MOHAVE TUI CHUB
Gila bicolor mohavensis

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Management Status: Federal: Endangered
California: Endangered (CDFG, 1998)

General Distribution:

The tui chub (*Gila bicolor*) is widely distributed throughout the hydrographic Great Basin Region, including the northern portion of the Mojave Desert, in much of the area formerly occupied by Lake Lahontan and other pluvial lakes during the Pleistocene (Grayson, 1993). The disappearance of these lakes isolated various populations, some better differentiated from others, and 13 subspecies have been recognized (Smith, 1979). Natural populations of the Mohave tui chub (*Gila bicolor mohavensis*) were restricted to the Mojave River during historic times.

Distribution in the West Mojave Planning Area:

During the Pleistocene *G. b. mohavensis* was probably found throughout the Mojave River system. Early collections of the fish suggest that it was most common downstream from Victorville (Snyder, 1918). The only surviving natural population is found in Soda Spring at the Desert Studies Center, or Zzyzx, near Baker, California (outside the planning area). Although they have disappeared from most of their natural range, they have been introduced into several areas including Lark Seep at the China Lake Naval Air Weapons Center, Camp Cady, the California Desert Information Center in Barstow, and the Desert Research Station near the town of Hinkley, all in California. The latter population no longer exists as the ponds dried up in 1992.

Natural History:

Mohave tui chubs are small fish rarely exceeding 6.7 inches (170 mm) standard length (tip of snout to end of vertebral column) but occasionally reaching 8.7 inches (220 mm), and possibly 10 inches (254 mm) according to the California Department of Fish and Game (personal communication). The body is stocky with a large, slightly concave head, and short rounded fins. Larger fish may develop a pronounced hump behind the head. The snout is short and the mouth is slanted downward posteriorly. In color, they are bright brassy-brown to dusky-olive dorsally, with gold and fine speckling laterally, and a bluish-white to silver ventral surface. Fins are olive to brown. Modal fin-ray counts reported by Hubbs and Miller (1943) are as follows: dorsal - 8, anal - 8, pectoral - 16, and pelvic - 10. Both sexes exhibit similar size and outward appearance.

According to information summarized in USFWS (1984) from Hubbs and Miller (1943), Mohave tui chubs differ from other subspecies of *G. bicolor* in having 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), numerous gill rakers (18-29, usually 21-27), and a typical pharyngeal tooth formula of 0,5-5,0, but up to 30% may be 0,5-4,0.

Transplanted Mohave tui chubs at Lark Seep spawn between May and June. Recruitment of young of the year fish was observed in August (Feldmeth et al., 1985). According to information summarized by USFWS (1984), Mohave tui chubs initiate spawning in March or April when water temperatures approach 64^{o} F (18^{o} C), and continues to some degree while water temperatures range from 63^{o}-79^{o} F (17^{o}-26^{o} C). Spawning occurs through the spring (with some indication of fall spawning), and involves groups of chubs releasing eggs over vegetation to which the eggs become attached. The adhesive eggs are about 0.04 inches (1 mm) in diameter and hatch in 6-8 days at temperatures of 64^{o}-68^{o} F (18^{o}-20^{o} C). Hatchlings spend about 12 hours on the bottom and then swim to the surface. Young fish, or fry, then form small schools in shallow areas of their habitat.

The growth of Mohave tui chubs was examined in a transplanted population at the Desert Research Station near Hinkley, California. During May, chubs gained weight at the rate of 0.03% of their body weight per day. However, during June, they lost 0.7% of the body weight per day. The rate of loss decreased in July and August and then increased again in September. By October, fish gained 0.006% of their body weight per day with weight gains continuing into November. Losses may reach 35% of initial body weight from June-October (Havelka et al., 1985). Little if any increases in standard length occur between August and April (Taylor and McGriff, 1985). Decreases in weight also occur in December. Decreases may have resulted from increased metabolism and a possible reduction of planktonic biomass in the summer (Havelka et al., 1982).

At Soda Springs, Mohave tui chubs in two artificial ponds exhibited the following range of mean standard lengths at various ages as follows: age 0+ 1.9-2.2 inches (48.3-57.0 mm), age 1+ 2.5-2.6 inches (63.8-65.2 mm), age 2+ 3.1-3.2 inches (78.3-82.2 mm), age 3+ 4.1-4.3 inches (103.8-108.0 mm), age 4+ 4.3 inches (109.5 mm; Taylor and McGriff, 1985).

Little is known of the feeding habits of the Mohave tui chub. At Soda Spring natural foods found in the intestines of Mohave tui chubs consisted of gyrinid larvae, chironomid larvae, organic debris and one small Mohave tui chub (U.S. Fish and Wildlife, 1984). The stomach contents of transplanted Mohave tui chubs living at Lark Seep contained vascular plants, *Spirogyra*, young chubs, *Daphnia*, chironomids, amphipods, Trichopteran cases, and detritus (Feldmeth et al, 1985). At Pyramid Lake, Nevada, the diet of juvenile tui chubs of the subspecies *G. bicolor pectinifer* was composed entirely of zooplankton, primarily the cladoceran, *Moina hutchinsoni*. The cladoceran *Diaphanosoma leuchtenbergianum* and the copepod *Cyclops vernalis* were consumed in significant quantities by nearshore fish. Changes in diet composition during the summer corresponded to seasonal changes in the zooplankton community (Galat and Vucinich, 1983).

In laboratory tests, Mohave tui chubs exhibited lower tolerance of decreasing oxygen tension, less appropriate resting-routine metabolic rate responses to increasing temperature, and poorer swimming performance response to high water velocity in comparison with arroyo chubs (*G. orcutti*). These differences contributed to the displacement of Mohave tui chubs by arroyo chubs and reflect the different evolutionary histories of the species. Mohave tui chubs were lake-dwelling fish until the disappearance of pluvial lakes in the Mojave Desert in the Pleistocene (Grayson, 1993). Their relatively poor adaptation to conditions typical of the Mojave River is a reflection of their lake origin. In contrast, the arroyo chub have long inhabited coastal stream systems characterized by extreme variations in flow rate, dissolved oxygen concentration, and temperature (Castleberry and Cech, 1986).

When a pond was being dredged for maintenance at the Desert Studies Center at Zzyzx, Mohave tui chubs were observed to swim from shrinking pools toward outflow areas. This behavior would have survival value under natural conditions when fish are forced to seek refugia as pools of water evaporate during dry periods (Courtois, 1984).

The Mohave tui chub was listed as a federally endangered species on 13 October, 1970. The state of California followed with an endangered listing in 1971. The American Fisheries Society also considers the subspecies to be endangered (USFWS, 1984).

Habitat Requirements:

Mohave tui chubs do not exhibit the wide range of tolerance to desert conditions seen in other desert fishes, like pupfish. McClanahan et al. (1986) observed that the mean critical thermal maxima for fish acclimated at 64.4, 75.2 and 86^{o} F (18, 24 and 30^{o} C) were 92.3, 94.8 and 97.2^{o} F (33.5, 34.9 and 36.2^{o} C), respectively. Mean critical thermal minima at the same acclimation temperatures were 37, 40.6 and 45^{o} F (2.8, 4.8 and 7.2^{o} C), respectively. The thermal scope, or difference between lower and upper lethal temperatures, is about 54^{o} F (30^{o} C). In contrast, pupfish have a thermal scope of about 72^{o} F (40^{o} C) according to McClanahan et al. (1986). However, Mohave tui chubs are capable of enduring hostile conditions with dissolved oxygen levels of less than 0.00013 ounces/gallon (1 mg/l), salinity of at least 11.55 parts per thousand, water conductivity of 18,000 micromhos/cm, and pH between 9 and 10 at Soda Springs (U.S. Fish and Wildlife, 1984).

In the laboratory, Mohave tui chubs can osmoregulate successfully at salinities of up to 897 mOsm/gallon (237 mOsm/l). Fish transferred from 1,223-1,964 mOsm/gallon (323 mOsm/l-519 mOsm/l) survived overnight but lost an average of 11% of their body mass: one fish lost 13% and died even after placed in a lower salinity environment (McClanahan et al., 1986).

The lake-dwelling history of Mohave tui chubs was reflected in the comments of Snyder (1918) who noted that they were always associated with deep pools and slough-like areas of the Mojave River. They are rarely found in streams without those features.

The presence of aquatic ditchgrass (*Ruppia maritima*) is important as it apparently provides a preferred structure for egg attachment when spawning and also provides thermal shelter to fish during the summer (U.S. Fish and Wildlife, 1984).

Population Status:

Efforts to ensure the survival of the Mohave tui chub have frequently utilized relocation of populations both within, and outside of, the historic range of the species. In 1969, 150 chubs were introduced to Piute Springs in San Bernardino County, California. In 1970, 147 chubs were released into an artificial pond at the South Coast Botanic Garden in Palo Verdes (Los Angeles County), California. Another transplant of 41 chubs was attempted in 1970 at Two Hole Springs in San Bernardino County, California. All of these three relocations were from stock at Soda Springs (St. Amant and Sasaki, 1971). Other transplant efforts included the Lark Seep sewage treatment lagoons at China Lake Naval Weapons Center in California, Dos Palmas spring in Riverside County, California, the Desert Research Station near Hinkley, California, the Barstow Way Station (California Desert Information Center), and various other natural and artificial wetlands in Orange, San Diego and Los Angeles Counties, California, Nevada, and Baja California, Mexico (U.S. Fish and Wildlife, 1984). Of at least 15 transplant attempts, only four (Lark Seep, Barstow Way Station, Camp Cady, and the Desert Research Station) were successful (Hoover and St. Amant, 1983; USFWS, 1984). However, fish no longer occur at the Desert

Research Station. Failures at various sites were attributed to poor water quality and quantity, floods, and lack of suitable spawning areas.

Mohave tui chubs can achieve relatively high population densities. A transplanted population at the Desert Research Station near Hinkley, California started from 16 chubs that were placed into a 30 m^2 pond in December, 1978. In the summer of 1981 the population was estimated at 2,516 fish, but fell to an estimated 880 in the winter of 1982 (Havelka et al., 1985). As many as 4,000 chubs have occupied the pond (USFWS, 1984) but in 1992 all perished when the pond dried up.

Threats Analysis:

Hybridization with introduced arroyo chubs (*G. orcutti*) virtually eliminated pure populations of the Mohave tui chub. Arroyo chubs were introduced into the headwaters of the Mojave River in the 1930's and quickly spread into the system. Chubs collected in Afton Canyon in 1936 consisted of pure Mohave chubs and some hybrids according to Hubbs and Miller (1943). By 1969 few pure Mohave tui chubs remained (Miller, 1969).

Introduction of other exotic species and habitat alteration also contributed to the decline of Mohave tui chubs. The invasion of saltcedar into the Mojave River system has caused large-scale changes in flow rates and geomorphology (Lovich et al., 1994; Lovich and de Gouvenain, in press).

Changes in water quality of artificial ponds have resulted in die-offs of up to 90% of Mohave tui chub populations at Soda Springs, nearly eliminating all fish less than 2 inches (50 mm) standard length (Taylor and McGriff, 1985). The aquatic ditchgrass beds in the pond died about two weeks prior to the fish kill (USFWS, 1984).

Biological Standards:

Maintenance of this species in the WMPA will require protection and restoration of appropriate habitat. Requirements include still or slow moving water with abundant, native, emergent vegetation, and exclusion of exotic species such as the arroyo chub and other fish, saltcedar, and giant cane (*Arundo*). Clean water within the range of acceptable physiological tolerances for temperature and chemistry are also requisites for survival.

The subspecies will be considered for reclassification as threatened when six self-sustaining populations of at least 500 fish each are firmly established. Delisting may be considered when it is reestablished, as viable populations, in a majority of its historic habitat in the Mojave River (USFWS, 1984).

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