Revised Recovery Plan for the Mohave Tui Chub
Gila bicolor mohavensis

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Mohave Tui Chub Recovery Plan

Executive Summary

1. Point or condition when species can be considered recovered.

   The Mohave tui chub will be eligible for consideration of reclassification to threatened when six populations (minimum 500 fish each) have each been established on a self-sustaining basis for 10 years (i.e. when each have reached the 1.7 category level). Delisting may be considered upon successful establishment of viable populations in a majority of the species' historic habitat in the Mojave River.

2. What must be done to reach recovery?

   Currently, there are four recovery populations, two of which have reached Category 1.7. These must be protected and enhanced. Two additional populations will need to be established and secured.

3. What specifically must be done to meet the needs of #2?

   Sufficient water flows of appropriate quality must be assured for existing populations. Interchanging individuals among populations may be necessary to promote genetic diversity. For the two additional populations, proposals for habitat construction and/or improvement will be necessary.

Management plans that assure adequate water free of exotic species must be implemented. Transplants will have to be performed.

4. What management/maintenance needs have been identified to keep species recovered?

Management needs include control of aquatic vegetation at certain sites, mixing of populations (if necessary) to control inbreeding depression, and development of management plans. Monitoring programs for current and proposed populations have been included. A public relations program and enhanced law enforcement programs are also proposed.

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PART I. INTRODUCTION

Brief Overview

The Mohave tui chub, Gila bicolor mohavensis (Synder), is the only cyprinid native to the Mojave River basin in San Bernardino County, California. Arroyo chubs, Gila orcutti, were introduced into Mojave River headwater reservoirs in the San Bernardino Mountains, and first appeared in the Mojave River during the 1930's. Aided by the severe floods of March 1938, the exotic species of Gila invaded the Mojave River and subsequently hybridized with the Mohave tui chub. By 1970, genetically pure Mohave tui chubs had been eliminated from the Mojave River by hybridization and subsequent introgression. Fortunately, a small population of genetically pure Mohave tui chubs persisted in isolated ponds at Soda Springs (= Ft. Soda), near the terminus of the Mojave River. Mohave tui chubs have been successfully introduced into seeps and marshlands on the U.S. Navy's China Lake Naval Weapons Center (NWC), into two ponds at the California Department of Fish and Game's Camp Cady Wildlife Area (Camp Cady), and into a small pond at the Desert Research Station (DRS) near the town of Hinkley (Figure 1). Current populations require protection and management. Additional populations, especially along the Mojave River, need to be established to minimize potential extinction and effect the recovery of the subspecies.

The depleted status of this fish has been widely recognized in government and scientific communities. The Mohave tui chub was listed by the U.S. Department of the Interior as endangered on 13 October 1970 (Federal Register 35:16047). Similarly, the State of California classified the Mohave tui chub as endangered in 1971. The American Fisheries Society also accords endangered status to the subspecies (Deacon et al. 1979).

Taxonomy

The Mohave tui chub has gone through several nomenclatural changes since it was originally collected by Dr. A. L. Heermann and identified as *Algansea formosa* by Girard (1857). Snyder (1918) recognized the chub in the Mojave River as distinct, and described it as a new species, *Siphateles mohavensis*. Miller (1961) and Bailey and Uyeno (1964) relegated *Siphateles* to subgeneric status within the genus *Gila* at the generic level. Miller (1973) reclassified the Mohave tui chub to subspecific status, *Gila bicolor mohavensis*, because no characters could be found to specifically separate it from all populations of *G. bicolor* in the Lahontan Basin. Morphologically, the Mohave tui chub is similar to the Owens tui chub, *G. b. snyderi*, and the Lahontan tui chub, *G. b. obesa*. Similarities among the tui chubs as well as hydrographic evidence suggest that these drainages were once connected, although probably not contemporaneously (Blackwelder 1954; Blackwelder and Ellsworth 1936; Blanc and Cleveland 1961; Hubbs and Miller 1943; Miller 1946).

Description

The Mohave tui chub is a moderate- to large-sized subspecies of Gila bicolor. Hubbs and Miller (1943) indicated that adult G. b. mohavensis collected from Deep Creek, a headwater tributary of the Mojave River, were typically 52 to 92 mm standard length (SL, length of fish as measured from tip of snout to end of vertebral column). However, adults from introduced pond and marsh populations often reach lengths of 150 mm SL or longer. One specimen from a sample of 1,258 taken from the DRS Pond reached ca. 170 mm SL, all others were shorter than 140 mm SL, and most adults were 40-90 mm SL (Havelka et al. 1982). At Camp Cady two Mohave tui chubs had fork lengths of 255 and 276 mm. The body is thick (chunky) with a large head and short, rounded fins. The snout, the mouth oblique, the interorbital space broad and rather flat, and the dorsal outline of the head is slightly concave. A distinct hump sometimes develops behind the head in older fish. The lateral line is complete and decurved, and each scale has a definite dark border with a lighter center. The origin of the dorsal fin is typically slightly anterior of the insertion of the pelvic finds, but occasionally may be slightly behind. Mohave tui chubs are bright brassy-brown to dusky-olive dorsally, gold and finely speckled laterally and bluish-white to silver on the belly. The fins are olive to rich brown, the lower fins paling outward. Modal fin-ray counts are: dorsal 8, anal 8, pectoral 16, and pelvic 10 (Hubbs and Miller 1943). The Mohave

tui chub does not exhibit obvious sexual dimorphism (Snyder 1918, Miller 1938, Moyle 1976).

Several key characteristics of the Mohave tui chub that separate it from other tui chubs are: shield-shaped scales, lack of lateral or basal scale radii, low lateral-line scale counts (44-55), low number of scale radii (6-12), high number of anal fin rays (7-9), pharyngeal tooth formula typically 0,5-5,0 (but up to 30% may be 0,5-4,0); and numerous gill rakers 18-29 (usually 21-27) (Hubbs and Miller 1943).

Ecology

Snyder (1918) observed that Mohave tui chubs appeared to be lacustrine and were always associated with deep pools and slough-like areas of the Mojave River. The occurrence of the subspecies in streams without these features was rare. Mohave tui chubs were not found very far into the small tributaries.

Mohave tui chubs are less able to endure flooding than arroyo chubs. During the floods of 1938, the downstream dispersal rate for Mohave tui chubs was much higher than it was for arroyo chubs (Hubbs and Miller 1943). Studies by Castleberry and Cech (1986) demonstrate that arroyo chubs are better able to resist certain adverse environmental conditions, including flooding, than Mohave tui chubs.

Although the Mohave tui chub may not be as capable of surviving flood flows as the arroyo chub, or as adapted to desert conditions as certain other desert fishes, it is adapted to the Mojave River's alkaline and hard water qualities. In studies conducted at Soda Springs during 1981, tui chubs survived in habitats where dissolved oxygen was less than 1 mg/l. The extreme conditions tolerated by Mohave tui chubs are illustrated by the data collected from Soda Springs on 18 August 1981, when water temperatures approached 34°C at the surface, salinity was 11.55 ppt, conductivity 18,000 micromhos/cm, and pH between 9 and 10. The actual microhabitat conditions of the Mohave tui chub in the field may be less extreme than those observed, as fish seek out water strata with more preferred conditions. Recent studies have shown that the upper lethal temperature limit of this tui chub may be slightly above 30°C. During respiratory metabolism experiments at University of California at Davis Fisheries Biology Physiology Lab, all tui chubs tested died during tests at 35°C while all survived at 30°C (Castleberry and Cech 1986). Studies by McClanahan et al. (1986) found the mean critical thermal maximum to range between 33.5-36.2°C depending on acclimation temperature.

Mohave tui chubs begin spawning in March or April when water warms to approximately 18°C (Vickers 1973). Spawning continues throughout the spring and there are indications that fall spawning may occur. Some spawning may take place as long as water temperatures are between 17°C and 26°C (D. Castleberry,

pers. comm.). Like most tui chubs, G. b. mohavensis broadcasts eggs and milt over vegetation, where the eggs become attached after fertilization. Eggs are about 1 mm in diameter, adhesive and hatch in 6 to 8 days at 18-20°C. Prolarvae spend about 12 hours on the bottom and then swim to the surface.

Tui chubs are not known to spawn before reaching at least one year of age. In older fish, eggs per female vary from 3,795 found in a 98 mm SL chub, to 49,847 found in a 215 mm SL chub (Vickers 1973). Mohave tui chubs as small as 54 mm SL have been observed to contain ripe eggs (Vickers 1973).

Fry form small schools in the shallow areas. Medium-sized tui chubs (30 to 80 mm SL) school in areas 20 to 50 cm deep at Soda Springs. Mohave tui chubs larger than 80 mm are usually solitary and are typically captured in the deepest parts of Lake Tuendae (greater than 70 cm). Although Mohave tui chubs of 4+ years of age have been captured there; most chubs are 1+ to 2+ years of age. Their rate of growth is approximately linear (Figure 1). The largest tui chubs tend to be females and, at least in Lake Tuendae at Soda Springs, can reach a length of 215 m SL.

An unusual aspect of the Mohave tui chub has been recently discovered at the DRS Pond. Tagged fish have shown a net weight loss from August to October. This weight loss can be as much as 25 to 30% of the body weight. Tui chubs start gaining weight again by October (Havelka et al. 1982).

Mohave tui chubs are morphologically adapted for feeding on plankton. However, during Vicker's (1973) studies, food habits of the tui chubs at Soda Springs were difficult to assess because the tui chubs consumed scraps of food provided by the guests of the resort. Gut contents of 60 chubs showed 17 were empty, 37 had only "scrap" food and 6 had "natural" food. Natural foods found in the gut of the chubs were gyrinid larvae, chironomid larvae, one small Mohave tui chub and organic debris. McEwan (1988) found that the most important food items of the closely related Owens tui chub (Gila bicolor snyderi) were chironomid larvae, caddis fly larvae and detritus.

Hydrographic History and Historic Distribution

Distribution of the Mohave tui chub during the Pleistocene is believed to have extended throughout the Mojave River drainage (Miller 1946). A major portion of the drainage during that period consisted of three lakes: Mohave, Little Mohave and Manix (Figure 2) (Blackwelder 1954; Blackwelder and Ellsworth 1936; Blanc and Cleveland 1961; Buwalda 1914; Thompson 1921, 1929).

Lake Manix filled the region east of Barstow and west of the Cady Mountains and was the largest of the Mojave River's Pleistocene lakes. The outflow from Lake Manix eventually carved Afton (Cave) Canyon and discharged alternately into Lake Mohave and Little Lake Mohave. The continued downcutting of these outlet

channels eventually drained Lake Manix (Buwalda 1914). Lake Mohave was located over the present playas of Soda Lake and Silver Lake (Figures 2 and 3). Little Lake Mohave was located over the current playas of East and West Cronese Lakes. Fossil fish remains from Lake Manix beds, dated 19,500 ± 500 years before present, represent the Mohave tui chub in its favored habitat (Uyeno and Miller 1963).

As the climate became more arid and the lakes dried, the Mohave tui chub was restricted to its recent fluviatile habitat (Hubbs and Miller 1943). Early collections of the Mohave tui chub indicate that the fish was primarily restricted in the Mojave River to the desert floor downstream of the forks south of Victorville (Snyder 1918). The Mohave tui chub prefers lacustrine habitats and does poorly in fast-flowing streams that are more typical of headwater localities (Hubbs and Miller 1943). Recent observations at China Lake and evaluation of other transplants indicate that the best habitat may be a combination of ponds and slow-water slough conditions.

Causes of Decline

The only fish thought to be native to the Mojave River drainage are the Mohave tui chub and the threespine stickleback (*Gasterosteus aculeatus*) (Roeder 1985). By the 1930's however, arroyo chubs, were introduced as baitfish by trout fishermen into headwater reservoirs of the Mojave River and began spreading

throughout the drainage. Mohave and arroyo chubs readily hybridized and the native fish quickly decreased in abundance (Hubbs and Miller 1943, Miller 1961). Individuals collected in 1936 through 1940 from Afton Canyon consisted of pure Mohave tui chubs, pure arroyo chubs and hybrids (Hubbs and Miller 1943, Miller 1936). By 1967, few genetically pure Mohave tui chubs remained in the river (Miller 1969).

Although the introduction of arroyo chubs was the primary cause of the decline of the Mohave tui chub, introduction of other exotic species and habitat alteration also contributed to the decline. The construction of headwater reservoirs altered natural flow regimes and provided favorable habitat for exotic species. Water diversions and pollution have decreased habitat suitability in other locations.

Present Distribution

Soda Springs

The existing Soda Springs population, near the southeastern edge of the dry bed of Soda Lake, San Bernardino County was most probably derived from a naturally isolated ancestor; however, the possibility exists that the population may have been derived from introduced stock (Soltz 1978). In 1916 and 1938, flood waters of the Mojave River filled Soda Lake and Silver Lake to a depth of approximately 3 m (Hubbs and Miller 1943, Thompson 1921). Such

an event could have allowed tui chubs access to habitats at Soda Springs. Records of the Mohave tui chub's presence at Soda Springs can be traced back at least to 1917 (Thompson 1929). Miller (1938) reported that a large spring-fed pool at Soda Springs contained "fish" as long ago as 1907.

Sometime during the 1950's the Saratoga Springs pupfish, Cyprinodon nevadensis nevadensis, was introduced at Soda Springs (LaBounty 1968, Turner and Liu 1976). The pupfish now occurs only in Lake Tuendae.

Lake Tuendae. Lake Tuendae, the largest of the three Soda Springs habitats, was excavated circa 1945 by Curtis Howe Springer who developed and operated a health retreat called Zzyzx Mineral Springs Resort until he was removed from the BLM land in 1974. Prior to Springer's occupation of the site, it had been a railroad siding for the Tonopah and Tidewater Railroad and prior to that, an Army fort. The springs were originally an important forage and water stop for travelers on the Mohave Road, a wagon supply route from the Los Angeles Plain to Ft. Mohave on the Colorado River.

The level of the 150 x 40 m lake is maintained by water pumped from Zzyzx Well adjacent to the pond. Plants found in or around Lake Tuendae include the bulrush (Scirpus olneyi), cattail (Typha domengensis), rush (Juncus cooperi), saltgrass (Distichlis spicata), and the exotic salt cedar (Tamarix sp.). The shallow

areas of the lake are filled with aquatic ditchgrass (Ruppia maritima). This latter plant is important for the tui chub because it apparently provides a preferred structure for egg attachment during spawning and is a thermal refuge during most of the summer. It is also useful as cover from avian predators. On August 6, 1977, at 1600 hr maximum observed temperature stratification in the ditchgrass beds was 12°C. Surface water temperatures were 34.6-36.5°C, while the temperature on the bottom was 25-27°C (air temperature was 44°C) (Soltz 1978).

West Pond. West Pond measures 60 m x 70 m and is shallower than Lake Tuendae. Water quality characteristics of the pond are more extreme than those of the lake and tui chubs in this pond typically do not grow as large as those in the lake. Water loss from the pond is mainly via evaporation. Inflow is from at least one and possibly two springs and probably some groundwater seepage. Heavy pumping from the Zzyzx Well probably reduces inflow to the pond. Vegetation in and around the pond is often sparse but includes all species listed for Lake Tuendae. However, during late summer, ditchgrass may form dense mats throughout much of the pond.

In November 1981, a fish kill occurred in West Pond. Although the exact cause has not been determined, high pH, low dissolved oxygen and/or ammonia toxicity were suspected. The ditchgrass beds died off about two weeks prior to the beginning of the fish kill. Although ammonia levels were relatively low, the pH in the

pond was near 10, which shifts the total ammonia to the toxic (unionized) form (Morgan and Turner 1976). Although the kill was not complete and numbers of both Mohave tui chubs and Saratoga Springs pupfish, gradually increased, a total kill probably occurred in the summer of 1985 when water conductivity reached 17,500 umhos and salinity was 11.0 ppt. No dieoff was apparent as in 1981 but subsequent sampling has yielded no fish.

MC Spring. The third habitat, MC Spring, includes the smallest population of Mohave tui chubs at Soda Springs. The spring is about 2 m deep and 3 m in diameter with a central open area of about 1.2 m diameter clear of cattail and bulrush. The size of this open-water area typically varies with season. Algae are the only other vegetation occurring in the spring. The chub population in MC Spring was estimated at 20 to 60 small fish in 1981-1982 based upon tagged/untagged ratios. Fish captured in August 1981 appeared emaciated. Fish captured during other parts of the year appeared healthy. The spring is typically low in dissolved oxygen, ranging from 0.5 to 2.5 ppm. The cattails have been partially removed in the past to maintain open water.

China Lake NWC

Mohave tui chubs were planted at Lark Seep Lagoon on the NWC in July 1971 (St. Amant and Sasaki 1971). The original plant of 400 was augmented with 75 fish in November 1976 (Hoover and St. Amant 1983). This Mohave tui chub population is the largest at

present. The fish have spread from Lark Seep Lagoon to G-1 Seep through a system of ditches connecting the two areas. Both habitats originate by seepage from water treatment settling ponds, small springs and possibly leakage from one or more pipelines on the base. Mosquitofish, Gambusia affinis, also inhabit these areas.

Desert Research Station

The Desert Research Station Pond is located near Hinkley, California, about 10 miles west northwest of Barstow. This small (30 m x 30 m) pond was planted with 16 tui chubs in December, 1978 (Hoover and St. Amant 1983). This population was augmented with 50 fish in October 1981 and another 176 chubs in December 1981. The population built up to between 2,000 and 4,000 fish before cattail encroachment caused a total dieoff in 1984. The pond was rebuilt and 59 tui chubs were reintroduced in April, 1986. Reproduction was again successful and by October, 1988, the population was estimated to be over 1,800 fish R. Schmidt, DRS, pers. comm.).

Camp Cady

Camp Cady, located about 20 miles east of Barstow, has two 1/4-acre ponds constructed as Mohave tui chub refugia. Ten tui chubs were used to test survivability then released in Pond 1 in July, 1986. In June, 1987, 55 additional tui chubs were released into

that pond and 59 were introduced into Pond 2. Shortly after the initial 10 fish were placed in Pond 1 there was a breach in the pond bank and some of the fish were possibly lost. Although no population estimates were made, it was thought that by fall, 1988, thousands of fish were present in each pond. In the fall of 1988, Pond 1 began leaking water at an unacceptable rate and most of the fish were transferred to Pond 2. A large fish kill subsequently occurred in Pond 2, due to overcrowding and disease.

Other Transplants

Sixty tui chubs were originally introduced into a pond at BLM's California Desert Information Center at Barstow, and the current population is estimated to be similar in number. This small (300 gallon) human-made habitat serves as an important public display for the Mohave tui chub but should not be considered a recovery introduction due to the small size of the habitat and tui chub population.

Attempts to transplant Mohave tui chubs into other areas have met with a large proportion of failures. Of fifteen attempts, only the China Lake Naval Weapons Center (NWC) transplant was successful in establishing a large population over a long period (Table 1) (Hoover and St. Amant 1983, Miller 1968, St. Amant and Sasaki 1971). Specific reasons for the large number of failures are speculative, but inadequate water quality and quantity, floods, and lack of appropriate spawning areas are probable

Table 1. Transplant Records for Mohave Tui Chubs as of _____.

Introduction Date(s)	Transplantation Sites	Status
5/23/39; 7/29/40	San Felipe Creek, San Diego Co., CA San Diego, CO., CA	Successful for 20 years then wiped out by flood
5/65	Rio Santa Tomas, Baja California	Unsuccessful
6/67	Paradise Spa, Las Vegas	Survived for a few years but then failed
12/18, 19/69	Piute Creek, San Bernardino Co., CA	Successful until 1976, then disappeared
12/27/70	South Coast Botanical Garden, Palos Verdes, Los Angeles Co., CA	Initially successful but then failed
8/20/70; 7/9/71	Two Hole Spring, San Bernardino Co., CA	Unsuccessful
7/12/72; 11/5/76	Lark Seep Lagoon, China Lake Naval Weapons Center, China Lake, San Bernardino Co., CA	Successful
5/25/72	Dos Palmas Spring, Riverside, Co., CA	Unsuccessful
6/1/72; 3/28/75	Lion Country Safari, Laguna Hills, Orange Co., CA	Unsuccessful
6/5/72	Eaton Canyon Nature Center, Altadena, Los Angeles Co., CA	Unsuccessful
7/27/72	Busch Gardens, Van Nuys, Los Angeles, Co., CA	Unsuccessful
7/22/75; 7/1/81	California Desert Information Center, Barstow, San Bernardino Co., CA	Successful as display population
2/8/78	Lake Norconian, Norco, Riverside Co., CA	Unsuccessful
12/12/78; 4/7/86	Desert Research Station, Hinkley, San Bernardino Co., CA	Initially but then failed; reintroduction successful to date
7/25/86; 6/11/87	Camp Cady, San Bernardino Co., CA	Successful to date

causes. Attempts to establish the tui chub in flowing-water habitats usually fail because no refuge (e.g. terminal lake or pond) exists for reinvasion of the stream following a flood. Future transplant sites should be closely scrutinized to ensure that adequate conditions exist; transplanted poulations need not suffer the uncertainties of indiscriminate introductions.

PART II. RECOVERY

Objectives

The ultimate objective of this recovery plan is to restore the Mohave tui chub to a point where it can be removed from the List of Endangered and Threatened Wildlife. Delisting will be considered upon successful reintroduction and establishment of viable Mohave tui chub populations into a majority of its historic habitat in the Mojave River. This will require extensive rehabilitation efforts and removal of the arroyo chubs. Since these fish inhabit tributaries in the San Bernardino Mountains, some of which are prime wild trout streams, it is unrealistic to expect their removal in the foreseeable future.

The interim objective of this recovery plan is to restore the Mohave tui chub to threatened status. This objective will be achieved when six populations have been self-sustaining for ten years in habitats secure from threats.

Populations/habitats will be ranked according to the following set of categories:

Category 1. The population is reproducing annually and the habitat is considered stable. Each year in this category advances the population toward downlisting and upgrades the population category 0.1 to a maximum of 0.7. Downlisting can occur when six populations reach 1.7.

Category 2. The population is reproducing annually and habitat management concerns are being successfully addressed. There are no significant abnormal fluctuations in population numbers and no significant threats to the habitat. After two years in this category the population can be upgraded to Category 1.

Category 3. Fish have been introduced into apparently suitable habitat and are surviving. After one year in this category the population can be upgraded to Category 2 if reproduction has occurred and the habitat appears secure.

Category 4. Habitat is deemed biologically suitable for Mohave tui chubs. Habitat modification and/or

further investigation may be necessary prior to introducing fish and upgrading to Category 3.

Category 5. Non-recovery populations (i.e. experimental introductions, display and public information populations etc.). Upgrading would not normally be expected to occur with these populations.

The downgrading of populations could occur for a variety of reasons. Category placement after downgrading and eventual upgrading will be considered on a case-by-case basis.

If chubs occur in more than one habitat at a location, it will normally be considered that all of the fish there constitute only one population, due to their vulnerability to a catastrophic natural event.

Currently, five populations of Mohave tui chubs exist. Two of these, Soda Springs and China Lake Naval Weapons Center, are in Category 1.7. Two populations, the Desert Research Station (DRS) and Camp Cady, are in Category 2. One population, California Desert Information Center, is in a small habitat for public information purposes and is therefore a Category 5 non-recovery population in Category 5.

Four more refugia need to be upgraded to Category 1.7 before considering the reclassification of the Mohave tui chub to both

State and Federal threatened status. These refugia will have to maintain a minimum population of at least 500 fish and should be located within or along the tui chubs' historic natural range, the Mojave River. The presence of arroyo chubs in the Mojave River and its tributaries prevents establishment of the Mohave tui chub in its historic riverine habitat at this time. All six refugia will need to remain free of any threats to their integrity for a period of 10 consecutive years before considering reclassification of the tui chub.

Step-down Outline

Prime Objective: The prime objective of this recovery plan is to restore the Mohave tui chub to a point where it could be removed from the List of Endangered and Threatened Wildlife. Delisting will be considered upon successful reintroduction and establishment of viable Mohave tui chub populations into a majority of the historic habitat in the Mojave River. This will require extensive rehabilitation efforts and removal of the arroyo chubs. Specific tasks to accomplish this goal will be developed pending evaluation of results on experimental reintroduction.

The interim objective of this recovery plan is to restore the Mohave tui chub to threatened status. This objective will be achieved by assuring the preservation of the existing two

category 1.7 populations and by establishing at least four additional ones.

1. Preserve and enhance Mohave tui chub populations and their habitats.

    11. Soda Springs: Lake Tuendae, West Pond, and MC Spring.

        111. Manage habitats.

            1111. Maintain and/or improve existing habitats.

                11111. Monitor water quality.

                11112. Maintain sufficient water quantity.

                11113. Remove sediments and aquatic vegetation as appropriate.

            1112. Develop and implement management plan.

        112. Manage populations.

            1121. Conduct census annually.

            1122. Mix populations if necessary.

1123. Reintroduce Mohave tui chubs to West Pond when conditions are appropriate.

12. China Lake Naval Weapons Center: Lark Seep and G-1 Lagoons.

121. Maintain and/or improve existing habitats.

1211. Enhance fish habitat by removal of sediments and aquatic vegetation as appropriate.

1212. Monitor water quality and flow rates.

122. Manage population.

1221. Conduct census annually.

1222. Mix populations if necessary.

13. Desert Research Station.

131. Maintain and/or improve existing habitat.

1311. Increase fish habitat.

1312. Monitor water quality.

132. Manage population.

1321. Conduct census as required.

1322. Mix populations if necessary.

14. Camp Cady.

141. Maintain and/or improve existing habitat.

1411. Maintain pond integrity.

1412. Develop a second source of water.

1413. Increase fish habitat.

1414. Monitor water quality.

142. Manage population.

1421. Conduct census annually.

1422. Mix populations if necessary.

2. Establish and protect Mohave tui chub populations in suitable

new or restored habitats.

21. Develop additional habitat at Camp Cady Wildlife Area.

    211. Construct habitat.

    212. Introduce Mohave tui chubs after food chain in habitat has become established.

    213. Monitor introductions.

    214. Mix populations if necessary.

22. Develop additional refugia.

    221. Determine suitability as refugia.

    222. Improve and/or construct habitat as necessary.

    223. Prepare management plan.

    224. Implement management plan including introduction of Mohave tui chubs.

3. Determine Mohave tui chub life history and ecology for application to management and recovery.

31. Determine spawning requirements and early life history.

32. Continue physiological tolerance studies of Mohave tui chubs and arroyo chubs to various water quality parameters.

33. Determine population genetics including electrophoretic studies of Mohave tui chubs, arroyo chubs and their hybrids.

34. Encourage continuing studies of tui chubs, including identification of natural and unnatural threats.

35. Incorporate findings into management and recovery plans.

4. Utilize laws and regulations to protect the Mohave tui chub and its habitats.

41. Enforce applicable State and Federal laws.

42. Evaluate effectiveness of applicable laws and regulations.

5. Inform public of Mohave tui chub status and recovery efforts.

51. Provide information to the media.

52. Prepare and distribute brochure on recovery rationale.

53. Prepare appropriate articles for popular and scientific publications.

54. Create and maintain interpretive centers.

Narrative

1. Preserve and enhance existing Mohave tui chub populations and their habitats. Initial efforts should be directed at improving the habitats of existing populations of Mohave tui chubs where necessary.

11. Soda Springs: Lake Tuendae, West Pond, and MC Spring. The primary habitats at Soda Springs need to be improved. In some instances, research is needed to determine necessary management procedures.

111. Manage habitats. Primary management activities should include the control of aquatic vegetation, deepening the pools and channels as required, and ensuring the quality and quantity of the water supply.

1111. Maintain and/or improve existing habitats. Lake Tuendae has gradually filled since it

was originally excavated in the 1940's. Overall depth is fairly shallow except for the west and east ends. Dense mats of ditchgrass die back each year adding to lake sediments. Eradication of the ditchgrass is not recommended because it appears to be important for spawning, as a thermal refuge and is an interesting botanical relict. However, a suction dredge or similar device that causes minimal disturbance to the habitat could be used to remove silt from the lake. This would also facilitate the partial removal of sedges, which encroach on the lake. The water level of Lake Tuendae should be maintained by groundwater pumping if necessary.

Cattails and bulrush occur around the edges of the pond. Occasionally, it is necessary to cut this vegetation back to keep the habitat from being overgrown. Similarly, aquatic vegetation may need controlling at the spring. Tui chubs occur in MC Spring, but the population is small and the fish are in relatively poor condition compared with the pond and lake.

Oxygen levels are fairly low throughout the year because sunlight is limited by the cattails that grows up around the spring. Cattails and bulrush have been removed in the past and, periodic removal will probably continue to be necessary.

The effect of heavy pumping from Zzyyxx Well, adjacent to the pond, may interfere with water flow into the pond. This could have adverse impacts on water quality. Increasing the surface outflow may improve water quality to the extent that high pH's or ammonia problems would not develop in the future.

11111. Monitor water quality. West Pond was enlarged in 1980 after extensive sedimentation occurred during flash floods. During November 1981, a fish kill occurred in the pond. Although the exact cause is not known, high pH levels (a pH of 10.8 was recorded on one occasion by L. L. McClanahan, pers. comm.) may have been the cause. In 1985, another

fish kill occurred that was probably due to high salinity. To detect changes in water quality and to prevent future die-offs, water quality in all three habitats should be monitored monthly. Water quality should also be monitored at Zzyzx Well.

11112. Maintain sufficient water quality. The water level of Lake Tuendae and other habitats should be maintained. Periodic pumping of groundwater may be necessary to supplement surface supplies.

11113. Remove sediments and aquatic vegetation as appropriate. Periodic removal of silt, debris, or aquatic plants may be necessary to maintain sufficient open-water habitat as discussed under Task 1111.

1112. Development and implement management plan. The California Desert Studies Consortium, (a group of university scientists and

resource managers) in cooperation with the U. S. Fish and Wildlife Service, the BLM, and the California Department of Fish and Game, should develop and implement a comprehensive management plan for the tui chub habitats at Soda Springs. The recently completed Soda Springs ACEC Management Plan includes several tasks related to management of tui chub populations and will substitute, in part, for the needed plan.

112. Manage populations. The chubs in all habitats should be monitored to study their response to changes in habitat. Management options should be instituted as necessary.

1121. Conduct census annually. The fish in the various habitats should be censused annually, or more often if personnel are available. Mark-recapture studies employing minnow traps seem appropriate to estimate population size.

1122. Mix populations if necessary. The fish in the various habitats probably need to be mixed periodically to prevent genetic

inbreeding. This should not occur, however, until more is known about their population genetics.

1123. Reintroduce Mohave tui chubs to West Pond when conditions are appropriate. After sediments are removed from West Pond and water quality conditions improve, tui chubs should be reintroduced.

12. China Lake Naval Weapons Center: Lark Seep and G-1 Lagoons. Mohave tui chubs have survived at the NWC since their introduction in 1971. This population has spread from its original transplant site at Lark Seep Lagoon to inhabit G-1 Lagoon and interconnected waterways. Because this is currently the largest Mohave tui chub population, it should be carefully managed.

121. Maintain and/or improve existing habitats. The primary goal is to insure the integrity of existing habitat and water supplies.

1211. Enhance fish habitat. Some habitat may need to be deepened and other areas may need to be cleared of dense aquatic

vegetation in order to increase or maintain fish habitat.

1212. Monitor water quality and flow rates. The sources of water for Lark Seep Lagoon need to be identified as to their quality, quantity and long-range viability.

122. Manage population. Our knowledge concerning this population is scant and must be improved if we are to provide proper management.

1221. Conduct census annually. The population has never been adequately sampled for size or age and growth. These characteristics need to be defined and compared with other Mohave tui chub populations.

1222. Mix populations if necessary. Once population genetics have ben examined, it may be necessary to exchange individuals between the Lark Seep Lagoon population and another population to prevent deleterious effects of inbreeding. If it is determined that population mixing is necessary, steps must be taken to prevent introductions of hybrid tui chubs,

unwanted fish species, diseases, or parasites.

13. Desert Research Station. The DRS pond near Hinkley, California, provides habitat for a small population of Mohave tui chubs and also provides Barstow School District students with an area for study.

131. Maintain and/or improve existing habitat. Because of its small size and abundant, fast growing vegetation, the habitat requires periodic maintenance.

1311. Increase fish habitat. The small (30 m x 30 m) pond constructed in 1979 is becoming overgrown with cattails and bulrush, which need to be controlled periodically.

1312. Monitor water quality. A thorough analysis of water in the pond should be made. Water quality should be monitored regularly.

132. Manage populations. The chubs at the DRS have been the subject of more study than any other population. Mark-recapture experiments, growth, and basic physiological work is being conducted

by students at DRS. These studies should continue in addition to the activities detailed below.

1321. Conduct census as required. Mark-recapture studies using minnow traps should be conducted at least annually, or quarterly, if student aid is available.

1322. Mix populations if necessary. It may be prudent to mix individuals of this population with another to prevent deleterious effects of inbreeding. This may be necessary because of the small population size and small number of founding individuals, but should only be done if population genetic studies indicate a problem and only if appropriate care is exercised to prevent the introduction of unwanted fish species, diseases, or parasites.

14. Camp Cady. The Camp Cady ponds provide two habitats for Mohave tui chubs.

141. Maintain and/or improve existing habitat. In one of the ponds, a bank washed out shortly after

filling and the pond later had an excessive seepage rate which required renovation work. The physical integrity of the ponds must be monitored and appropriate action taken to maintain them.

Currently, only one well provides water to the ponds. Should it go out of production for an extended period, the population of chubs could be lost.

Periodic removal of emergent vegetation may be necessary to prevent loss of fish habitat.

1411. Maintain pond integrity. Take appropriate action to maintain the physical integrity of the ponds.

1412. Develop a second source of water. Another well should be developed to provide a secondary source of water to the ponds in case of emergency.

1413. Increase fish habitat. Control emergent vegetation to prevent encroachment and subsequent loss of fish habitat.

1414. Monitor water quality. The water quality should be regularly monitored to detect the development of deleterious situations. If salinity increases due to evaporation rates, it will be necessary to release water from the ponds.

142. Manage population. Since this is a relatively new population, information must be obtained for proper management.

1421. Conduct census annually. The population has never been sampled for size or age and growth. These characteristics need to be defined and compared with other Mohave tui chub populations.

1422. Mix populations if necessary. Once population genetics have been examined, it may be necessary to exchange individuals between the Camp Cady populations and other populations to prevent deleterious effects of inbreeding. If population mixing is necessary, extreme care should be taken to prevent the introduction of hybrid tui chubs or other undesirable fish species, diseases, or parasites.

2. Establish and protect Mohave tui chub populations in suitable new or restored habitats. There are limited options available for creating additional refugia for the Mohave tui chub. Protection of current refugia is not assured. In order to increase the chances of recovery of this fish, three or more additional populations need to be established. Establishment of additional populations should not follow the "shotgun approach" but should be considered only after careful analysis of the sites.

21. Establish additional chub habitat at Camp Cady. Camp Cady Wildlife Area was developed to accommodate wildlife needs in desert riparian systems. Two ponds for Mohave tui chubs have been constructed on the facility and one or more ponds may be beneficial to chub maintenance. Because the DFG's Wildlife Management Program has the lead in planning and development of the wildlife area, the creation or enhancement of habitat for the tui chub needs close coordination with the wildlife staff.

211. Construct habitat. After the site has been chosen and analyzed, a suitable habitat should be constructed. The habitat should be large enough to support at least 500 tui chubs and ideally,

should include pond areas and stretches of slow-flowing water.

212. Introduction of Mohave tui chubs after food chain in habitat has become established. After the habitat has been filled with water it should be left undisturbed so the food chain can become established. Following this, a minimum of 100 randomly-chosen individuals should be introduced. Chubs should be chosen from an existing population that is most similar in habitat conditions to the introduction site, or from the population with the highest level of genetic diversity (see Task 33).

213. Monitor population. Following the chub introduction, fish numbers should be censused quarterly for one year to determine population size and dynamics. Thereafter, censusing should occur in the fall and spring.

214. Mix populations if necessary. In order to insure genetic heterogeneity and reduce inbreeding effects, the populations may require mixing. However, see task 1222 for appropriate cautions.

22. Develop additional refugia. Additional ponds or springs that could provide appropriate Mohave tui chub habitat exist in, or adjacent to, the Mojave River drainage. These should be examined and appropriate habitats developed as refugia.

221. Determine suitability as a refugia. Preliminary analysis should include the folowing considerations: water quality and quantity, site security, ownership, availability as a refugium, necessary protective measures and manageability as an endangered fish refugium.

222. Improve and/or construct habitat as necessary. Habitat modification should be accomplished if necessary.

223. Prepare management plan. Development of a management plan will be necessary to improve the chances for reintroduction successes.

224. Implement management plan including introduction of Mohave tui chubs. A minimum of 100 randomly-chosen individuals should be introduced. The Mohave tui chubs should be chosen from an existing population that is most similar in habitat conditions to the introduction site, or

from the population with the highest level of genetic diversity (see Task 33).

3. Determine Mohave tui chub life history and ecology for application to management and recovery. Studies on the biology of the Mohave tui chub are needed. Little taxonomic and life history information is available on this fish.

31. Determine spawning requirements and early life history. Infomration on Mohave tui chub spawning requirements, egg and larval development, habitat requirements of larvae and juveniles need to be acquired.

32. Continue physiological tolerance studies Mohave tui chubs and arroyo chubs to various water quality parameters. Additional studies are needed to determine ecological differences between Mohave tui chubs and arroyo chubs based on their physiological tolerances to various water quality parameters.

33. Determine population genetics, including electrophoretic studies of Mohave tui chubs, arroyo chubs and their hybrids. As a result of the small population sizes and small numbers of founding individuals (less than 20 in some habitats) population genetics of the Mohave tui chub should be analyzed. Such information would assist in establishing new

populations and determining if mixing of individuals among populations is desirable. Coupled with available morphometric data (Hubbs and Miller 1943), electrophoretic data would enable managers to identify pure Mohave tui chubs or the presence of any hybrids in a population.

34. Encourage continuing studies of tui chubs, including identification of natural or human threats. Students and staff of the DRS, the California Desert Studies Consortium, and others should be encouraged to continue their studies.

35. Incorporate findings into management and recovery plans. Research results should be incorporated into management plans and revisions of the recovery plan.

4. Utilize laws and regulations to protect the Mohave tui chub and its habitats. All activities threatening Mohave tui chub populations or their habitats should be subject to law enforcement activities. Enforcement personnel from all agencies should be given maps denoting the location of refugia and access points to all habitats within their area of responsibility.

Enforcement personnel and land managers should be made aware of the types of activities detrimental to the tui chub

and/or its habitat. A procedural manual to handle emergencies, such as a fish kill or pesticide spill, should be available.

41. Enforce applicable State and Federal laws. The Endangered Species Act of 1973, as amended, should be strictly enforced along with other applicable State and Federal laws in order to prevent "take" of the fish and to protect essential habitat.

42. Evaluate effectiveness of applicable laws and regulations. Current law enforcement programs should be examined as to their effectiveness. Any new laws or regulations that are necessary to protect the Mohave tui chub or its habitats should be proposed and enacted.

5. Inform public of Mohave tui chub status and recovery efforts. Public awareness and support can be increased by providing press coverage of the fish's history and plans for its recovery. The public needs to be aware of this unique fish, its role in the Mojave River ecosystem and the reasons for its current status.

51. Provide information to the media. Information concerning the status of the Mohave tui chub should be

made available to the public via press, television and radio.

52. Prepare and distribute brochure on recovery rationale. A brief, attractive brochure is needed to respond to inquiries from the public and to provide additional information at interpretive centers.

53. Prepare appropriate articles for popular and scientific publications. Longer, more informative articles need to be prepared for both popular and scientific publications. Transplant efforts should be documented in appropriate scientific journals.

54. Create and maintain interpretive centers. Interpretive centers, complete with signs and brochures, should be maintained at Soda Springs and developed for all of the newly established populations to inform visitors of recovery efforts and to encourage public support.

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PART III.

IMPLEMENTATION SCHEDULE

MOHAVE TUI CHUB RECOVERY PLAN

The table that follows is a summary of scheduled actions and costs for the Mohave tui chub recovery program. It is a guide to meet the objectives of the Mohave tui chub Recovery Plan, as elaborated upon in Part II, Narrative Section. This table indicates the priority in scheduling tasks to meet the objectives, identifies the agencies responsible for performing the tasks, specifies a time-table for completing the tasks, and indicates the estimated costs to each agency. Implementing Part III is the action of the recovery plan that, when accomplished, will satisfy the prime objective. Initiation of these actions is subject to the availability of funds.

RECOVERY ACTION PRIORITIES

1 = An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

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 = All other actions necessary to provide for full recovery of the species.

APPENDIX

List and Location of Agencies Asked to Submit Review Comments

1. Desert Studies Consortium - Fullerton
2. California Department of Fish and Game - Sacramento, Long Beach
3. U. S. Bureau of Land Management - Sacramento, Riverside, Barstow
4. U. S. Fish and Wildlife Service - Sacramento, Laguna Niguel