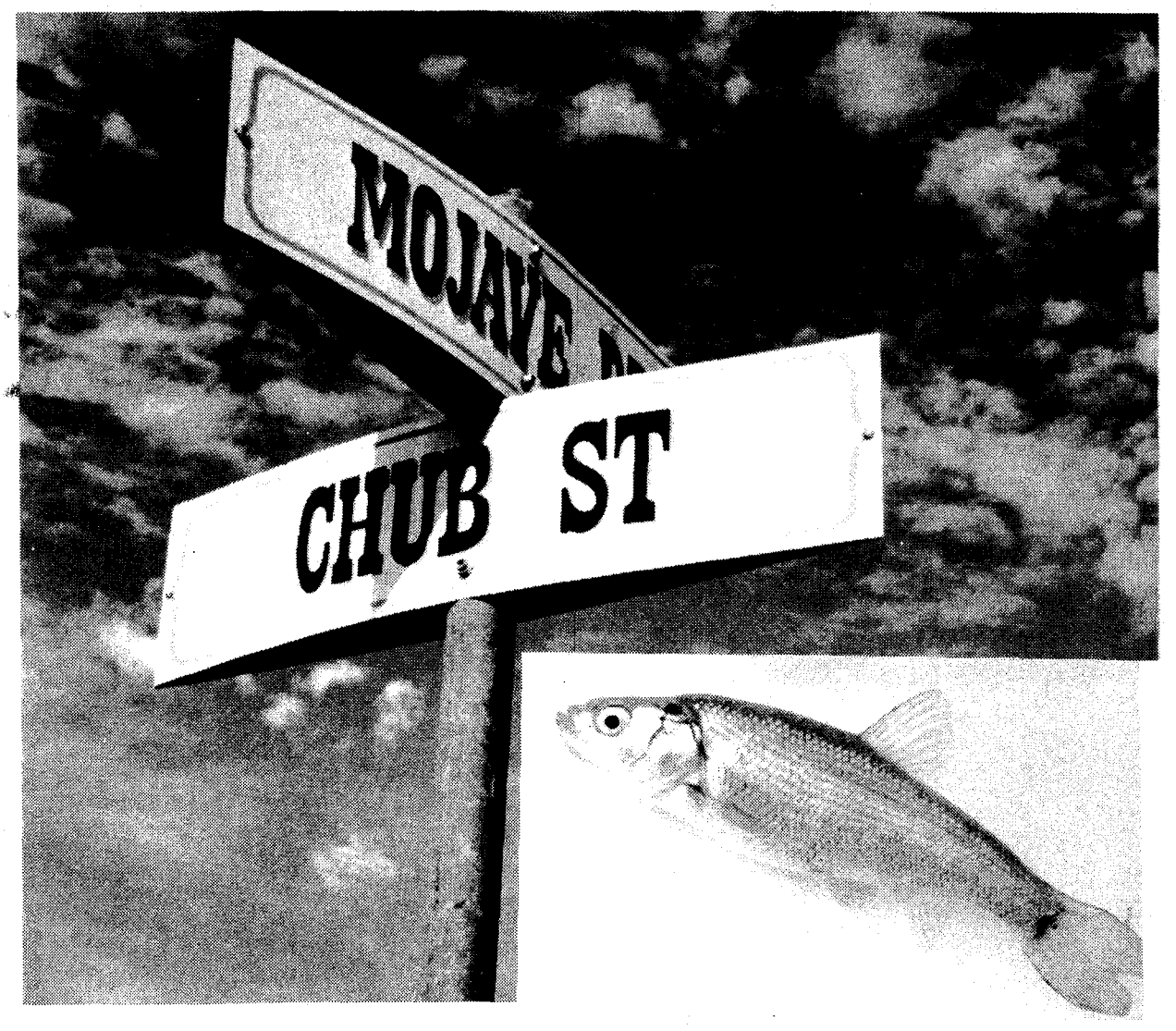

MOHAVE TUI CHUB
Gila Bicolor Mohavensis

RECOVERY PLAN

Recovery Plan

for the

Mohave Tui Chub,

Gila bicolor

mohavensis

Published by

U.S. Fish and Wildlife Service

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Regional Director, U.S. Fish and Wildlife Service

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Date

THIS IS THE COMPLETED RECOVERY PLAN FOR THE MOHAVE TUI CHUB. IT HAS BEEN APPROVED BY THE U.S. FISH AND WILDLIFE SERVICE. IT DOES NOT NECESSARILY REPRESENT OFFICIAL POSITIONS OR APPROVALS OF COOPERATING AGENCIES AND IT DOES NOT NECESSARILY REPRESENT THE VIEW OF ALL INDIVIDUALS INVOLVED IN THE PLAN FORMULATION. THIS PLAN IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS AND CHANGES IN SPECIES STATUS AND COMPLETION OF TASKS DESCRIBED IN THE PLAN. GOALS AND OBJECTIVES WILL BE ATTAINED AND FUNDS EXPENDED CONTINGENT UPON APPROPRIATIONS, PRIORITIES AND OTHER BUDGETARY CONSTRAINTS.

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THE RECOVERY PLAN FOR THE MOHAVE TUI CHUB, DATED SEPTEMBER 12, 1984, PREPARED BY THE U.S. FISH AND WILDLIFE SERVICE UNDER CONTRACT WITH THOMAS L. TAYLOR (CALIFORNIA DEPARTMENT OF FISH AND GAME) AND BY JACK E. WILLIAMS (ENDANGERED SPECIES OFFICE, U.S. FISH AND WILDLIFE SERVICE).

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Cover Photographs: Road sign and Mohave tui chub from Soda Springs. Photos by Thomas L. Taylor.

Note: Mohave is often spelled Mojave, but owing to its Indian derivation rather than Spanish, is correctly spelled as Mohave throughout this plan.

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 self-sustaining populations (minimum 500 fish each) have been established and secured. Delisting may be considered upon successful establishment of viable populations in a majority of the species' historic habitat in the Mohave River.

2. What must be done to reach recovery?
   Three current populations must be protected and enhanced. Three additional populations will need to be established and secured. The three likely sites are along the Mohave River at Camp Cady Wildlife Area, Afton Canyon Campground and Mohave Narrows Regional Park.

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 three 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* (Snyder), is the only fish native to the Mohave River basin in San Bernardino County, California. Arroyo chubs, *Gila orcutti*, were introduced into Mohave River headwater reservoirs in the San Bernardino Mountains, and first appeared in the Mohave River during the 1930's. Aided by the severe floods of March 1938, the exotic species of *Gila* invaded the Mohave River and subsequently hybridized with the Mohave tui chub. By 1970, genetically pure Mohave tui chubs had been eliminated from the Mohave 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 Mohave River. Mohave tui chubs have been successfully introduced into seeps and marshlands on the China Lake Naval Weapons Center and into a small pond near the town of Hinkley. Current populations require protection. Additional populations, especially along the Mohave 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). Similarily, 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) originally recognized the chub in the Mohave 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* because morphological and osteological comparisons conducted by Uyeno (1961) failed to reveal significant characters to distinguish *Siphateles* and *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, 1948; 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 Mohave 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 Desert Research Station 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). The body is thick (chunky) with a large head and short, rounded fins. The snout is short, 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 fins, 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 Mohave River. The occurrence of the subspecies in streams without these features was rare. 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).

Although the Mohave tui chub may not be as capable of surviving flood flows as the arroyo chub, it is adapted to the Mohave 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 that 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 at University of California at Davis (UCD) have shown that the upper lethal temperature

limit of this tui chub may be slightly above 30°C. During respiratory metabolism experiments at UCD's Fisheries Biology Physiology Lab, all tui chubs tested died during tests at 35°C while all survived at 30°C (J. Cech and D. Castleberry, pers. comm.).

Two of three habitats at Soda Springs are artificially excavated ponds whereas the the third is a spring. Lake Tuendae, the largest of the three habitats, measures 150 m x 40 m. The lake level is maintained by water pumped from Zzyzx Well adjacent to the pond. Plants found in or around Lake Tuendae include the bullrush (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, allowing the fish to elude avian predators. Maximum observed temperature stratification in the Ruppia beds was 12°C. Surface water temperatures were 34.6-36.5°C while the temperature on the bottom was 25-27°C on August 6, 1977, at 1600 hours (air temperature was 44°C) (Soltz 1978).

Three Bats Pond at Soda Springs 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 do 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, Ruppia may form dense mats throughout much of the pond.

In November 1981, a fish kill occurred in the Three Bats Pond at Soda Springs . Although the exact cause has not been determined, high pH, low dissolved oxygen and/or ammonia toxicity were suspected. The Ruppia 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).

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 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.

Although information regarding the life history of the Mohave tui chub is incomplete, studies are currently being conducted at the Desert Research Station (DRS) at Hinkley, the University of California at

Davis (UCD), and Claremont College at Pomona to identify some physiological limits of the Mohave tui chub and arroyo chub. These studies as well as three ongoing studies at Soda Springs could provide information to assist in the recovery and management of the Mohave tui chub.

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 of a fall spawning. 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 spawns in mass 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 98.5 mm SL female to 49,847 found in a 215 mm SL female (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, 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 mm 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 Vickers (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. Intestinal contents of 60 chubs showed 17 were empty, 37 had only "scrap" food and 6 had "natural" food. Natural foods found in the intestines of the chubs were gyrinid larvae, chironomid larvae, one small Mohave tui chub and organic debris.

Hydrographic History and Historic Distribution

Distribution of the Mohave tui chub during the Pleistocene is believed to have extended throughout the Mohave 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).

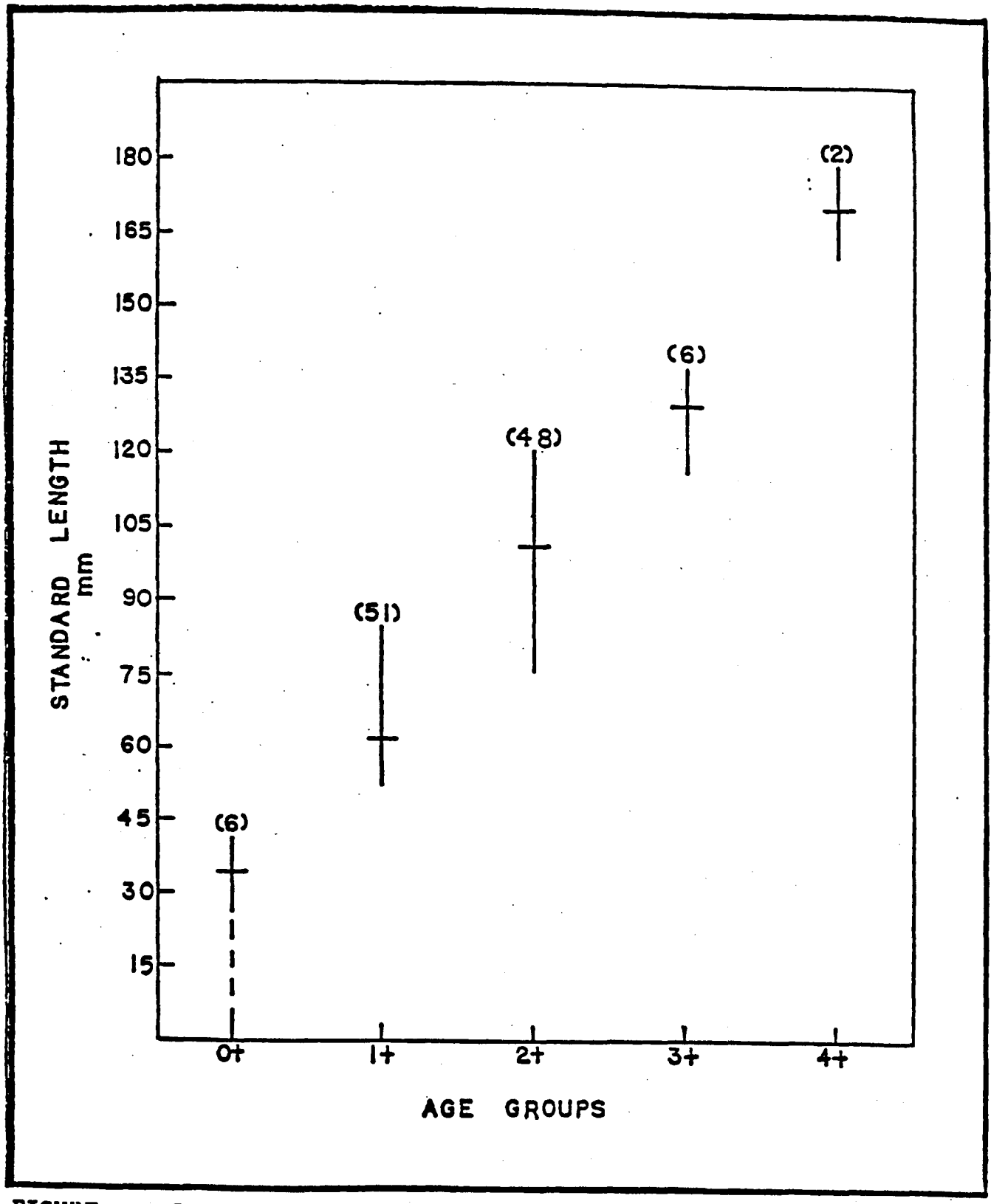


FIGURE 1. Growth rate of G. b. mohavensis based on a sample of 113 specimens collected on March 14, 1970. Vertical lines indicate the range, horizontal lines the mean, and the number in parentheses the sample size. The broken vertical line represents lengths of chubs in age-group 0+ not included in the sample. From Vickers (1973).

Lake Manix filled the region east of Barstow and west of the Cady Mountains and was the largest of the Mohave 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 Mohave 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 transplant sucessfulness indicate that best habitat may be a combination of ponds and slow-water slough conditions.

Causes of Decline and Present Distribution

As the only fish native to the Mohave River drainage, the Mohave tui chub evolved in isolation. By the 1930's however, arroyo chubs, *Gila orcutti*, were introduced as baitfish by trout fishermen into headwater

Figure 2. Pluvial hydrology of the Mohave River area.

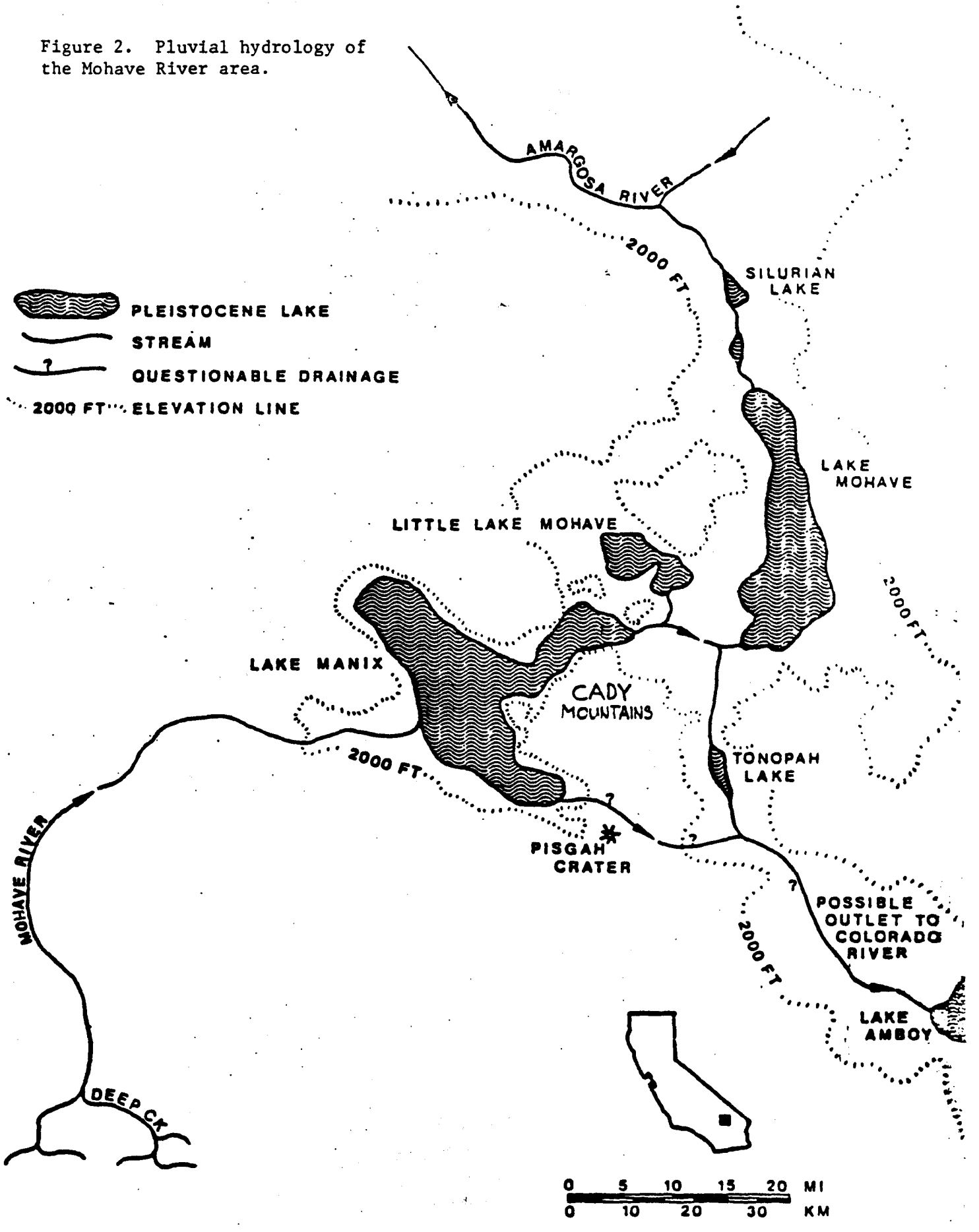
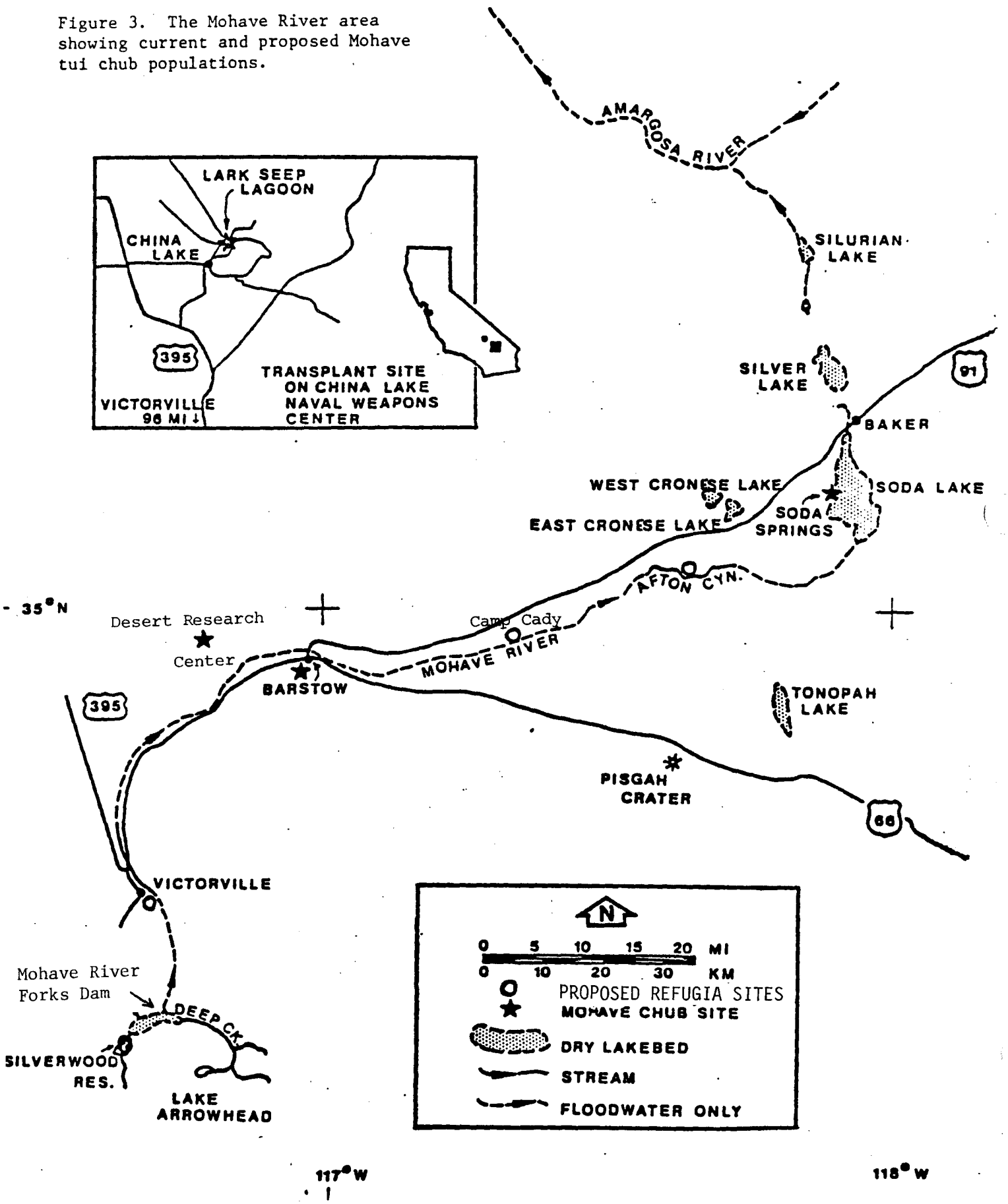


Figure 3. The Mohave River area showing current and proposed Mohave tui chub populations.



reservoirs of the Mohave River and began spreading throughout the drainage. Mohave tui chubs and arroyo chubs readily hybridized and the native fish quickly decreased in abundance (Hubbs and Miller 1943, Miller 1961). Individuals collected in 1936 from Afton Canyon consisted of pure Mohave tui chubs and some 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. Habitat modification at Soda Springs (formerly known as Ft. Soda or Zzyzx Springs) may have contributed to the decline of the remaining tui chubs.

Presently, the Mohave tui chub survives only in modified habitats at Soda Springs, near the southeastern edge of the dry bed of Soda Lake, San Bernardino County. The existing Soda Springs population 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 Mohave River filled Soda Lake and Silver Lake to a depth of approximately 3 meters (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.

Attempts to transplant Mohave tui chubs into other areas have met with a large proportion of failures. Of fourteen attempts, only three, Lark Seep Lagoon, Desert Research Station Pond and Barstow Way Station Pond, have been successful (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 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 insure that adequate conditions exist. Future transplants need not suffer the uncertainties of indiscriminate introductions.

Soda Springs currently has two ponds and a spring, each with a tui chub population. The largest pond, Lake Tuendae, 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 road from the Los Angeles Plain to Ft. Mohave on the Colorado River.

Table 1. Transplant records for Mohave tui chubs.

Introduction Date(s)	Transplantation Sites	Status
5/23/39; 7/29/40	San Felipe Creek, San Diego Co., CA	Successful for 20 years then wiped out by flood
5/6/55	Rio Santo Tomas, Baja California	Unsuccessful
6/67	Paradise Spa, Las Vegas, NV	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	Barstow Way Station, Barstow, San Bernardino Co., CA	Successful
2/8/78	Lake Norconian, Norco, Riverside Co., CA	Unsuccessful
12/12/78	Desert Research Station, Hinkley, San Bernardino Co., CA	Successful

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 in Lake Tuendae and Three Bats Pond.

Mohave tui chubs were planted at Lark Seep Lagoon on the China Lake Naval Weapons Center (NWC) in July 1971 (St. Amant and Sasaki 1971). The original plant of 400 Mohave tui chubs was augmented by 75 more 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 and small springs on the base. Mosquitofish, Gambusia affinis, also inhabit these areas.

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 has since been augmented with fish taken from Soda Springs, 50 in October 1981 and another 176 in December 1981. A relatively large population (2,000 to 4,000) now exists in the pond.

Sixty chubs were originally planted into BLM's Barstow Way Station Pond. This small (300 gallon) man-made habitat serves as an important public display for the Mohave tui chub but it should not be considered as secure habitat. The current population is estimated at only about 50 to 60 fish.

PART II. RECOVERY

Objectives

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 its historic habitat in the Mohave 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 reintroductions.

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 three populations and by establishing at least three additional self-sustaining populations that are protected from threats to their habitats.

Currently, three populations of Mohave tui chubs exist. The three habitats at Soda Springs are considered one population because of their close proximity and dependence on a common water supply. The second population inhabits Desert Research Station (DRS) Pond at Hinkley and another population occurs in interconnected seeps and marshlands on the China Lake Naval Weapons Center. An exhibit of Mohave tui chubs exists at BLM's Barstow Way Station, but these fish

are maintained in a small, artificial environment and are not considered a population for the purposes of this plan.

Three more refugia need to be established before considering the reclassification of the Mohave tui chub to threatened (Federal) or rare (State) status. These refugia will have to maintain a minimium population of at least 500 fish and they should be located adjacent to the Mohave River and therefore within or along the tui chubs' historic natural range. The presence of arroyo chubs in the Mohave River 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 five consecutive years before considering reclassification of the tui chub. Also, the refugia populations should have been exposed to and have survived a flood before reclassification can proceed.

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 its historic habitat in the Mohave 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 reintroductions.

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 three populations and by establishing at least three additional self-sustaining populations that are protected from threats to their habitats.

1. Preserve and enhance existing Mohave tui chub populations and their habitats.
    - 11. Soda Springs : Lake Tuendae, Three Bats Pond, and MC Spring.
        - 111. Manage habitats.
            - 1111. Maintain and/or improve existing habitats.
                - 11111. Monitor water quality.
                - 11112. Determine water budget.
                - 11113. Maintain sufficient water quantity.
                - 11114. 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.

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

121. Maintain and/or improve existing habitats.

1211. Enlarge fish habitat.

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. Enlarge fish habitat.

1312. Monitor water quality.

132. Manage population.

1321. Conduct census as required.

1322. Mix populations if necessary.

2. Establish and protect Mohave tui chub populations in suitable new or restored habitats.

21. Establish population at Camp Cady Wildlife Area.

211. Determine suitability as a refugium.

212. Construct habitat.

213. Prepare management plan.

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

22. Establish population at Afton Canyon Campground Pond.

221. Determine suitability as a refugium.

222. Develop and implement a Land Protection Plan.

223. Control exotic species.

224. Prepare management plan.

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

23. Establish population at Mohave Narrows Regional Park.

231. Determine suitability as a refugium.

232. Improve and/or construct habitat.

233. Prepare management plan.

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

24. Reestablish Mohave tui chubs in mainstream Mohave River: Afton Canyon and Victorville areas.

241. Evaluate flood potential and effects on stream morphology.

242. Enhance habitats.

243. Control exotic species.

244. Develop management plan.

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

25. Determine population status.

251. Monitor transplants.

252. Mix populations if necessary.

26. Examine suitability of additional sites.

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

31. Determine losses from bird predation.

32. Determine spawning requirements and early life history.

33. Determine physiological tolerances of Mohave tui chubs and arroyo chubs to various water quality parameters.

34. Determine population genetics.

35. Conduct electrophoretic studies of Mohave tui chubs, arroyo chubs and their hybrids.

36. Encourage continuing studies of tui chubs.

37. 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 press, TV and radio.

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, Three Bats 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 insuring 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 *Ruppia maritima* die back each year adding to lake sediments. Eradication of the *Ruppia* 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 (*Scirpus olneyi*), which encroach on the lake. The water level of Lake Tuendae should be maintained by groundwater pumping if necessary.

Typha sp. and *Scirpus olneyi* 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 *Scirpus* that grows up around the spring. *Typha* and *Scirpus* have been removed in the past and their future, periodic removal will probably be necessary.

The effect of heavy pumping from Zzyzx 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. Three Bats Pond was enlarged in 1980. It had filled to about one-half of its original size because of sediment washed down from the Soda Mountains during flash floods. During November 1981, a fish kill occurred in the pond. Although water quality samples were inconclusive, high pH levels (a pH of 10.8 was recorded on one occasion by L. L. McClanahan, pers. comm.) may have been the cause of the die-off. The fish kill was preceded by a die-off of the *Ruppia maritima* beds. 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. Determine water budget. Elucidation of water budgets at the various habitats may also allow managers to prevent die-offs and to assist in overall proper management.

11113. Maintain sufficient water quantity. The water level of Lake Tuendae and other habitats should be maintained. Periodic pumping of groundwater may be necessary to supplement surface supplies.

11114. 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. Develop and implement management plan. The Desert Consortium, (a group of university scientists and resource managers) in cooperation with U.S. Fish and Wildlife Service, BLM, and 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. All three populations should be monitored to study their response to changes in

habitat. Management options should be instituted as necessary.

1121. Conduct census annually. Populations 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 lake and pond populations probably need to be mixed periodically to prevent genetic inbreeding. This should not occur however, until more is known about their population genetics.

12. China Lake Naval Weapons Center: Lark Seep and G-1 Lagoons. Mohave tui chubs have survived at China Lake Naval Weapons Center 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. Enlarge 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 dependability.

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 been 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 the introduction of the following: hybrid tui

chubs, unwanted fish species, diseases, or parasites.

13. Desert Research Station. The Desert Research Station 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 may require periodic maintenance.

1311. Enlarge fish habitat. The small (30 m x 30 m) pond constructed in 1979 is becoming overgrown with *Typha* and *Scirpus*, which will need to be controlled.

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

132. Manage population. The population at DRS has been the subject of more study than any other population of Mohave tui chubs. Mark-recapture experiments, growth and basic physiological work is being conducted by students at DRS. This work 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 necessary 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 (see Task 1222).

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. The Mohave Tui Chub Advisory Committee (which includes representative from USFWS, CDFG, BLM, DRS and the Desert Consortium) has identified the following sites as having the best potential for establishing additional populations: Camp Cady Wildlife Area, Afton Canyon Campground, and Mohave Narrows Regional Park.

21. Establish population at Camp Cady Wildlife Area. The Camp Cady Wildlife Area of California Department of Fish and Game is being developed to accommodate wildlife needs in desert riparian systems. Plans for the area call for several ponds as well as construction of a reservoir to supply water to the ponds. The reservoir will probably be filled with pumped groundwater and could be an ideal prospect for a Mohave tui chub refuge. The reservoir should be designed to meet the specific needs of the Mohave tui chub as well as other wildlife. Because CDFG's wildlife managment program has the lead in planning and development of the wildlife area, the concept of a refugium for the tui chub needs close coordination with the wildlife staff.

211. Determine suitability as a refugium. Although the overall area appears well-suited to development of a Mohave tui chub refugium, location of a particular site has yet to be determined. Once an area is chosen, it should receive careful scrutiny for its water supply, potential for exotic fish introductions, and conflicting uses.

212. 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.

213. Prepare management plan. Perpetuation of this population will require a carefully coordinated management plan.

214. 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 34).

22. Establish population at Afton Canyon Campground Pond. There are two ponds in Afton Canyon that are candidates for Mohave tui chub refugia (Figure 3). Both ponds are outside of the main river channel. The Afton Canyon Campground Pond (T12N, R8E, Sec. 17) is protected from most flooding by a levee, whereas the Union Pacific Railroad Pond (T12N, R8E, Sec. 11) is protected form all except the most devastating floods by the railroad fill. Preliminary analysis indicates that the campground pond is the best choice for the attempted establishment of the tui chub.

221. Determine suitability as a refugium. Although preliminary analysis is favorable, the site should be examined for water quality, protection from floods, and manageability as an endangered fish refugium.

222. Develop and implement a Land Protection Plan. Because these ponds are on private land, a Land Protection Plan is necessary. The plan will identify the best method to protect the habitat. The area in question is included in a potential land exchange with the Bureau of Land Management. If the land becomes publically owned, no Land Protection Plan would be necessary.

223. Control exotic species. The fish present in the Afton Canyon Campground Pond are black bullhead (*Ictaluras melas*), green sunfish (*Lepomis cyanellus*), fathead minnows (*Pimephales promelas*) and arroyo chubs (*Gila orcutti*). Eradication of the arroyo chub, and probably the other exotic species as well, is necessary prior to the introduction of Mohave tui chubs.

224. Prepare management plan. If deemed viable as a refugium, a management plan will be needed.

225. 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 34).

23. Establish population at Mohave Narrows Regional Park. Two lakes, Pelican and Horseshoe, operated by the San Bernardino County Department of Regional Parks exist near Victorville alongside the Mohave River (Figure 3). The lakes may make suitable refugia for Mohave tui chubs and would provide refugia in the upper Mohave River Valley. Also, a small holding pond within the park may be a suitable refugium site.

231. Determine suitability as a refugium. Preliminary analysis indicates that either the small holding pond or Pelican Lake would be the preferred site. The substantial sport fishery at Lake Silverwood may preclude the selection of this site. Regardless, the potential of these areas needs close evaluation. Conflicts with exotic species should be closely considered.

232. Improve and/or construct habitat. If the holding pond or another site is chosen, habitat modifications may be necessary to insure suitability for the Mohave tui chub.

233. Prepare management plan. If deemed viable as a refugium, a management plan will be needed.

234. Implement managment 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 34).

24. Reestablish Mohave tui chubs in mainstream Mohave River: Afton Canyon and Victorville areas. These two sections of the Mohave River have perennial flows and provided habitat for the Mohave tui chub prior to establishment of the arroyo chub. The section through Afton Canyon is approximately 10 km in length. Near Victorville, the Mohave River flows permanently on the surface through the Mohave Narrows.

241. Evaluate flood potential and effects on stream morphology. Floods can substantially alter stream morphology as well as provide routes for exotic species introductions. A flood control project is being considered for the Barstow area. The development of this project and continued demands on groundwater resources in the area may substantially reduce or eliminate flooding. Evaluation of future water demands, flood control projects, and flooding frequencies are needed prior to experimental reintroductions.

242. Enhance habitats. The habitats may require modification to protect from flooding and the introduction of exotic species.

243. Control exotic species. A fish survey will be required at the sites. Once exotic species have been identified, they should be controlled as needed.

244. Develop management plan. Development of a management plan will be necessary to enhance the chance that these reintroductions will succeed.

245. 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 34).

25. Determine population status. For the first three years, transplanted populations should be monitored quarterly to determine population size and dynamics. Thereafter, populations should receive monitoring in the fall and spring.

251. Monitor transplants. All transplants should be regularly monitored to determine their status, presence of exotic species, and water supply. The physical and chemical qualityies of the water should be monitored seasonally.

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

26. Examine suitability of additional sites. Additional ponds or springs that could provide appropriate Mohave tui chub habitat exist along or near the Mohave River. These should be examined to determine water quantity, seasonal water quality, security of the site, ownerships and necessary protective measures.

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 are available on this fish.

31. Determine losses from bird predation. In the pond and lake habitats at Soda Springs, many tui chubs have marks or scars, possibly indicating they have escaped from avian predators. The effect of this possible predation could be a significant factor in regulating population size and growth rates. The relationship between exposure to predation and cover availability needs evaluation.

32. Determine spawning requirements and early life history. Mohave tui chub spawning requirements are unknown and need to be determined. Egg and larval development are also unknown

and need to be defined. Habitat requirements of larval and juvenile Mohave tui chubs should be determined.

33. Determine physiological tolerances of Mohave tui chubs and arroyo chubs to various water quality parameters. The ecological differences of *Gila bicolor mohavensis* and *G. orcutti* in relation to water quality parameters need to be more clearly defined. The Department of Wildlife and Fisheries Biology at U.C. Davis and the Desert Research Station have completed some basic oxygen consumption and blood oxygen experimentation with the Mohave tui chub. Similar work is proceeding with the arroyo chub. Studies are also underway on the China Lake Naval Weapons Center population.

34. Determine population genetics. As a result of the small population sizes and small numbers of founding individuals in a population, 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.

35. Conduct electrophoretic studies of Mohave tui chubs, arroyo chubs and their hybrids. Coupled with available morphometric data (Hubbs and Miller 1943), electrophoretic data will enable managers to identify pure Mohave tui chubs or the presence of any hybrids in a population.

36. Encourage continuing studies of tui chubs. Students and staff of the Desert Research Station and Desert Consortium should be encouraged to continue their studies.

37. Incorporate findings into managment 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 all 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 Mohave River ecosystem, and the causes for its current status.

51. Provide information to press, TV and radio. Information concerning the status of the Mohave tui chub should be made available to the public as soon as feasible.

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 at all of the newly

established populations to inform the public of recovery efforts and to encourage their support.

Literature Cited

Bailey, R. M., and T. Uyeno. 1964. Nomenclature of the blue chub and the tui chub, cyprinid fishes from western United States. Copeia 1964:238-239.

Blackwelder, E. 1954. Pleistocene lakes and drainages in the Mohave region, southern California. Bull. California Div. Mines 170:35-40.

Blackwelder, E., and E. W. Ellsworth. 1936. Pleistocene lakes of the Afton basin, Calif. Am. J. Sci. 31:453-463.

Blanc, R. P., and G. B. Cleveland. 1961. Pleistocene lakes of southeastern California. Mineral Information Service, Division of Mines, State of California. Vol. 14.

Buwalda, J. P. 1914. Pleistocene beds at Manix in the eastern Mohave Desert region. Univ. California Dept. Geol. Bull. 7:443-464.

Deacon, J. E., G. Kobetich, J. D. Williams, S. Contreras, et al. 1979. Fishes of North America endangered, threatened, or of special concern: 1979. Fisheries (Bull. Am. Fish. Soc.). 4:29-44.

Girard, C. 1857. Researches upon the cyprinoid fishes inhabiting the fresh waters of the United States, west of the Mississippi Valley, from specimens in the museum of the Smithsonian Institution. Proc. Acad. Nat. Sci. Philadelphia 8(for 1856):165-213.

Havelka, M., C. A. Booth, K. G. Whitney, and C. E. Whitney. 1982. Growth and population structure of the Mohave chub. Cal-Neva Wild. Trans. 1982:9-15.

Hoover, F., and J. A. St. Amant. 1983. Results of Mohave tui chub, Gila bicolor mohavensis, relocations in California and Nevada. California Fish and Game. 69:54-56.

Hubbs, C. L., and R. R. Miller. 1943. Mass hybridization between two genera of cyprinid fishes in the Mohave Desert, California. Pap. Michigan Acad. Sci., Arts, Letters 28:343-378.

Hubbs, C. L., and R. R. Miller. 1948. The zoological evidence: correlation between fish distribution and hydrographic history in the desert basins of western United States. Pp. 17-166. In The Great Basin with emphasis on glacial and postglacial times. Bull. Univ. Utah Vol. 38.

LaBounty, J. F. 1968. Some ecological and taxonomic considerations of Death Valley cyprinodonts. M.S. thesis. University of Nevada, Las Vegas.

Miller, R. R. 1936. Classification of a Mojave River fish. Pomona College J. Ent. and Zool. 28:58-59.

Miller, R. R. 1938. Description of an isolated population of the freshwater minnow Siphateles mohavensis from the Mohave River basin, California. Pomona College J. Entom. and Zool. 30:65-67.

Miller, R. R. 1946. Correlation between fish distribution and Pleistocene hydrography in eastern California and southwestern Nevada, with a map of the Pleistocene waters. J. Geol. 54:43-53.

Miller, R. R. 1961. Man and the changing fish fauna of the American Southwest. Pap. Michigan Acad. Sci., Arts, 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 54:170-179.

Miller, R. R. 1969. Conservation of fishes in the Death Valley system in California and Nevada. Cal-Neva Wild. Trans. 1969:107-122. (Modified from a report submitted to U.S National Park Service in 1967).

Miller, R. R. 1973. Two new fishes, Gila bicolor snyderi and Catostomus fumeiventris, from the Owens River basin, California. Occ. Pap. Mus. Zool. Univ. Michigan 667:1-19.

Morgan, N. L., and J. L. Turner. 1976. Calculation of unionized ammonia for freshwater. California Fish and Game Environ. Serv. Branch Admin. Report 77-1.

Moyle, P. B. 1976. Inland fishes of California. Univ. California Press, Berkeley.

St. Amant, J. A., and S. Sasaki. 1971. Progress report on reestablishment of the Mojave chub, Gila mohavensis (Snyder), an endangered species. California Fish and Game 57:307-308.

Snyder, J. O. 1918. The fishes of Mohave River, California. Proc. U.S. Nat. Hist. Mus. 54:297-299.

Soltz, D. L. 1978. Mohave chub (Gila mohavensis) at Fort Soda, California habitat management plan. Report to U.S. Bureau of Land Management, Sacramento, California.

Thompson, D. G. 1921. Pleistocene lakes along Mohave River, California. J. Washington Acad. Sci. 11:423-424.

Thompson, D. G. 1929. The Mohave Desert region, California. U.S. Geol. Surv. Water Supply Pap. 578:1-759.

Turner, B. J., and R. K. Liu. 1976. The specific identity of the introduced pupfish population at Zzyzx Spring, California. Copeia 1976:211-212.

Uyeno, T. 1961. Osteology and phylogeny of the American cyprinid fishes allied to the genus Gila. Ph.D. dissertation. The University of Michigan.

Uyeno, T., and R. R. Miller. 1963. Summary of late Cenozoic freshwater fish records for North America. Occ. Pap. Mus. Zool. Univ. Michigan 631:1-34.

Vickers, C. E. 1973. Aspects of the life history of the Mohave chub, Gila bicolor mohavensis (Snyder) from Soda Lake, California. M.S. thesis. California State Univ., Fullerton.

PART III. IMPLEMENTATION SCHEDULE

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 recovery plan for the Mohave tui chub, as elaborated upon in Part II, the Narrative. This table indicates the general category for implementation recovery plan tasks, corresponding action outline numbers, priority duration of the tasks, which agencies are responsible to perform these tasks [an asterisk (*) denotes the lead agency], and the estimated cost of implementation. Implementing Part III is the action of the recovery plan, that when accomplished, will bring about the protection of the Mohave tui chub and its unique habitats.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES

Information Gathering - I or R

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

RECOVERY ACTION PRIORITIES

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

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

3. Priority 3 - All other actions necessary to provide for full recovery of the species.

PART III. IMPLEMENTATION SCHEDULE

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other Agencies	Fiscal Year Cost's (Est.) ($1,000's) FY 1	FY 2	FY 3	Comments/Notes
R3	Monitor water quality [at Soda Springs]	11111	1	Contin-uous			BLM* DSC		1 0.5	1 0.5	
R3	Determine water budget [at Soda Springs]	11112	2	2			BLM*		2	5	
M3	Maintain sufficient water quantity [at Soda Springs]	11113	1	Ongoing			BLM*	4	4	4	
M3	Remove sediments and aquatic vegetation as appropriate [at Soda Springs]	11114	1	Ongoing			BLM*	1.5	1.5	1.5	
M3	Develop and implement management plan [for Soda Springs]	1112	2	Ongoing			BLM*	2	1	1	
M7	Conduct census annually [at Soda Springs]	1121	2	Ongoing			CDFG*	0.5	0.5	0.5	
M7	Mix populations if necessary [at Soda Springs]	1122	2	Contin-uous			CDFG*		0.5	0.5	
M3	Enlarge fish habitat [at China Lake Naval Weapons Center]	1211	2	Ongoing			USN* CDFG	1	2 1	2 1	
R3	Monitor water quality and flow rates [at China Lake Naval Weapons Center]	1212	2	Ongoing			USN*	2	1	1	

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other Agencies	Fiscal Year Cost's (Est.) ($1,000's) FY 1	FY 2	FY 3	Comments/Notes
M7	Conduct census annually [at China Lake Naval Weapons Center]	1221	3	Ongoing			CDFG* USN	0.5 0.2	0.5 0.2	0.5 0.2	
M7	Mix populations if necessary [at China Lake Naval Weapons Center]	1222	2	Contin-uous			CDFG*		0.25	0.25	
M3	Enlarge fish habitat [at DRS]	1311	1	Ongoing			DRS*	0.25	0.25	0.25	
M3	Monitor water quality [at DRS]	1312	2	Ongoing			DRS*	0.25	0.25	0.25	
M7	Conduct census as required [at DRS]	1321	2	Ongoing			DRS* CDFG	0.25 0.2	0.25 0.2	0.25 0.2	
M7	Mix populations if necessary [at DRS]	1322	2	Contin-uous			CDFG*		0.25	0.25	
M2	Determine suitability as a refugium [at Camp Cady Wildlife Area]	211	3	1			CDFG*	2			
M2	Construct habitat [at Camp Cady Wildlife Area]	212	3	1			CDFG*		12		
M2	Prepare management plan [for Camp Cady Wildlife Area]	213	3	1			CDFG*		2		

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Cost's (Est.) ($1,000's): FY 1	FY 2	FY 3	Comments/Notes
M2	Implement management plan including introduction of Mohave tui chubs [at Camp Cady Wildlife Area]	214	3	Contin-uous			CDFG*			4	
M2	Determine suitability as a refugium [at Afton Canyon Campground Pond]	221	3	1			BLM* CDFG	1 1			
A7	Develop and implement a Land Protection Plan [for Afton Canyon]	222	3	1	1	ACQ		To be determined			LPP should be developed in FY 3
M4	Control exotic species [at Afton Canyon Campground Pond]	223	3	1			CDFG* BLM		2 1		
M2	Prepare management plan [for Afton Canyon Campground Pond]	224	3	1			BLM*		2		
M2	Implement management plan including introduction of Mohave tui chubs [at Afton Canyon Campground Pond]	225	3	Contin-uous			CDFG BLM*			1 2	
M2	Determine suitability for a refugium [at Mohave Narrows Regional Park]	231	3	1			CDFG*	1			
M2	Improve and/or construct habitat [at Mohave Narrows Regional Park]	232	3	1			CDFG*		10		Cost will vary depending on site chosen

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other Agencies	Fiscal Year Cost's (Est.) ($1,000's) FY 1	FY 2	FY 3	Comments/Notes
M2	Prepare management plan [for Mohave Narrows Regional Park]	233	3	1			CDFG* SBC		2 1		
M2	Implement management plan including introduction of Mohave tui chubs [at Mohave Narrows Regional Park]	234	3	Contin-uous			CDFG* SBC			3 0.5	
M2	Evaluate flood potential and effects on stream morphology [for mainstream Mohave River]	241	3	1			BLM*				Task will be implemented in FY 4
M2	Enhance habitats [at mainstream Mohave River]	242	3	1			BLM*				Task will be implemented in FY 5
M4	Control exotic species [at mainstream Mohave River]	243	3	1			CDFG*				Task will be implemented in FY 5
M7	Develop management plan [for mainstream Mohave River]	244	3	1			BLM*				Task will be implemented in FY 5
M2	Implement management plan including introduction of Mohave tui chubs [at mainstream Mohave River]	245	3	Contin-uous			CDFG*				Task will begin in FY 6

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other Agencies	Fiscal Year Cost's (Est.) ($1,000's) FY 1	FY 2	FY 3	Comments/Notes
I1	Monitor transplants	251	3	Contin-uous			CDFG*				Task to begin in FY 4
							BLM				
I1	Mix populations if necessary [at transplant sites]	252	3	Contin-uous			CDFG*				Task to begin in FY 5
R13	Examine suitability of additional sites	26	3	1			BLM*	3			Task currently underway
R9	Determine losses from bird predation	31	3	2	1	SE			2	1	
							CDFG*		2	1	
R14	Determine spawning requirements and early life history	32	2	2	1	SE			1	1	
							CDFG*		3	3	
R3	Determine physiological tolerances of Mohave tui chubs to various water quality parameters	33	2	3	1	SE		2	3	3	
							CDFG*	2	3	3	
							DRS		0.5	0.5	
							DSC		0.5	0.5	
							USN	3	3	3	
R14	Determine population genetics	34	2	2	1	SE*		3	4		
							CDFG	1	2		
							USN	1	1		
R14	Conduct electrophoretic studies of Mohave tui chubs, arroyo chubs and their hybrids	35	2	2	1	SE*			3	3	
							CDFG		1	1	

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other Agencies	Fiscal Year Cost's (Est.) ($1,000's) FY 1	FY 2	FY 3	Comments/Notes
R14	Encourage continuing studies of tui chubs	36	2	Ongoing			CDFG*		0.5	0.5	
							DRS		0.5	0.5	
M7	Incorporate findings into management and recovery plans	37	3	Contin-uous	1	SE			0.5	0.5	
							CDFG*		0.5	0.5	
							BLM		0.5	0.5	
02	Enforce applicable State and Federal laws	41	1	Ongoing	1	LE		1	1	1	
							CDFG*	1	1	1	
							BLM	2	2	2	
03	Evaluate effectiveness of applicable laws and regulations	42	2	Contin-uous	1	SE			0.5	0.5	
							CDFG*		0.5	0.5	
							BLM		0.5	0.5	
01	Provide information to press, TV and radio	51	3	Contin-uous	1	SE			0.5	0.5	
							CDFG*		0.5	0.5	
							BLM		0.5	0.5	
							USN		2	1	
01	Prepare and distribute brochure on recovery rationale	52	3	1	1	SE*			1		
01	Prepare appropriate articles for popular and scientific publications	53	3	2	1	SE				0.5	
							CDFG*		0.5	0.5	

Category	Plan Task	Task Number	Task Priority	Task[1] Duration (Yrs.)	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other Agencies	Fiscal Year Cost's (Est.) ($1,000's) FY 1	FY 2	FY 3	Comments/Notes
01	Create and maintain interpretive centers	54	3	1			CDFG* BLM* SBC*		2.5 4 1		CDFG has lead at Afton Canyon and Ft. Soda; CDFG and SBC share lead at Mohave Narrows Regional Park

FWS - U.S. Fish and Wildlife Service
SE - Endangered Species Program of FWS
LE - Law Enforcement Program of FWS
ACQ - Land Acquisition Program of FWS
DRS - Desert Research Station, Barstow School District
DSC - Desert Consortium
USN - U.S. Navy
SBC - San Bernardino County
CDFG - California Department of Fish and Game
BLM - U.S. Bureau of Land Management

* - denotes lead agency

[1]Ongoing - task currently underway, and to be continued from year to year

Continuous - once funded, task continues from year to year

APPENDIX

List of Agencies Asked to Submit Review Comments.

1. Desert Studies Consortium - Fullerton*
2. California Department of Parks and Recreation - Sacramento*
3. Califonia Department of Fish and Game - Long Beach*
4. U.S. Bureau of Land Management - State Office*
5. U.S. Fish and Wildlife Service - Washington, D.C.*

* Comments received and incorporated during agency review period.