."

5. **Page 7, Paragraph 1:** At least 8 Colorado River form desert pupfish populations (Deer Valley High School, Boyce-Thompson Arboretum, Flowing Wells Junior High School, Desert Botanical Garden, private [W.L. Minckley], private [R. Engel-Wilson], Arizona Historical Society [Tucson], AD-Wash [transplanted on March 1993]) are known to exist as of March 1993. Status for five additional populations (Howard Well, Roper Lake State Park, Buehman Canyon, Hassayampa River Preserve, Cold Spring Seep) is uncertain as of March 1993. Population status in California and Mexico should be updated as of spring 1993.

6. **Page 20, Paragraph 2:** Since 1992, the Secretaría de Desarrollo Urbano y Ecología (SEDUE) is now called Secretaría de Desarrollo Social (SEDESOL). The acronym should be changed throughout the document.

7. Page 28, Paragraph 2: Reintroduction efforts in the Arizona portion of the lower Colorado River must only use broodstock from Dexter National Fish Hatchery (Santa Clara Slough origin) unless future studies clearly demonstrate that use of other lineages is advantageous.

8. Page 28, Paragraph 2: Add the following paragraph: "A cooperative agreement with Mexico should be developed and pursued to allow future acquisition of desert pupfish broodstock. Addition of individuals from existing natural populations (Santa Clara Slough, El Doctor) will alleviate problems associated with in- and outbreeding depression which may occur in refugia populations."

9. Page 30, Paragraph 3: Replace "AZGFD files" with Bagley et al. (1991) and Brown and Abarca (1992) as better citations for this information.

10. Page 35, Paragraph 2: Present development plans north of Santa Clara Slough and operation of the desalinization plant in Yuma may threat the continuous existence of this desert pupfish population. None of these is discussed in the document.

11. Page 51, Priority 2, Task 3.0: Under responsible party - other Arizona Game and Fish Department is abbreviated AZGF, it is AGFD elsewhere in the Implementation Schedule, and AZGFD throughout the document.

12. Page 54, Table 2: Population status must be reflected as in item 5 (above) with the additional information:

    2. Howard Well: Status uncertain as of March 1993.
    3. Deer Valley High School: transplant date(s) 1983, 1987, 1991.
    8. Roper Lake State Park: Status uncertain as of March 1993.
    10. Buehman Canyon: Status uncertain as of March 1993.
    11. Hassayampa River Preserve: Status uncertain as of March 1993.
    12. Cold Spring Seep: Status uncertain as of March 1993.

13. Page 56, Table 3: Bog Hole: Possibly extinct.

A R I Z O N A S T A T E U N I V E R S I T Y
Center for Environmental Studies
Tempe, AZ 85287-3211
(602) 965-2977 FAX (602) 965-8087
E-mail ICPCM@ASUACAD

24 March 1993

Field Supervisor
U.S. Fish and Wildlife Service
3616 West Thomas Road, Suite 6
Phoenix, Arizona 85019

Dear Sir:

As requested, I have reviewed the draft Desert Pupfish, Cyprinodon macularius, Recovery Plan. Revisions by the Service are generally acceptable, however, several comments, suggestions, and corrections are offered for your consideration. These are provided sequentially as they appear in the Plan.

Under Current Species Status within the Executive Summary, the last sentence needs to be restructured. The "status" of the Rio Sonoyta population is not "limited," rather its taxonomic status is uncertain (at the subspecific level), while its distribution is apparently "quite limited."

Protection and establishment of refugium populations of the Quitobaquito and Rio Sonoyta forms of desert pupfish should be included among Recovery Criteria, since the tasks are specifically identified in the Narrative Outline (see also below).

Under Recovery Criteria, are all extant populations (including transplants, refugia, and aquaria) to be secured, maintained and replicated, or only extant natural populations? This should be clarified.

Page 1, 3rd line from bottom. Add IUCN 1990 to the Miller 1979 reference (citation provided below, along with others mentioned here).

Page 1, last line. California Department of Fish and Game should be abbreviated CADFG (global change throughout document).

Page 2, line 8. Delete "as" in the statement "...are referred to as C. m. macularius..."

Page 3, last line. Underline macularius

Page 4, para 1. Include CAS record provided in litt. by R.R. Miller, and plot Puerto Penasco location on Fig. 1 (page 5).

Page 6, last line. Extirpated and most captive stocks of desert pupfish have been eliminated from the Appendix. What is the justification for this deletion? (more on this below).

Page 7. Text should be updated to include information in Brown and Abarca (1991), Bagley et al. (1992), and NPS (1992), plus other monitoring/trip reports prepared by AZGFD, Service, or other entity.

Page 7, para 3, last sentence. Restructure to read as follows: "These populations should be destroyed because they all are outside the historic range of the subspecies, are of questionable genetic purity, and threaten recovery of downstream populations."

Page 7. A paragraph from the technical draft (immediately preceding California), which presented "failed" populations and introduced the appendix, has been deleted. What is the justification for this deletion, and of the appendix? This information is valuable because it provides guidance in selection of potential transplant/refugium sites, and provides an important historical perspective. Further, while I have always been concerned about the proliferation of desert pupfish into private ponds and aquaria for reasons that are less than obvious, acknowledgement and identification of these "populations" is nonetheless a requirement of the Plan. If the Service chooses to hide such populations (both extant and extirpated) by requiring the reader to search AZGFD files, a reason for this posture should be provided. At the very least, reference should be made to appropriate reports (e.g., Bagley et al. 1991, Brown and Abarca 1992, and others) where this information is available. As an author of the technical draft and compiler of original data, I would like to see the Appendix resurrected. See also page 28 last para, for further justification.

Page 8, first para. Plug in transplant records in Miller (1968), with citation.

Page 8, second para, next to last sentence. Recently extirpated populations are not included in Table 2.

Page 10, second para, first sentence. Switch the s's between behavior and include.

Page 14, second line. Matsui (1981) is not in the literature cited.

Page 14, second para, middle. Fix sentence to read "... because of increased depth and which, because of its lentic character..."

Page 14, last complete sentence into first on page 15. This was changed from the technical draft so that statement is no longer precise. It should be appropriately modified. For example, adult (implied) largemouth bass do not occupy shallow habitat used by desert pupfish.

Page 16, first para, last sentence. Add an s to bullfrog.

Pages 18-19. Protection and establishment of refugium populations of Quitobaquito and Rio Sonoyta forms of desert pupfish are integral parts of the Plan, and thus should be included among downlisting criteria. According to criteria as stated, these forms could be extinguished and the Colorado River form could still be downlisted. This was not the intent of the technical draft, nor would such an eventuality be acceptable. See also bottom page 20-top page 21.

Page 23, first line. Delete "Norte."

Page 25, last complete para. Change to "Each operation must be supported..."

Page 26, second para. add an s to "include"

Page 29, Specifications. I do not agree at all with even "minor" management of tier 2 populations (other than monitoring and genetic maintenance) because the term is inexact and subject to differing interpretation (depending on who or what entity is doing the interpretation). A door is opened here that could lead to significant confrontations in the future, to the detriment of the species. This section must be changed to indicate that tier 2 populations can be counted toward recovery only if they have persisted for 10 years without human intervention.

Page 30, last para and 31, first para. The reader should not be referred to AZGFD files for information on pupfish transfers (successful and otherwise). Either the original appendix should be resurrected (preferred) or appropriate agency reports should be referenced.

Page 31, first complete sentence. Delete s from "appears"

Literature cited should be carefully checked for errors, and cross-referenced to the text to ensure that all citations are referenced (I did not do this).

Implementation schedule (tabulation): preferred acronym for Arizona Game and Fish Department is AZGFD, and for California Department of Fish and Game is CADFG.

Table 1, last line. Change sp to ssp.

Table 2, items 6 and 25. As indicated above, mention of "Numerous captive aquarium populations (AZGFD files)" is inadequate. This Plan should provide complete information in this regard, as the Plan may be readily available long after the voluminous grey literature from which the original appendix was complied has become lost or obscured. We owe it to future scientists and managers to leave as complete a record as possible.

References to be incorporated into text and included in literature cited:

Bagley, B.E., D.A. Hendrickson, F.J. Abarca, and S.D. Hart. 1991. Status of the Sonoran topminnow (Poeciliopsis occidentalis) and desert pupfish (Cyprinodon macularius) in Arizona. Arizona Game and Fish Department, Phoenix. 64 pages.

Brown, M. and F.J. Abarca. 1992. An update status report of the Sonoran topminnow (Poeciliopsis occidentalis) and desert pupfish (Cyprinodon macularius) in Arizona. Arizona Game and Fish Department, Phoenix. 37 pages.

IUCN (International Union for the Conservation of Nature and Natural Resources). 1990. 1990 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland and Cambridge, U.K. 228 pages.

Miller, R.R. 1968. Records of some native freshwater fishes transplanted into various waters of California, Baja California, and Nevada. California Fish and Game 54(3): 170-179.

NPS (National Park Service). 1992. Annual summary of activities, Quitobaquito desert pupfish (Cyprinodon macularius eremus). Organ Pipe Cactus National Monument, Arizona. 10 pages.

Thank you for this opportunity to comment on the draft Desert Pupfish Recovery Plan. Please contact me if you have any questions or require further information.

Sincerely,

Paul C. Marsh
Research Professor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR
FISH AND WILDLIFE SERVICE

In Reply Refer To:
FWS/MA

MAR 29 1993

Memorandum

To: Field Supervisor, Ecological Services Field Office, Phoenix, AZ

From: Chief, Division of Fish & Wildlife Management Assistance

Subject: Desert Pupfish Draft Recovery Plan

We have reviewed the draft recovery plan and, for the most part, concur with its content and direction. We are particularly pleased with its recognition of the interaction between habitat alteration and introduced species and the proposed efforts to deal with both. We are also very interested in following the progress of your efforts to develop protocols for genetic exchange. Two general concerns relate to the use of language not likely understood by the public and occasional reference to target numbers or ratios without explaining the basis for their selection. The status of populations of desert pupfish in the Salton Sink needs clarification and we are concerned with the suggestion that certain populations of pupfish should be destroyed. These and a number of other specific concerns and editings are addressed more fully in the attached comments.

Two people whose names did not appear on the Recovery Team listing who would make excellent reviewers are Phil Pister (Desert Fishes Council) and Dr. Peter Moyle (University of California, Davis).

Thank you for the opportunity to comment on the document. If you have any questions about our comments, please feel free to contact Dennis Lassuy at (703) 358-1718.

Attachment

RECEIVED
MAR 31 1993
U.S. FISH & WILDLIFE SERVICE
ES FIELD OFFICE - PHOENIX, AZ

Comments on Desert Pupfish Draft Recovery Plan:

General

There are a number of places throughout the document where language is used that may not be widely understood (e.g., panmixia [p.6], ejido [p.23], phreatophyte [p.24]). Alternative language or explanations of such words are in order in a public document that addresses a species of national concern.

Proposed actions to mitigate most of the cited threats to the desert pupfish (nonindigenous species, water control, habitat alterations) are addressed under the Recovery Tasks. Pollution in the form of aerial pesticide application is also cited as a threat but receives no specific mention in the Recovery Tasks. Was this an oversight or was there a reason for this?

Page 6, paragraph 2:

Reference is made here to desert pupfish colonizing the Salton Sink as the consequence of a "diversion of the Colorado River." Yet, throughout the remainder of the document, you refer to pupfish in the Salton Sink as naturally occurring populations. This needs to be clarified. If the species is native to this area, it should be protected as indicated in the document. If it is present as the result of human activity, it is nonindigenous and may require some reconsideration of proposed protection measures and downlisting criteria. Would this, in fact, suggest "experimental population" designation under the Endangered Species Act?

P.7, par. 2, first sentence:

It appears that you are saying that a large population of *C.m. macularius* inhabits Quitobaquito Spring, are you actually referring to *C.m. eremus*?

P.7, par.3, last sent.:

We are troubled with the suggestion that several populations of "questionable genetic purity" be destroyed. At a minimum, before destroying these fish, the "question" of genetic purity should first be addressed. In particular, the types of concerns raised in the recent article of Dowling and Childs (1992, see Conservation Biology 6(3):355-364) regarding the potential dangers in destroying such fish should be addressed. Another alternative to destruction would be to use these fish for the public displays called for under Recovery Task No. 7 (Information and Education, p. 38).

P.10, par.3:

Is it really necessary to carrying out the Recovery Plan to include such extensive details on the spawning behavior of the species?

P.12, par.2, last sent.:

The authors noted that "other mortality factors have not been investigated," but then go on (pp.14-15) to discuss studies of other mortality factors such as nonindigenous species and water manipulations.

P.13, first heading:

It appears that "co-occurring fishes" refers only to co-occurring native fishes. If so, the title should reflect this.

P.14, partial sentence at top:

Cited interactions with nonindigenous species include only competition and predation. Are hybridization and pathogen transfer not evident or suspected?

P.14, par.2:

If the terms "non-native" and "exotic" are used synonymously (as appears to be the case), this should be noted. Consistent use of one or the other would be preferable.

Also in this paragraph, certain conclusions are made about the effects of nonindigenous species. Though these are supported in later text, a reference to the existence of supporting evidence should be made at the point that the conclusion is made.

P.17, Recovery, par. 1:

It seems that an effort should be made, regardless of the likelihood of its successful achievement, to at least define what would need to occur to enable delisting.

P.18, par.2:

"... a viable population ... will include not fewer than 500 overwintering adults or existing numbers ... in a normal sex ratio ..." What is the basis for the number 500? What is the basis for accepting existing numbers as viable and could this weaken the rationale for setting 500 as a target? What is a normal sex ratio for this species?

P.20, par.1, line 4:

"... watershed ~~struggle to~~ stabilize." — assigns anthropomorphic traits to watersheds.

P.29, Re-establishment targets table:

What is the basis for the target numbers under tiers 2 and 3?

P.31, Task 3, par.1:

In other recovery plans for species restricted to a single site (e.g., Borax Lake Chub, *Gila boraxobius*), it is recognized that the species may be unique precisely because of the particular characteristics of that environment. The establishment of a second population is specifically discouraged except as a last resort. How does this differ in the case of Quitobaquito Spring pupfish?

Also in this paragraph, again what is the basis for the number 500 and the 1:1 sex ratio? Is this 1:1 ratio the "normal sex ratio" (p.18) for the species?

P.32, Task 4:

We applaud the Recovery Team's intent to develop a protocol for genetic exchange for the desert pupfish and are hopeful that it will aid the successful recovery of the species. We also believe that the exercise will prove useful to other Service functions. We encourage the team to continue to share the results of this effort. One concern we have with the protocol development is alluded to in the final sentence of this section (p.33) in referring to possible pre-existing anthropogenic influences. How will this affect the selection of your baselines (controls) for genetic comparisons?

P.35, par.1, line 4:

Again, what is the basis for the numbers? Why 50 pupfish and why 25 of each sex?

P.38, Task 7:

We strongly support the intent to use "information and education" programs to help promote a successful recovery of the species. Again, however, we would encourage you to consider using the previously cited pupfish "of questionable genetic purity" for the public displays instead of destroying them and then depending on pupfish otherwise useful to recovery.

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

IN REPLY REFER TO:

LC-1578
ENV-4.00

MAR 30 1993

Memorandum

To: Mr. Sam Spiller, Field Supervisor, Division of Ecological Services, Fish and Wildlife Service, 3616 W. Thomas Road, Suite 6, Phoenix AZ 85019

From: Regional Environmental Officer

Subject: Review of Draft Recovery Plan of Desert Pupfish, Cyprinodon Macularius (Endangered Species)

We have reviewed the subject draft and have no comments or suggestions to make. The plan is clear, concise, and well written. The authors should be congratulated for a job well done.

Thank you for the opportunity to comment on this important document. If you have any questions, please contact Mr. Tom Burke at 702-293-8711.

William E. Rinne

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U.S. FISH & WILDLIFE SERVICE
ES FIELD OFFICE - PHOENIX, AZ

ARIZONA DEPARTMENT OF WATER RESOURCES
15 South 15th Avenue, Phoenix, Arizona 85007
Telephone (602) 542-1553
Fax (602) 256-0506

FIFE SYMINGTON
Governor

RITA P. PEARSON
Director

March 30, 1993

Gilbert D. Metz
Acting Field Supervisor
U.S. Fish and Wildlife Service
3616 West Thomas Road, Suite 6
Phoenix, AZ 85019

Re: Comments on the Desert Pupfish Recovery Plan.

Dear Mr. Metz:

The Department has reviewed the report, submitted to us for comment, on the Desert Pupfish Recovery Plan. Listed under Recovery Task 1. was mention of acquiring water rights and legally protecting instream flows. If more information is needed in these two matters, or assistance please let us know.

If you have any questions please feel free to contact me at 542-1552.

Sincerely,

Mason R. Bolitho

Mason Bolitho
Division Manager
Program Planning and Management

cc: Greg Bushner, ADWR Hydrology Division

INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

OFFICE OF THE COMMISSIONER
UNITED STATES SECTION

MAR 2 1993

Mr. Sam Spiller
Field Supervisor
Arizona Ecological Services Field Office
U.S. Fish and Wildlife Service
3616 West Thomas Road
Suite 6
Phoenix, Arizona 85019

Dear Mr. Spiller:

Thank you for the February 2, 1993, letter signed by Acting Field Supervisor Gilbert D. Metz, providing the United States Section of the International Boundary and Water Commission, United States and Mexico (USIBWC), the review draft of the recovery plan for the desert pupfish (Cyprinodon macularius). The desert pupfish is listed as endangered under the Endangered Species Act of 1973, as amended, and you have requested agency and public comments on the draft plan.

The draft plan indicates that the desert pupfish is a member of the Cyprinodontid Family. It was once widespread and abundant in portions of southern Arizona and southeastern California in the United States, and northern Baja California and Sonora in Mexico. Naturally-occurring populations of the desert pupfish are now restricted in Arizona to Quitobaquito Springs and in California to two streams tributary to, and a few shoreline pools of, the Salton Sea. The species is currently found in Mexico at scattered localities along Rio Sonoyta, on the Colorado River delta, and in Laguna Salada basin. The desert pupfish is threatened with extinction throughout its native range primarily because of habitat loss or modification, pollution, and introduction of exotic fishes.

The USIBWC is concerned about the extraterritorial application of the desert pupfish recovery plan. The draft plan envisions the management of ground water along the border to assure sufficient water, particularly at Quitobaquito Spring, Arizona. Within the draft plan there is the potential for an international agreement to control the use of ground water; and the United States, at this time, is not prepared to enter into negotiations for a United States and Mexico ground-water treaty.

Other issues that must be addressed include those of surface water quality and quantity associated with the Colorado River and the Santa Clara Slough. The Santa Clara Slough in Baja

THE COMMONS, BUILDING C, SUITE 310 • 4171 N. MESA STREET • EL PASO, TEXAS 79902
(915) 534-6700 • (FTS) 570-6700

California is designated by the recovery plan as one of the areas in Mexico where naturally occurring populations occur and that must be secured for downlisting to be considered.

As you are aware, the USIBWC by virtue of the Treaty of February 3, 1944, for "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande" (TS 994; 59 Stat. 1219), and agreements concluded thereunder by the United States and Mexico, is responsible for ensuring that the United States Government meets the obligations incurred in those agreements. The USIBWC's statutory authority for carrying out those actions in the United States under these agreements rests in 22 U.S.C. 277 a-d.

The 1944 Water Treaty distributed between the two countries the waters of the Rio Grande and the Colorado River. The 1944 Treaty provides a guaranteed annual quantity of 1,850,250 thousands of cubic meters (1.5 million acre-feet) of the Colorado River waters be delivered in accordance with schedules formulated in advance by Mexico within specified limitations, and it also provides any other waters arriving at the Mexican points of diversion under certain understandings. These deliveries are made to Mexico by the USIBWC at Morelos Dam on the Colorado River near Yuma, Arizona. Releases are made from upstream reservoirs to assure that treaty obligations reach Morelos Dam for diversion by Mexico.

On August 30, 1973, the United States and Mexico reached agreement under the terms of the 1944 Water Treaty for a "Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River" (International Boundary and Water Commission Minute No. 242). This Minute provided for immediate reduction in the salinity of the waters delivered to Mexico, stipulating that the United States shall adopt measures to assure that the waters delivered upstream of Morelos Dam have an annual average salinity of no more than 115$\pm$30 parts per million over the annual average salinity of the Colorado River at Imperial Dam.

Immediate interim measures were put into effect under the authorization of the Colorado River Salinity Control Act of June 24, 1974. The United States Bureau of Reclamation constructed works which bypassed all of the saline drainage waters to the Santa Clara Slough in Mexico on the Gulf of California. Waters of low salinity were substituted for the bypassed waters.

Compliance with the agreement is jointly monitored by the USIBWC and Mexican Section of the International Boundary and Water Commission (MXIBWC). The waters delivered upstream from Morelos Dam are jointly sampled each weekday, and they are analyzed for their salt content by the USIBWC and the MXIBWC, and the results

are jointly compared by the International Boundary and Water Commission. Since the agreement was signed, the records show that the United States is fully complying with its terms.

It was recognized that to continue the interim measures to implement the agreement with Mexico would result in a serious loss of waters needed to meet Colorado River Basin uses within the United States. The Salinity Control Act authorized the construction, operation and maintenance of a desalting plant in the United States to reduce the salinity of the drain waters. The Yuma Desalting Plant is now constructed and is presently undergoing startup studies at one-third operation through 1994. As the plant is brought into full operational capacity, the reject waters will become more and more saline. If there is a requirement to dilute the reject waters to protect the Santa Clara Slough, there could be an international problem as the waters of the Colorado River are over appropriated. We doubt that Mexico would be willing to use any of its treaty waters from the Colorado River, or from other Mexican sources to dilute the reject stream for the protection of the habitat.

The USIBWC would be favorable to the United States Fish and Wildlife Service utilizing sites in Mexico if it can be done without governmental involvement, that is if non-governmental organizations can purchase lands and available water rights to protect the habitat. Can the Service consult with the USIBWC on site specific recovery plans? In this manner potential international problems possibly could be avoided. We foresee such problem areas to be avoided as international ground-water management, increasing the United States commitment to deliver Colorado River to Mexico through the Santa Clara drain, changing the operations of the Yuma Desalting Plant, etcetera.

The USIBWC is currently consulting with the Department of State on the issues raised by the desert pupfish recovery plan, and we respectfully request that no action be taken until that consultation is completed. We are prepared to work with you in assuring that treaty obligations are met and avoiding international problems while at the same time providing for recovery of endangered species.

Sincerely,

for Conrad G. Keyes, Jr.
Principal Engineer, Planning

cc: Department of State, Attorney Adrian Steffan
U.S. Bureau of Reclamation, Yuma

United States Department of the Interior

TAKE PRIDE IN AMERICA

FISH AND WILDLIFE SERVICE
911 N. E. 11th Avenue
Portland, Oregon 97232-4181

APR 26 1993

Memorandum

To: Field Supervisor, Arizona Ecological Services Field Office
Phoenix, Arizona

From: Acting Assistant Regional Director-Ecological Services
Region 1, Portland, Oregon

Subject: Review of Technical/Agency Draft Desert Pupfish Recovery Plan

Thank you for the opportunity to review the subject technical/agency Draft Desert Pupfish Recovery Plan. We have forwarded a copy of the Plan to our Carlsbad Field Office and you should be receiving their comments within 2 weeks. For any further questions, please call Art Davenport, Carlsbad Field Office at (619) 431-9440.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
Carlsbad Field Office
2730 Loker Avenue West
Carlsbad, California 92008

July 19, 1993

MEMORANDUM

To: Field Supervisor,
Arizona Ecological Services Field Office, Region 2

From: Acting Field Supervisor

Subject: Review of Desert Pupfish Recovery Plan

Staff at the Carlsbad Field Office have reviewed the draft Desert Pupfish, Cyprinodon macularius, Recovery Plan (Plan) and have developed the following comments and recommendations.

Page; Executive Summary; Under Habitat Requirements and Limiting Factors, we recommend the following addition: ...streams and margins of large lakes and rivers...

Under Recovery Objectives, we believe it would be clearer if two separate sentences were developed.

Under Recovery Criteria, we recommend the following modification: ...until a viable population has persisted for...

Page 1; Move "I. Introduction" to left margin

Page 2; Top of page, underline "Description"

Page 4; Underline "Distribution and Abundance"

Page 5; A more detailed map indicating counties and drainages would be helpful

Page 6; Include panmixia in the Glossary of Terminology

Page 7; General Comment: Prior to populations being destroyed due to "questionable genetic purity", conclusive information regarding their genetic makeup should be obtained.

The population of desert pupfish within the Salton Sea raises several issues which may need addressing in the Plan. Based on the results of recent surveys, Nicol et al. (1991), desert pupfish likely occupy more than a few shoreline pools. With this apparent increase in desert pupfish

population numbers it seems plausible that the movement of genetic material between the Salt Creek population and the San Felipe Creek population currently exists. Planned water conservation measures, if implemented, will affect the aquatic ecosystem of the Salton Sea and shorten the amount of remaining time that introduced fishes can persist due to increases in salinity. This loss of introduced fishes will likely benefit the desert pupfish but may cause harm through the loss of suppression large predatory fish may have on potential competitors and smaller predators. The Salton Sea issue is further complicated by the presence of a variety of contaminants (e.g., selenium, DDT, and metabolites of DDT). Information needs to be developed concerning the affects of these substances on the desert pupfish and should be identified as an action within the Plan.

Page 8; 2nd paragraph; 3rd sentence; ...in Baja California are found...

Page 8; Underline "Life History"

Page 13; Underline "Reasons for Listing"

Page 14; Add lentic to the Glossary of Terminology

Page 17; Move "II. Recovery" to left margin

Page 19; General comment: Having a legally binding, long-term (>25 years) agreement would not seem to meet the "perpetual" standard. That is, an agreement that provides protection for 30 years should not be considered adequate in regards to downlisting or delisting a species if threats return at the end of the agreement.

Page 19; Underline "Narrative Outline for Recovery Actions Addressing Threats"

Page 27; Add SEDUE and CES to the Glossary of Terminology

Page 30; 1st paragraph; 2nd sentence; ...security as regards to land ownership...

Page 49; Underline "Glossary of Terminology"

If you have any questions regarding our recommendations or comments please contact Arthur Davenport at (619) 431-9440

Reference

Nicol, Kimberly, L. Sabrina, and C. Boehm. 1991. A distribution survey of desert pupfish (Cyprinodon macularius) around the Salton Sea, California. Prepared for California Department of Fish and Game, Inland Fisheries Division.

SECRETARIA DE DESARROLLO SOCIAL

INSTITUTO NACIONAL DE ECOLOGIA.
DIRECCION GENERAL DE APROVECHAMIENTO
ECOLOGICO DE LOS RECURSOS NATURALES.
RIO ELBA No. 20, 10o. PISO.
COL. CUAUHTEMOC
06500 MEXICO. D.F.

FORMA C G - 1 A

OFICIO No. A00702. 01994

Ciudad de México. 12 MAYO 1993

GILBERT D. METZ.
ACTING FIELD SUPERVISOR
U.S. FISH AND WILDLIFE SERVICE
3616 W. THOMAS ROAD.
SUITE 6, PHOENIX, ARIZONA 85019
U.S.A.

ANEXO

Me refiero a su escrito mediante el cual envía el plan de recuperación para Cyprinodon macularius especie amenazada incluida en la lista del Acta de Especies Amenazadas de 1973, a fin de que se envíen comentarios e información referente al citado plan con el propósito de ser considerados en el Desarrollo del plan de recuperación final.

Sobre el particular, anexo envio nota informativa que contiene algunos comentarios respecto al citado plan.

Sin otro particular, le reitero mi consideración más distinguida.

SUFRAGIO EFECTIVO. NO REELECCION.
EL DIRECTOR GENERAL.

DR. EXEQUIEL EZCURRA.

SECRETARIA DE DESARROLLO SOCIAL
INSTITUTO NACIONAL DE ECOLOGIA
DIRECCION GENERAL DE APROVECHAMIENTO
ECOLOGICO DE LOS RECURSOS NATURALES

C.c.p. C. Fis. Sergio Reyes Luján.-Presidente del Instituto Nacional de Ecología.-Pte
C. Biól. Wilfrido Márquez Ramírez.-Director de Conservación y Manejo.-Pte
C. Biól. Eleazar Loa Loza.-Subdirector de Evaluación y Diagnóstico.-Pte
C. M. en C. Silvia E. Zárate Vidal.-Jefa del Depto. de Evaluación.-Pte.
- Archivo General (1730).-

EE/VMR/ELL/SEZV/amcs

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JUN - 7 1993
U.S. FISH & WILDLIFE SERVICE
ES FIELD OFFICE - PHOENIX, AZ

ASUNTO: COMENTARIOS AL PLAN DE RECUPERACION DEL "PUPFISH DEL DESIERTO" Cyprinodon macularius.

EL "PUPFISH DEL DESIERTO" Cyprinodon macularius BAIRD Y GIRARD ES UN PEZ PEQUEÑO DE LA FAMILIA Cyprinodontidae, QUE SE DISTRIBUYE AMPLIAMENTE Y ES ABUNDANTE EN LAS PORCIONES DEL SUR DE ARIZONA Y SURESTE DE CALIFORNIA, ESTADOS UNIDOS, ASI COMO EN EL NORTE DE BAJA CALIFORNIA Y SONORA EN MEXICO; SE SEÑALA LA EXISTENCIA DE 3 SUBESPECIES, DOS DE ELLAS YA BIEN DEFINIDAS Y OTRA MAS EN ESTUDIO (INDESCRITA), ESTA ULTIMA ES LA QUE SE DISTRIBUYE EN MEXICO. Cyprinodon macularius OCUPA UNA GRAN DIVERSIDAD DE HABITATS, DESDE CIENEGAS Y ARROYOS HASTA PEQUEÑOS RIOS Y LAS MARGENES DE GRANDES CORRIENTES; REQUIERE DE AGUAS SOMERAS CON SUSTRATO BLANDO Y AGUAS CLARAS. ES UNA ESPECIE CON UNA EXTRAORDINARIA HABILIDAD PARA SOBREVIVIR BAJO CONDICIONES EXTREMAS, COMO SON ALTAS TEMPERATURAS DEL AGUA, BAJAS CONCENTRACIONES DE OXIGENO DISUELTO Y ALTA SALINIDAD, LO CUAL EXCEDE LAS TOLERANCIAS PRESENTADAS POR OTRAS ESPECIES DULCEACUICOLAS. TAMBIEN SOBREVIVE A LOS CAMBIOS BRUSCOS DE SALINIDAD Y TEMPERATURA, LO QUE ES LETAL PARA OTRAS MUCHAS ESPECIES DE PECES.

LA INFORMACION INCLUIDA EN EL PLAN DE RECUPERACION PERMITE TENER UNA IDEA DE TODOS LOS ASPECTOS QUE HAN SIDO TRATADOS EN ESTA ESPECIE, LOS QUE ABARCAN DESDE ESTATUS TAXONOMICO, DISTRIBUCION Y ABUNDANCIA, HISTORIA DE VIDA EN LO REFERENTE A HABITAT, REPRODUCCION, CRECIMIENTO, ALIMENTACION Y HABITOS ALIMENTARIOS, ASI COMO LA CO-OCURRENCIA CON OTRAS ESPECIES, Y UN ASPECTO MUY IMPORTANTE QUE YA SE HA INVESTIGADO ES LO QUE SE REFIERE A LAS RAZONES QUE HAN AFECTADO O HAN PROVOCADO LA DECLINACION DE LAS POBLACIONES NATURALES DE ESTA ESPECIE.

EL ASPECTO MAS IMPORTANTE QUE MANEJAN EN ESTE PLAN DE RECUPERACION, SE REFIERE A QUE LAS POBLACIONES HAN DISMINUIDO PRINCIPALMENTE DEBIDO A LA PERDIDA DE HABITATS, A LA MODIFICACION DE LOS MISMOS, A LA CONTAMINACION Y A LAS INTERACCIONES CON ESPECIES EXOTICAS CON LAS CUALES COMPITEN POR ESPACIO, ALIMENTO Y POR LAS QUE SUFREN DEPREDACION. ALGUNOS PUNTOS DE ESTOS ASPECTOS YA SE HAN ESTUDIADO Y ELLO A PERMITIDO OBTENER MAYOR INFORMACION AL RESPECTO.

EN MEXICO SE REQUIERE PROFUNDIZAR EN EL ESTUDIO DE LA DISTRIBUCION Y ABUNDANCIA DE LAS POBLACIONES DE LA SUBESPECIE INDESCRITA QUE SE ENCUENTRA EN EL RIO SONOYTA EN SONORA; ASI COMO LAS DE Cyprinodon m. cremus TANTO EN SONORA COMO EN BAJA CALIFORNIA.

OTRO ASPECTO QUE REQUIERE DE ESTUDIO ES EL CONOCIMIENTO GENETICO DE LAS MISMAS, PARA DETERMINAR LA PUREZA GENETICA DE LAS POBLACIONES QUE SE ENCUENTRAN DISTRIBUIDAS FUERA DEL RANGO HISTORICO DE DISTRIBUCION, YA QUE ESTA SITUACION AMENAZA LA RECUPERACION DE POBLACIONES.

LOS OBJETIVOS SEÑALADOS EN EL PLAN DE RECUPERACION INCLUYEN LA DESCRIPCION DE LAS ACCIONES NECESARIAS PARA ELIMINAR LA PERDIDA DE POBLACIONES Y ESTABLECER ACCIONES QUE EN LO SUCESIVO AYUDEN AL RESTABLECIMIENTO DE LA ESPECIE EN HABITATS SEGUROS DENTRO DE SU RANGO HISTORICO DE DISTRIBUCION PROBABLE.

EL ALCANCE DE ESTOS OBJETIVOS ES MUY AMPLIO, YA QUE INCLUYE:

1) PROTECCION DE LAS POBLACIONES NATURALES DEL PUPFISH DEL DESIERTO.

2) RESTABLECIMIENTO DE LAS POBLACIONES DE ESTE PEZ.

3) ESTABLECIMIENTO DE UN REFUGIO PARA LA POBLACION DEL "QUITOBAQUITO PUPFISH" (C. m. cremus).

(ESTA SUBESPECIE, NATURALMENTE, SOLO SE DISTRIBUYE EN QUITOBAQUITO SPRING, ARIZONA, Y ACTUALMENTE SU ABUNDANCIA SE DESCONOCE PORQUE EL HABITAT HA SIDO MODIFICADO PRINCIPALMENTE POR EL HOMBRE).

4) DESARROLLO DE PROTOCOLOS PARA EL INTERCAMBIO DE MATERIAL GENETICO ENTRE POBLACIONES DE C. macularius (EN ESTE PUNTO ES IMPORTANTE ANALIZAR LA PARTICIPACION MEXICANA.

MEXICO ES JOVEN EN EL CAMPO DE LA INVESTIGACION GENETICA EN PECES, POCOS SON LOS RECURSOS HUMANOS CON QUE CUENTA EN ESTA DISCIPLINA Y ES AQUI DONDE VALDRIA LA PENA ENCAMINAR MUCHOS ESFUERZOS PARA SALIR AVANTE EN ESTE PUNTO QUE ES DE GRAN IMPORTANCIA. ESTE VA A SER EL PUNTO DE PARTIDA PARA LOGRAR DETERMINAR LA PUREZA DE LAS POBLACIONES, PORQUE DE ELLA DEPENDE LA RECUPERACION DE LAS MISMAS, ES DECIR QUE LA RECUPERACION SE REALICE CON POBLACIONES GENETICAMENTE PURAS QUE POSTERIORMENTE PERMITAN MANTENER LOS NIVELES NATURALES DE LA DIVERSIDAD GENETICA).

5) MONITOREO Y MANTENIMIENTO NATURAL, RESTABLECIMIENTO Y REFUGIO DE LAS POBLACIONES.

6) DETERMINACION DE LOS FACTORES QUE AFECTAN LA PERSISTENCIA DE LAS POBLACIONES.

7) INFORMACION Y EDUCACION.

ESTOS SIETE PUNTOS CONFORMAN LAS TAREAS QUE SE LLEVAN A CABO EN ESTE PLAN, CADA UNA DE ELLAS TIENE UN APOYO FINANCIERO; EN ESTE PLAN SE INVOLUCRA A LAS INSTITUCIONES EDUCATIVAS, CIENTIFICAS Y GUBERNAMENTALES DE AMBOS PAISES.

LAS ACCIONES DENTRO DE ESTE PLAN DE RECUPERACION ESTAN ENFOCADAS DE LA SIGUIENTE MANERA: EN ESTADOS UNIDOS SE DARA ENFASIS A LOS HABITATS RELATIVAMENTE PEQUEÑOS Y AL ESTABLECIMIENTO DE REFUGIOS PARA LAS POBLACIONES, MIENTRAS QUE EN MEXICO LAS ACCIONES ESTARIAN ENCAMINADAS A LA PROTECCION DE TIERRAS PANTANOSAS Y GRANDES EXTENSIONES OCUPADAS POR EL PUPFISH DEL DESIERTO" Y OTRAS ESPECIES NATIVAS.

LA PROTECCION DE LA TIERRA Y AGUA EN LA CUAL SE DISTRIBUYE ESTA ESPECIE ES MUY IMPORTANTE. MUCHOS DE LOS HABITATS EN LOS QUE SE DISTRIBUYE LA ESPECIE (POBLACIONES SILVESTRES) PRESENTAN PROBLEMAS PORQUE SON TIERRAS DE PROPIEDAD PRIVADA, PRINCIPALMENTE EN SONORA Y BAJA CALIFORNIA, MEXICO, EN DONDE SE OBSERVA LA MAYOR DESPROTECCION DE LOS HABITATS, POR LO QUE PARA UN MANEJO ADECUADO DEBEN ENCONTRARSE LOS MECANISMOS APROPIADOS PARA ADQUIRIR LAS TIERRAS Y CON ELLO PROTEGER LOS HABITATS NATURALES DE ESTA ESPECIE. OTRO ASPECTO QUE SE CONSIDERA ES EL DEL ABASTECIMIENTO DE AGUA, UN MAL MANEJO DE ESTE RECURSO AFECTA CATASTROFICAMENTE EL HABITAT DE ESTA ESPECIE, DEBEN IMPLEMENTARSE UNA SERIE DE MECANISMOS, QUE INCLUYAN ASPECTOS LEGALES DE PROTECCION DEL AGUA, EN CUANTO A SU USO Y MANEJO Y ESPECIFICAMENTE DEBE ESTUDIARSE CASO POR CASO PARA DE ESTA MANERA PARTICULARIZAR EN ESTOS ASPECTOS (TIERRA Y AGUA).

EL PLAN INCLUYE LA PROPUESTA DE EXTENDER LA RESERVA DE LA BIOSFERA "EL PINACATE" PARA INCORPORAR A ELLA LOS LUGARES EN LOS QUE SE DISTRIBUYE ESTA ESPECIE EN EL RIO SONOYTA. ES IMPORTANTE QUE INVESTI——

GADORES MEXICANOS ESTE INMERSOS DENTRO DE ESTA PROPUESTA, Y QUE SE REALICE LA IMPLEMENTACION DE LOS PLANES DE CONSERVACION Y MANEJO DE LA ESPECIE.

ESTE PLAN DE RECUPERACION DE LA ESPECIE Cyprinodon macularis ES UN CLARO EJEMPLO DE LO QUE SE PUEDE HACER SOBRE EL MANEJO, RECUPERACION Y MANTENIMIENTO DE UNA ESPECIE, EN LA CUAL SE HAN PERDIDO POBLACIONES NATURALES. ES UN PUNTO DE REFERENCIA A SEGUIR PARA OTRAS ESPECIES QUE SE ENCUENTRAN EN IGUALES CONDICIONES O PEOR AUN; NOS MUESTRA LA IMPORTANCIA QUE TIENE EL QUE SE CONOZCAN LOS DIFERENTES PARAMETROS BIOLOGICOS Y ECOLOGICOS DE UNA ESPECIE, COMO SON LA DISTRIBUCION, ABUNDANCIA, REPRODUCCION, ALIMENTACION Y OTROS ASPECTOS REFERENTES A LAS RELACIONES INTERESPECIFICAS E INTRAESPECIFICAS.

EN MEXICO, GRAN PARTE DE LA INVESTIGACION EN PECES SE HA ENFOCADO HACIA LAS ESPECIES CON APROVECHAMIENTO PESQUERO, PRINCIPALMENTE MARINAS, DEJANDO DE LADO A LAS PEQUEÑAS ESPECIES FUNDAMENTALMENTE DULCEACUICOLAS; DE AHI QUE EXISTA UN GRAN DESCONOCIMIENTO BIOLOGICO Y ECOLOGICO DE LOS PECES. ACTUALMENTE SE TIENEN IDENTIFICADAS LAS AREAS EN LAS CUALES LOS ENDEMISMOS SON ALTOS, SIENDO LAS QUE EN PRINCIPIO REQUIEREN DE MAYOR ATENCION EN LO QUE SE REFIERE A IMPLEMENTAR MECANISMOS DE PROTECCION.

COMO ES CASO DEL "DESERT PUPFISH" EN MEXICO EXISTEN VARIOS, (EJ: LAS ESPECIES DEL VALLE DE MEXICO) Y ASI SE PUEDEN IDENTIFICAR VARIOS CASOS.

PODRIAN FORMULARSE PLANES DE RECUPERACION COMO EL QUE NOS OCUPA, LO ELEMENTAL ES CONTAR CON LA INFORMACION QUE NOS PERMITA HACER ESTO. ANTERIORMENTE SE SEÑALO QUE AUN SE TIENEN CIERTAS CARENCIAS EN LO QUE A RECURSOS HUMANOS SE REFIERE, Y GENTE ESPECIALIZADA EN EL MANEJO DE TECNICAS GENETICAS. SE CONSIDERA QUE SON ASPECTOS QUE SE PUEDEN IR COMBATIENDO Y RESOLVIENDO. ES NECESARIO ADEMAS ESTABLECER MECANISMOS Y REGLAMENTACIONES QUE NOS DIRIJAN HACIA LA PROTECCION Y MANEJO DE LAS ESPECIES.

EE/WMR/EHL/SEZV/amcs.

SUBJECT: COMMENTS TO THE "DESERT PUPFISH" RECOVERY PLAN Cyprinodon macularius.

The "Desert Pupfish" Cyprinodon Macularius Baird and Girard is a small fish of the Cyprinodontidae family, it is distributed extensively and abundant in South Arizona, South East of California, and the United States, as well as in the north part of Lower California and Sonora in Mexico; it is known the existence of three sub-species, two of then are already well defined and the other one is being studied (non-described), this last one is distributed in Mexico. Cyprinodon macularious lives in a great diversity of habitats, from swamps and streams to small rivers and banks of large flows; it requires shallow waters with soft substratum and clear water. It is a species with great ability to survive under extreme conditions, such as high water temperature, low concentration of dissolved oxygen and high salinity. This exceeds the tolerances presented by other sweet water species. It also survives to sudden changes of salinity and temperature, which is lethal for many other species of fish.

The information included in the recovery plan provides an idea of all the aspects treated of this specie, which are from a taxonomic state, distribution and abundance, life history in reference to habitat, reproduction, growth, feeding and feeding habits, as well as co-occurrence (relationship) with other species. Another very important aspect that has been investigated is the reasons that have affected or caused the decrease of natural populations of the species.

The most important aspect handled in this recovery plan is that the populations have decreased mainly because the lost of habitats, its modification, contamination and the interaction with exotic species competing for space, food and for the ones suffering depredation. Some of these aspects have already been studied and it has allowed to obtain more information about it.

A deeper study is required in Mexico to determine the distribution and abundance of the sub-species non-described population found in the Sonoyta river in Sonora; as well as Cyprinodon m. eremus in Sonora and Lower California.

Another aspect that requires study is genetics, to determine the genetic purity of the populations distributed outside the historic distribution range, because this situation is a threat to the recovery of populations.

The outlined objectives in the recovery plan include the description and necessary actions to eliminate the loss of populations and to establish actions that will help in the future to re-establish the spicies in secure habitats within their historic range of probable distribution.

The significance of these objectives is extensive, including:

1) Protection of the natural Desert Pupfish populations.

2) Re-establishment of these fish populations.

3) Establishment of a refuge for the "Quitobaquito Pupfish" (C. m. cremus) population.
(This sub-specie is only distributed in Quitobaquito Spring, Arizona and, at present, the abundance is unknown because the habitat has been modified mainly by men).

4) Develop protocols to exchange genetic material among C. macularius populations (on this point it is important to analyze the Mexican participation.

Mexico is young in the genetic investigation field of fish, the human resources are scarce. It is necessary to implement the force to further progress in this important area. This is going to be the starting point to determine the purity of the populations. Their recovery depends on genetically pure populations that later will allow to maintain the natural levels of genetic diversity).

5) Monitoring and natural maintenance, re-establishment and refuge of the populations.

6) Determine factors that affect the persistence of populations.

7) Information and education.

These 7 points are the tasks carried on in this plan, each one has financial support. Educational, scientific and government institutions from both countries are involved in this plan.

The actions within the recovery plan are focused as follows:
Emphasis to the relatively small habitats and the establishment of refuges for the population will be given emphasis in the United States. In Mexico, the actions would be aimed towards the protection of swampy land and large extensions occupied by the "Desert Pupfish" and other native species.

The protection of the land and water in which this species is distributed, is very important. Many of the habitats in which the species is distributed (rural populations) present problems because they are private owned lands, mainly in Sonora and Lower California, Mexico, where the highest unprotected habitat is located. Because of this problem and in order to develop an adequate management, there is a need to find the appropriate mechanisms for the acquisition of the lands and then to protect the natural habitats of this specie. Another aspect considered is the water supply. A bad management of this resource has deadly effects on this specie's habitat. A series of mechanisms must be

implemented, including legal aspects for water protection, its use and management, and specifically, case by case must be studied to be able to individualized on these aspects (land and water).

The plan includes the proposal to extend the biosphere reserve of "El Pinacate" to incorporate the locations in which this specie is distributed in the Sonoyta river. It is important that Mexican investigators get fully involved on this proposal, and implement the plans for conservation and management of the specie.

This recovery plan of the specie Cyprinodon macularis is a clear example of what can be done through management, recovery and maintenance of a specie, of which natural populations have been lost. This is a reference point to follow for other species under the same or worse conditions. It also shows the importance of recognizing the different biological and ecological parameters, such as distribution, abundance, reproduction, feeding, and other aspects in reference to the inter-specific and intra-specific relationships.

In Mexico, the majority of the fish investigation has been focused towards the species for fishing exploitation, mainly coastal (marinas), putting aside the small species basically of sweet water habitats; this is why there is great biological and ecological ignorance concerning this fish. At the moment the areas in which the endemic are high are identified, and these are the ones that require more attention in reference to implementation of mechanisms of protection.

There are several cases like the "Desert Pupfish" in Mexico (Example: The species in the valley of Mexico). Several cases like this one can be identified.

More recovery plans could be made, but it is essential to make adequate information available that will allow to do it. Previously, it was mentioned that there is still a lack of human resources and specialized people on the management of genetic techniques. It is considered that these aspects can be resolved. In addition, it is necessary to establish mechanisms and regulations that will direct towards the protection and management of the species.

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, Governor

DEPARTMENT OF FISH AND GAME
1416 NINTH STREET
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SACRAMENTO, CA 94244-2090
(916) 653-7664

August 12, 1993

Mr. Gilbert D. Metz
Acting Field Supervisor
Arizona Ecological Services Field Office
U.S. Fish and Wildlife Service
3616 West Thomas Road, Suite 6
Phoenix, Arizona 85019

Dear Mr. Metz:

This responds to your February 2, 1993 request to review the draft recovery plan for the desert pupfish. Our comments are as follows:

Page 6 Second full paragraph: The second sentence should read "The Salton Sea...and irrigation drains...". Records of pupfish are from drains rather than canals.

Page 7 Last paragraph: Populations of pupfish in irrigation drains are not mentioned, yet their numbers are significant (see enclosed report). None of the definitions on page 48 adequately describes their role in the recovery of the species. Pupfish in the drains are apparently self-sustaining in an artificial environment in which the only management on their behalf is modification of drain maintenance techniques. Although awkward to classify, an administrative "niche" for these populations should be assigned and drain populations should be addressed throughout the report (e.g. page 1 discussion of "naturally-occurring populations" and page 53 [see below]).

Page 8 Line 3: "Salt Creek State Recreation Area" should be deleted. It is the same as Salton Sea State Recreation Area.

Page 15 Second paragraph: The last sentence should read "In the Salton Sink, pupfish now survive only as remnant populations in tributary streams, a few shoreline pools, and several irrigation drains,..."

Page 16 Second paragraph: Aerial application of pesticides and direct runoff from agricultural fields may also affect pupfish populations in the drains.

Page 29 Specifications: "Major" and "minor" vegetation removal should be defined.

Page 30 Second paragraph: The second sentence should read "Pupfish stocks...among habitat types within each region,..." .

Page 33 Task 5: While we support the recommended level of population and habitat condition monitoring, recent (1986 to present) staffing levels, workload and budgetary constraints rarely allow us to monitor biannually. Typically, all populations are monitored annually.

Page 50 Task 5.0 Other: Include The Nature Conservancy (TNC) and the California Department of Parks and Recreation (CDPR) since they maintain refugium populations.

Page 51 Task 7.0 Other: Include TNC and CDPR.

Page 53: Include agricultural drains?

Page 55, 18. CA, Riverside Co., Oasis Spring Ecological Reserve: This consists of an artesian well and two earthen ponds. Each pond overflows into a short stream, approximately 0.25 mi and 1.0 mi long, respectively.

We appreciate the opportunity to comment on this recovery plan. Should you have any questions regarding our comments, please contact Ms. Betsy Bolster at (916) 355-7115 or 1701 Nimbus Road, Suite C, Rancho Cordova, California 95670.

Sincerely,

Boyd Gibbons
Director

Enclosure