State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

FIVE-YEAR SPECIES REVIEW OF OWENS TUI CHUB (*Siphateles bicolor snyderi*)

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Owens Tui Chub from Upper Mule Spring, Inyo County. California Department of Fish and Wildlife (CDFW/Department) file photo.

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I. EXECUTIVE SUMMARY

The Owens Tui Chub (*Siphateles bicolor snyderi* Miller) is a moderate-sized freshwater fish that is endemic to the Owens Basin in eastern-central California, near the communities of Mammoth Lakes, Bishop, Big Pine and Lone Pine (Figure 1). Owens Tui Chub face ongoing threats, have a very limited current distribution, exist in small and isolated populations, and their overall status has remained largely unchanged since their listing under the California Endangered Species Act (CESA) in 1974. Their widespread hybridization with a closely related tui chub species, continued presence of non-native predatory and competitive species within their range, loss of much of their historic habitat from water development activities, and predicted outcomes of climate change are the principal threats to Owens Tui Chub.

Owens Tui Chub is currently listed as endangered under CESA. (Fish & G. Code, § 2050 et seq.; Cal. Code Regs. tit. 14 § 670.5, subd. (a)(2)(C).) Pursuant to Fish and Game Code section 2077, subdivision (a), CDFW has prepared this Five-Year Species Review to evaluate whether the conditions that led to the original listing of Owens Tui Chub are still present or have changed. This review is based on the best scientific information currently available to the Department, regarding each of the components listed under section 2072.3 of the Fish and Game Code and section 670.1, subdivisions (d) and (i)(1)(A) of title 14 of the California Code of Regulations. In addition, this document contains a review of the identification of habitat that may be essential to the continued existence of the species and the Department's recommendations for management activities and other recommendations for recovery of the species. (Fish & G. Code, § 2077, subd. (a).)

In completing this Five-Year Species Review for Owens Tui Chub, the Department finds there is sufficient scientific information to indicate the conditions and associated threats that led to the listing of Owens Tui Chub as endangered are still present and, in some cases, have worsened. The Department, therefore, recommends no change to the status of Owens Tui Chub on the list of endangered species at this time.

II. INTRODUCTION

A. Five-Year Species Review

Upon a specific appropriation of funds by the Legislature the Department shall, or, if other funding is available in the absence of a specific appropriation, may, review species listed as endangered or threatened under CESA every five years to determine if the conditions that led to the original listing are still present. (Fish & G. Code, § 2077, subd. (a).) Owens Tui Chub is also listed as endangered under the federal Endangered Species Act. Pursuant to Fish and Game Code section 2077, subdivision (b), the Department contacted the U. S. Department of the Interior, U.S. Fish and Wildlife Service (Service) in an effort to coordinate this species review with the Service's five-year review process (last completed in 2009). However, the Service does not plan to complete a species review of Owens Tui Chub until their Fiscal Year 2021-22 (Bjorn Erickson, USFWS, pers. comm., 2019).

Using the best scientific information available to the Department, this Five-Year Species Review includes information on the following components pursuant to Fish and Game Code sections 2072.3 and 2077, subdivision (a), and California Code of Regulations section 670.1, subdivisions (d): species' population trend(s), range, distribution (including a detailed distribution map),

abundance, life history, factors affecting the species' ability to survive and reproduce, the degree and immediacy of threats, the impact of existing management efforts, the availability and sources of information, identified habitat essential for the continued existence of the species, and the Department's recommendations for future management activities and other recovery measures to conserve, protect, and enhance the species.

B. Listing and Species Review History

Owens Tui Chub was listed as endangered under CESA in 1974 and under the federal Endangered Species Act in 1985. The main identified threats to the species at the time of listing included: hybridization, habitat loss and degradation, with associated restricted distribution and reduced abundance, along with threats (predation and competition) from non-native introduced species (USFWS 1985).

Critical habitat for Owens Tui Chub was designated by the Service on August 5, 1985 (USFWS 1985).

In 1998, the federal Owens Basin Wetland and Aquatic Species Recovery Plan was published (USFWS 1998).

In 2009, the federal 5-year species review of Owens Tui Chub was published (USFWS 2009).

This Five-Year Species Review was initiated in 2020 and prepared by Jeff Weaver, in the Department's Fisheries Branch, Native Fishes Conservation and Management Program. Nick Buckmaster,[a] Environmental Scientist; Steve Parmenter,[b] Senior Environmental Scientist (Specialist) and lead biologist for Owens Tui Chub; Rob Titus,[c] Senior Environmental Scientist (Supervisor); and Claire Ingel,[d] Senior Environmental Scientist (Specialist) ([ab]CDFW Inland Deserts Region, Bishop Field Office; [cd]CDFW Fisheries Branch) also contributed substantially to this review.

C. Notifications and Information Received

On November 26, 2019, the Department notified by e-mail persons who had expressed their interest in CESA actions in writing to the California Fish and Game Commission (Commission) and had provided contact information to the Commission, consistent with Fish and Game Code section 2077, subdivision (a).
The e-mail notification included a link to the Department's dedicated web page for five-year reviews of threatened and endangered species at https://www.wildlife.ca.gov/Conservation/CESA/Five-Year-Reviews.

III. BIOLOGY

A. Taxonomic and Physical Description

Owens Tui Chub are members of the minnow family (Cyprinidae) and are a moderate- to large-sized subspecies of what was formerly lumped into the broader taxonomic designation of *Gila bicolor* (USFWS 1985). Tui chubs were previously considered to belong to the subgenus *Siphateles*, which was elevated to full genus status in a taxonomic revision by Simons and Mayden (1991). Females attain a maximum length of slightly more than 127 mm (5 in), whereas males reach a maximum length of approximately 102 mm (4 in) (USFWS 1985). The body is typically chunky, large scaled and olive, brown, or brassy on the back, with white to silver bellies, and blue or gold iridescence on the head and flanks. Smaller fish tend to be more uniformly silver in color (Moyle 2002). They have a small, terminal and slightly oblique mouth, a decurved lateral line, and all fins are short and rounded (Moyle 2002). The head, especially in older adults, becomes larger relative to the rest of the body, is usually convex in profile, and may be framed by a posterior hump (Moyle 2002). The Owens Tui Chub is distinguished from other tui chubs by the presence of lateral radii on the scales and a rounded or shield-shaped scale base (Miller 1973, Madoz et al. 2005). Genetic analysis suggests there are two distinct lineages of Owens Tui Chub – a “Long Valley” lineage and a Cabin Bar or “Toikona” lineage (Chen et al. 2007). The Toikona Tui Chub was discovered in 1987 at Cabin Bar Ranch, on the southwest end of the dry lakebed of historic Owens Lake (see Population Trends and Abundances section). The Owens Tui Chub is, surprisingly, genetically more similar to the disjunct Lahontan Tui Chub (*S. bicolor pectinifer*) than to the Toikona Tui Chub, with which it shared the same historic river basin. Thus, the Toikona Tui Chub is more diverged and regarded as an important population to manage separately in order to maintain genetic diversity within the broader Owens Tui Chub group (Chen et al. 2007). Overall, genetic analyses have shown that the Owens Tui Chub is the most distinct form of tui chub in the western United States and may merit full species recognition (May 1999 in USFWS 2009).

B. Life History and Ecology

Four endemic fish species comprise the Owens Basin native fish assemblage: Owens Tui Chub, Owens Pupfish (*Cyprinodon radiosus*), Owens Speckled Dace (*Rhinichthys osculus* ssp.), and Owens Sucker (*Catostomus fumeiventris*) (USFWS 1998). All are omnivorous and non-predatory, with the exception of the tui chub, and are habitat generalists with, presumably, little interspecific competition related to habitat utilization, resource partitioning, or demography (USFWS 1998). All Owens Basin fishes are also highly mobile, with the ability to rapidly colonize vacant habitats and have high reproductive capacity (USFWS 1998). This suggests all four occupied most, if not all, historically available aquatic habitats within their range. These traits also make them highly susceptible to introduced species, particularly predatory fishes (e.g., trout species of the genera *Salmo* and *Oncorhynchus* and Largemouth Bass (*Micropterus salmoides*)) and those that can hybridize with the native forms (e.g., introduced Lahontan Tui Chub, which readily hybridize with Owens Tui Chub).

Owens Tui Chub life expectancy is generally regarded to be up to several years (Scoppettone 1988 in USFWS 2009) and they become sexually mature by age 2 (McEwan 1990 in USFWS 2009). However, analysis of annular growth rings in opercular bones of Eagle Lake Tui Chub (*Siphateles bicolor* ssp.) aged fish up to 30+ years (Scoppettone 1988, Crain and Corcoran 2000), so further study on the maximum age of Owens Tui Chub is probably warranted.

Spawning occurs from late winter to early summer, generally over gravel substrate or aquatic

vegetation (USFWS 2009). McEwan (1989) reported that females can produce large numbers of eggs and multiple spawning events may occur across the breeding season. Similar species of tui chubs produce 4,000 to 5,000 eggs per season (USFWS 1984). Hatching time is likely influenced by water temperature, with eggs hatching earlier in warmer water (Cooper 1978 in USFWS 2009). Fry congregate in areas with cover (Moyle 1976 in USFWS 2009). Growth during the first summer is rapid, with yearling fish ranging in size from 22 to 42 mm (0.9 to 1.8 in) (Moyle 1976 in USFWS 2009). Owens Tui Chub prefers slow-moving water, with abundant submerged aquatic vegetation and cover (Jenkins 1990, McEwan 1990, Leunda et al. 2005 in USFWS 2009). They are opportunistic feeders and consume aquatic insects, vegetation, and detritus (McEwan 1991 in USFWS 2009). They are also known predators of juvenile fish and are the only piscivorous fish native to the Owens Basin (N. Buckmaster, CDFW, pers. comm., 2019).

C. Habitat Necessary for Species Survival

The key features of generalized tui chub habitats are slow-moving waters, with well-developed beds of aquatic plants that provide cover and support abundant aquatic insects for forage, along with substrates comprised of sand or other fines (Bond et al. 1988 in Moyle 2002). No information on thermal or water chemistry tolerances, specific to Owens Tui Chub, was found in the literature. However, Moyle (2002) reports that Mohave Tui Chub, native to the Mojave River in southern California and the southernmost representative of the species, can survive in water temperatures from 2°C (36°F) to 36°C (97°F), but optimal temperatures are between 15°C (59°F) and 30°C (86°F). Alkalinity tolerances are reportedly broad, with tui chubs regularly found in waters with pH values greater than 9 and they can tolerate pH levels up to about 11 (Moyle 2002). They also tolerate low dissolved oxygen levels, with tui chubs in Pyramid Lake, NV regularly found in water with oxygen levels less than 50% saturation and, in cold temperatures, they can survive less than 25% saturation levels (Moyle 2002). Their preferred habitat types include springs, lakes, sloughs, ponds, backwaters, drainage ditches, irrigation canals, and other slower waters in the Owens Basin. In 1985, the USFWS designated critical habitat for Owens Tui Chub at the following two sites: 1) 13 km (8 mi) of Owens River and 15 m (50 ft) of riparian vegetation on either side of the river, encompassing a total of approximately 39 ha (97 ac) in the Owens Gorge; and 2) two spring provinces, and 15 m (50 ft) of riparian vegetation on either side of these spring brooks, encompassing approximately 2 ha (5 ac) at Hot Creek Fish Hatchery (Federal Register, Volume 50, Number 150, pg. 31594). The reported constituent elements of this critical habitat include high quality, cool water with adequate cover in the form of rocks, undercut banks, or aquatic vegetation and a sufficient insect food base (USFWS 1998).

IV. DISTRIBUTION AND ABUNDANCE

A. Range and Distribution

As noted, the Owens Tui Chub is endemic to the Owens Basin in Inyo and Mono counties, California (Figure 1). They historically occupied diverse slow-water habitats across the Owens Valley floor. Chen et al. (2007) reported that they occurred in all valley floor wetlands near or connected to the Owens River, much of which has been lost or degraded due to habitat alteration and water resource development. The fish was reportedly common in these habitats at the beginning of the 20th century (Snyder 1917, Miller 1973 as cited in Chen et al. 2007). Early fish collections in the Owens Basin documented tui chub in Owens Lake (Gilbert 1893), several sites along the Owens River from Long Valley to Lone Pine, tributary streams near the

Owens River in Long Valley and Owens Valley, Fish Slough, and irrigation ditches and ponds near Bishop, Big Pine, and Lone Pine (Snyder 1917, Miller 1973 in USFWS 1998).

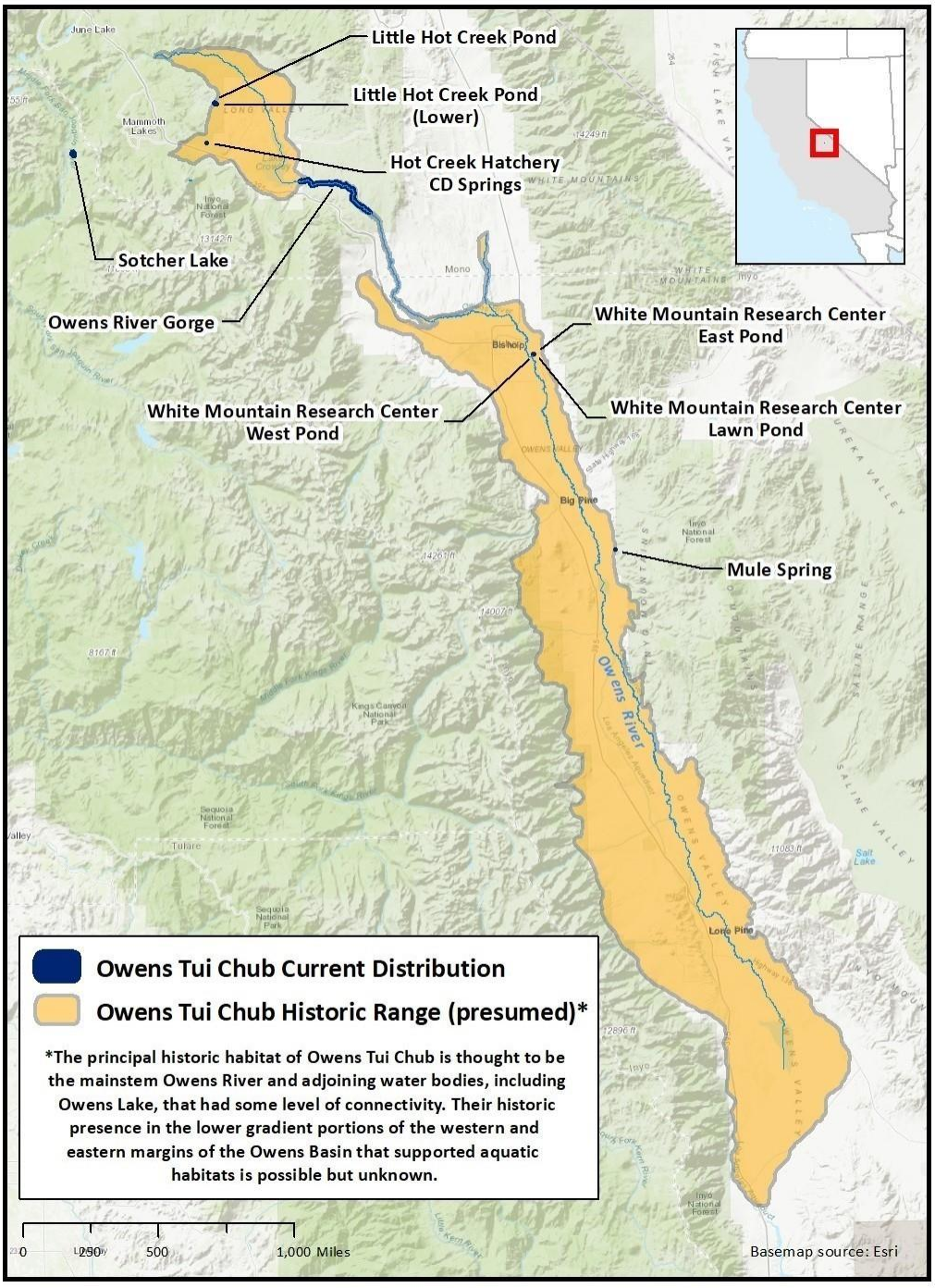

Figure 1. Inferred historic range and known current distribution of Owens Tui Chub.

The current distribution of genetically pure Owens Tui Chub is restricted to five, small, isolated sites within their historic range in the Owens Basin: Hot Creek headwaters (now limited to CD Spring), Little Hot Creek Pond, Upper Owens Gorge, Mule Spring, and White Mountain Research Center (WMRC), operated by the University of California (Figures 1 and 2a-g). A transplanted sixth population exists in Sotcher Lake, near Devil's Postpile National Monument, which is outside the historical range of the species, in Madera County (USFWS 2009) (Figures 1 and 3). While genetically pure Owens Tui Chub are very restricted and isolated in their distribution, hybridized Owens Tui Chub x introduced Lahontan Tui Chub are widespread in the Owens Basin, including in important climate change-resilient habitats (see the Climate Change subsection under Section V.A. - Threats and Survival Factors in this report). These habitats include Crowley Lake and the Upper Owens River; hybridized tui chub populations in these areas are the principal limitation to recovery and population expansion of non-introgressed Owens Tui Chub within their historic range (N. Buckmaster, CDFW, pers. comm., 2019).

Figure 2a. Upper Mule Spring

Figure 2b. Vegetation removal in Mule Spring

Figure 2c. Electrofishing CD Spring

Figure 2d. Vegetation comb in CD Spring

Figure 2e. Little Hot Creek Pond

Figure 2f. Little Hot Creek pothole (blasted)

Figure 2g. White Mountain Research Center “Cottonwood Pond”

Figures 2a-g. Existing Owens Tui Chub habitats within its historic range.

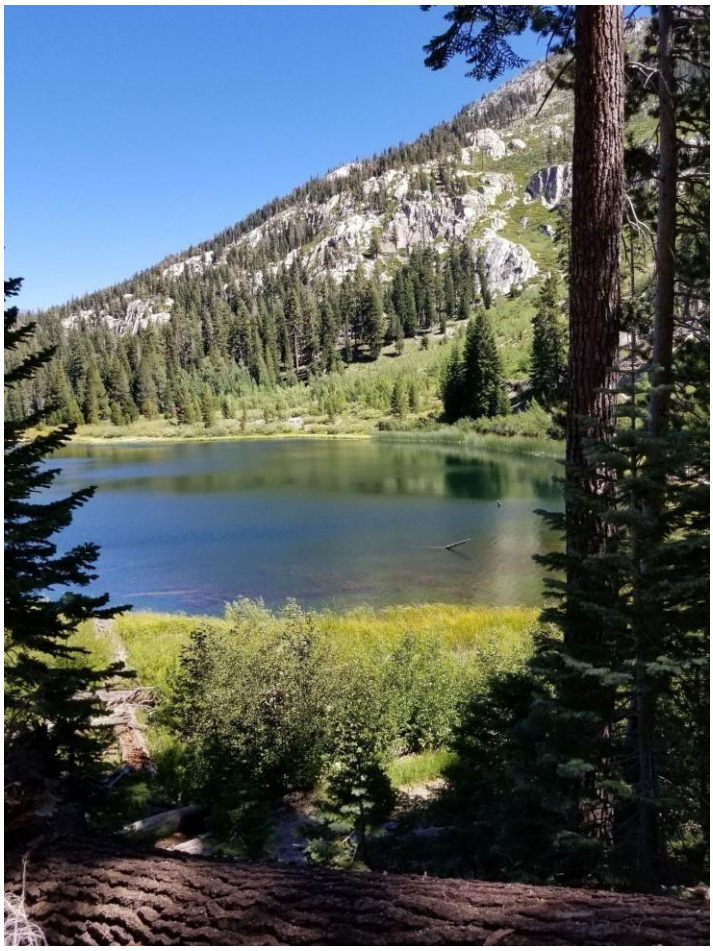

Figure 3. Sotcher Lake, Madera County, located at the western base of Mammoth Mountain Ski Area, near Mammoth Lakes, California.

B. Population Trend and Abundance

Museum records indicate that the period from 1930 to 1970 was characterized by a rapid decline in abundance and distribution of Owens Basin native fishes (Miller 1969, Sada 1989 in USFWS 1998). However, it should be noted that even earlier declines likely occurred due to undocumented introduction of non-native predatory and competitive fishes and other aquatic organisms during settlement of the area by European-Americans. The first segments of the Los Angeles Aqueduct, built to divert Owens Basin waters to provide municipal water supply to Los Angeles, were completed in 1913 and led to dewatering of much of the Owens River and associated aquatic habitats. Further declines likely occurred during this period, owing to the construction of Long Valley Dam in 1941. Long Valley Dam was built at the head of the Owens River Gorge as part of a hydropower project, which led to the complete dewatering of the Lower Owens Gorge reach from 1953 to 1991. Adjoining marsh and pond complexes were invariably dried in the process of the Owens River dewatering, leading to extensive habitat loss. However, a considerable number of groundwater seeps and springs persisted in the Owens Basin through the 1980s. Their disappearance in recent decades is likely due to excessive groundwater pumping (N. Buckmaster, CDFW, pers. comm., 2019).

While hybridized Owens Tui Chub x Lahontan Tui Chub remain relatively widespread in the Owens Basin, a few populations of unhybridized Owens Tui Chub exist and occur only where suitable habitat is isolated from non-native fishes, particularly hybridized tui chub and predatory fishes (USFWS 1998). The USFWS (1985) reported that threats to Owens Tui Chub have reduced their occupancy to less than one percent of their historical range. When federally listed in 1985, only two populations of Owens Tui Chub were believed to exist (Chen et al. 2007), both of which remain extant. One is the Hot Creek Headwaters population, which is located upstream of the Hot Creek Fish Hatchery (Figure 2c and d). The site consists of two currently disjunct springs, AB Spring and CD Spring; however, only the population in CD Spring remains unhybridized (Benjamin and Finger 2016). The second population is in the Upper Owens Gorge, located below Long Valley Dam and north of the town of Bishop (Figure 1).

In 1987, Owens Tui Chub were found occupying irrigation ditches and a spring at Cabin Bar Ranch, on the southwest shore of the dry lakebed of historic Owens Lake. They became known as the Cabin Bar Ranch population (USFWS 2009) and the common name of Toikona Tui Chub was suggested by Chen et al. (2007). Predation from introduced Largemouth Bass and Bluegill (*Lepomis macrochirus*), along with failure to maintain adequate water quality and quantity, extirpated the Cabin Bar Ranch population of Owens Tui Chub in 2003 (USFWS 2009). However, prior to their extirpation, 24 individuals were salvaged and placed in an artificial pond on the ranch in 1988-89. It is believed that all remaining fish in this population were salvaged in the effort (S. Parmenter, CDFW, pers. comm., 2020). Fifty-one of their progeny were moved to Upper Mule Spring Pond (Figure 2a and b) in 1990. All extant fish of this group descendent from this transplant (Chen et al. 2007) are now divided between Upper Mule Spring Pond and the “Cottonwood Pond” at WMRC and have not been mixed with tui chubs of Long Valley origin.

Prior to 1998, individuals from the Hot Creek Headwaters and Upper Owens Gorge populations were translocated to establish additional populations of Owens Tui Chub, of which only Little Hot Creek Pond remains. Tui chubs were not known to exist in Sotcher Lake prior to 1955 and are considered nearly identical, genetically, to the CD Spring population by Chen et al. (2007). In spite of extensive and long-term efforts to establish and maintain the few existing populations of Owens Tui Chub, their trend in abundance has substantially declined from historic levels. Little is known about current population sizes (all estimated roughly between 100 to 1,000 individuals each) and their trends (S. Parmenter, CDFW, pers. comm., 2019). No information about population age structure, sex ratio, or mortality is known to exist (USFWS 2009).

V. THREATS AND SURVIVAL FACTORS

A. Factors Affecting Ability to Survive and Reproduce

Title 14 of the California Code of Regulations, section 670.1, subdivision (i)(1)(A) requires the Commission to consider the following factors when determining whether a species should be listed as threatened or endangered in California: present or threatened modification or destruction of its habitat; overexploitation; predation; competition; disease; and other natural occurrences or human-related activities.

Modification or destruction of habitat

Many aquatic habitats in the Owens Basin have been substantially degraded or lost due to introduction of non-native species, land use practices, and extensive water development activities. Historic maps of the area show surprisingly extensive wetland complexes around the

Owens River and its tributaries (Appendix A), particularly given the naturally arid nature of the Owens Basin. Present or threatened (future) loss of Owens Tui Chub habitat may occur primarily as a result of the following: emergent aquatic plant encroachment; water quality impairment; groundwater overdraft associated with agricultural, municipal, or water export operations; as well as continued and potentially increasing surface water diversions. The widespread presence of non-native species that are predatory or competitive (or both) and of hybridized tui chubs also substantially diminishes the availability of suitable habitats for Owens Tui Chub.

Of the five extant populations within the historical range of the Owens Tui Chub, two (Mule Spring and White Mountain Research Center (Figures 1, 2a, 2b and 2g)) require routine management of water quantity and water quality and three (Mule Spring, Hot Creek Headwaters, and Little Hot Creek (Figures 1, 2a, 2b, 2c, 2d, 2e and 2f)) require routine removal of emergent vegetation. Of the three latter refuge habitats, Little Hot Creek is currently the most self-sustaining in terms of needing the least human intervention (N. Buckmaster, CDFW, pers. comm., 2019). One refuge (Upper Owens Gorge) has been severely altered by the construction of a dam, with no mechanism to manage adequate releases of water downstream of the dam. As such, there are no means by which to manage water quantity, water quality, and water velocity in the Owens Gorge (USFWS 2009) to meet the needs of native fishes, such as Owens Tui Chub. Given the dependence of these populations upon routine maintenance of their habitats, along with the small size of most of these refuges, the continued existence and capacity of these habitats to support populations of Owens Tui Chubs into the future is tenuous.

Aquatic plant encroachment—While cattail (*Typha* sp.) and other aquatic emergent vegetation are native to the area, active management of existing tui chub habitats is required to prevent aquatic plant encroachment, including routine manual removal to maintain open water habitats that Owens Tui Chub requires (Figures 2b and 2d). Aquatic vegetation encroachment is likely promoted by altered hydrography in the Owens Basin, owing to lack of seasonal surface flooding and reduced wetland complexes that historically maintained more open water habitats, and disturbance across the Owens Tui Chub's range.

Groundwater pumping—Groundwater, or aquifer, pumping is largely associated with agricultural irrigation and municipal supply demands in the Owens Basin. Unregulated groundwater use historically eliminated most of the large Owens Valley floor springs. Current pumping rates may result in overdrafting the aquifer in the Tri-Valley region of the Owens Valley Groundwater Basin area, which underlies the Benton, Hammil, and Chalfant valleys in Mono County, jeopardizing the water source of Fish Slough Springs and wetlands. The remainder of the Owens Valley Groundwater Basin, comprised of Round and Owens valleys in Inyo County, is managed under the "Agreement Between the County of Inyo and the City of Los Angeles and its Department of Water and Power on a Long Term Groundwater Management Plan for Owens Valley and Inyo County" (Agreement) (https://www.inyowater.org/documents/governing-documents/water-agreement/). Groundwater withdrawal is an activity under state jurisdiction, with regulation by the State Water Resources Control Board. However, in California, groundwater withdrawal is regulated and monitored only in those areas that have been adjudicated (settled by judicial procedure) or are subject to the Sustainable Groundwater Management Act (SGMA). The aquifer in the Tri-Valley Basin has not been adjudicated and has been determined by the California Department of Water Resources to be a low-priority basin under SGMA (https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization); therefore, it will remain unregulated into the future. Without regulation, groundwater pumping could result in reduced or complete lack of water input to existing isolated springs and headwater springs of streams in the Owens Basin. This change would result in a further reduction or loss of the

already extremely limited aquatic habitat occupied by Owens Tui Chub (USFWS 2009). In the notably arid region where Owens Tui Chub occurs, further reductions in aquifer recharge to support surface water habitats may pose a substantial threat.

Geothermal Electrical Generation—Geothermal power plants in the "Casa Diablo Known Geothermal Resource Area" have been in operation for almost 30 years. Monitoring suggests they have had measurable influence on wellfield temperatures and pressures, as well as input flows and water quality in the Hot Creek headwater springs. The Federal Energy Regulatory Commission has recently licensed a new geothermal plant, "Casa Diablo IV", which will double existing capacity at the site. The USFWS determined, in its biological assessment, that implementing the project "may affect, but is not likely to adversely affect," Owens Tui Chub or its designated Critical Habitat (S. Parmenter, CDFW, pers. comm., 2020). In its final joint Environmental Impact Statement/Environmental Impact Report, the U.S. Bureau of Land Management (BLM) adopted Mitigation Measure WIL-10 requiring the "Long Valley Owens Tui Chub Population and Habitat Monitoring Plan" (BLM et al. 2013). Construction is expected during 2020-2021, followed immediately by project operation.

Surface water diversions—As noted, much of the aquatic habitat in the Owens Valley has been eliminated or modified since the early 1900s. Most of the water rights (and lands) in the Owens Basin are owned by the City of Los Angeles and operated by the Los Angeles Department of Water and Power (LADWP). LADWP operates and maintains dams, diversion structures, groundwater pumps, and canals to capture and convey much of the water from the Owens Basin to Los Angeles. Currently, the demand for water from the Owens Basin is high and continues to grow, as human population growth and associated metropolitan development in southern California expand. The remaining water (both surface and groundwater) is used extensively for agriculture and municipal purposes in the Owens Basin. These anthropogenic changes to aquatic habitats in the Owens Basin have eliminated much of the suitable habitat for Owens Tui Chub. Consequently, their populations have been reduced from common and wide-ranging to only a few small populations in heavily managed refuge sites (USFWS 2009).

While some hydrological restoration and mitigation has occurred in the Owens River Basin, the direct benefits to Owens Tui Chub have been minimal. For example, a 1997 Memorandum of Understanding (MOU) among litigants over groundwater exportation (LADWP and Inyo County) and interveners (Sierra Club, Owens Valley Committee, California Department of Fish and Game, and California State Lands Commission) required LADWP to release a permanent base flow of 40 cubic feet per second in the lower Owens River. After delays, the Superior Court of the State of California, County of Inyo issued an Order and Injunction (Case No.: S1CVCV01-29768; 'ORDER RE: DEFENDANTS' VIOLATIONS OF COURT ORDERS') on August 8, 2005, and restoration of flows commenced shortly thereafter. The LADWP initiated this release and, in 2007, the court determined that LADWP had complied with the permanent base flow release requirement in the MOU (Inyo County Water Department website). These flows reestablished important aquatic habitat in nearly 60 miles of the lower Owens River, much of which was historical habitat for the Owens Tui Chub. Unfortunately, the increase in available habitat has not benefited the Owens Tui Chub. This section of river is now dominated by non-native fish species, which prey on or compete with the Owens Tui Chub (USFWS 2009). In addition, LADWP has not implemented CDFW-recommended adaptive management actions specifically intended to benefit imperiled native fishes, including the Owens Tui Chub, so realization of the suite of desired outcomes has not yet occurred (N. Buckmaster, CDFW, pers. comm., 2019).

Overexploitation

Overexploitation as a result of commercial, recreational, scientific, or educational activities was not considered a threat at the time of listing, and there is no information to suggest that it has become a threat at the present time (USFWS 2009).

Predation

Non-native predators are an ongoing threat to the Owens Tui Chub. Aquatic predators introduced to the Owens Basin include Largemouth Bass, Smallmouth Bass (*M. dolomieu*), Brown Trout (*Salmo trutta*) Bluegill, Red Swamp Crayfish (*Procambarus clarki*),Signal Crayfish (*Pacifastacus leniusculus*), and American Bullfrog (*Lithobates catesbeianus*). These non-native predators may have the capacity to eat both young and adult Owens Tui Chub, while they also likely compete with Owens Tui Chub for food and habitat. Non-native predators are currently present in much of the habitat tui chub historically occupied. Therefore, establishing new populations of Owens Tui Chub will require reintroductions or creation of new refuge sites in locations where non-native predators can be excluded (USFWS 2009).

Competition

Owens Tui Chub may face competition with non-native introduced fishes, but little specific information is available in the literature. Non-native fishes that are primarily insectivorous, such as Rainbow Trout (*Oncorhynchus mykiss*) and Mosquitofish (*Gambusia affinis*), likely compete with Owens Tui Chub, where they co-occur, for some of the same food base (USFWS 2009).

Disease

Disease was not known to be a threat to Owens Tui Chub at the time of listing in 1974, and there is no information to suggest that it has become a threat since that time.

Other natural occurrences or human-related activities

Other factors that may negatively affect the ability of Owens Tui Chub to persist include hybridization and other genetic threats, stochasticity, and climate change.

Hybridization—The Owens Tui Chub and closely related Lahontan Tui Chub were historically geographically isolated from one another. However, Lahontan Tui Chub has been introduced as baitfish into many water bodies in the Owens Basin. Chen et al. (2007) cited Miller (1973), who indicated that hybridization had already occurred and been documented by the 1960s. However, the overall timespan, number of illegal introductions, and locations of these introductions are unknown. Hybridized tui chubs are now widespread throughout the Owens Basin and are a principal threat to the persistence of the Owens Tui Chub. A hybridized swarm exists in the Owens River and its tributaries, occupying most of the Owens Tui Chub's historic habitats in this portion of their historic range. Hybridized tui chubs also occupy the Rush Creek watershed in the Mono Basin (Chen et al. 2007). Examples of locations where verified hybrids have been identified include: Hot Creek downstream from Hot Creek Hatchery; Mammoth Creek; Twin Lakes-Mammoth; June Lake; and Owens River Upper Gorge Tailbay (Mono Co.) and A1 Drain, C2 Ditch, and McNally Canal (Inyo Co.) (Madoz et al. 2005, Chen 2006, Leunda et al. 2013). If artificial barriers isolating Owens Tui Chub from Lahontan Tui Chub (or hybrids) fail, this could result in the loss of the pure Owens Tui Chub populations at Hot Creek Headwaters (CD Spring), Little Hot Creek Pond, and the Upper Owens Gorge (USFWS 2009). Given there are

currently only five extant populations of non-hybridized Owens Tui Chub, the loss of one or more of any of these populations would be a substantial threat, particularly related to maintaining maximum genetic diversity.

Benjamin and Finger (2016) indicated that other genetic threats to Owens Tui Chub include genetic differentiation, owing to the nearly complete isolation of existing populations. Without intentional human intervention and admixing of populations, in accordance with a genetic management plan, this differentiation will likely continue. The Toikona Tui Chub group was also reported to be the least genetically diverse, probably stemming from a genetic bottleneck and associated founder effect of the original transplant of only 24 individuals in 1987 (USFWS 2009 in Benjamin and Finger 2016). All analyzed populations, except for two introgressed populations, showed evidence of genetic bottlenecks (Benjamin and Finger 2016).

Stochasticity—With such small and isolated populations (all estimated between 100-1,000 individuals each), Owens Tui Chub are particularly susceptible to stochastic (random) threats, including demographic, genetic, and environmental stochasticity or catastrophic events (Shaffer 1981 in USFWS 2009). Portions of the Owens Basin, (e.g., Long Valley in the northern part of the Basin) are highly volcanically active and earthquakes could lead to disruption of subsurface flows that feed springs or contribute to other surface flows, potentially threatening Owens Tui Chub refuge habitats. Likewise, shifts in geothermal activity and associated rerouting of subsurface flows could lead to inundation of Owens Tui Chub habitats, rendering them lethal by increasing water temperatures or altering water chemistry outside of their physiological tolerances. Long Valley, site of the massive 10 x 20-mile (16 x 32 km) Long Valley Caldera, is listed by the California Volcano Observatory as one of the top three sites in California with the highest chance of an eruption (U.S. Geological Survey (USGS) California Volcano Observatory website). Furthermore, the Long Valley Caldera is a blast volcano, increasing the chances of catastrophic impacts to the local environment due to the explosive nature of this type of volcanic eruption (Worldatlas.com website). The USGS rates the threat potential of Long Valley as “Very High” (United States Geological Survey Volcano Hazards Program website).

Climate change—Increasing temperatures and more extreme weather patterns associated with climate change are also likely to negatively affect Owens Tui Chub, which exist in an already arid region in the “rain shadow” of the Sierra Nevada. Owens Tui Chub habitats are fed by aquifers and surface flow, which are dependent on snow melt for recharge. It is predicted that climate change will lead to a reduction in snowpack throughout much of the Sierra Nevada, due to warmer temperatures and a shift in precipitation toward rainfall in late winter and early spring months (Costa-Cabral et al. 2012). Sierra Nevada snowpack levels are already demonstrably variable from year to year, with some of the lowest levels in recorded history in the recent past (e.g., during the prolonged and severe drought during 2012-2016). However, the Owens Valley is at the base of the southernmost portion of the Sierra Nevada, where the range attains maximum elevations. Thus, the effects of climate change may be mitigated, at least to some extent, by greater accumulation and retention of snowpack in this portion of the range.

Notwithstanding, Moyle et al. (2013) scored other Owens Basin fish taxa, such as Owens Speckled Dace and Owens Sucker, as highly vulnerable to climate change, indicating extinction may occur if measures to counter climate change effects are not taken. Given that Owens Speckled Dace are similarly limited to a few (three known) populations (Moyle et al. 2015), the potential threat(s) of climate change to Owens Tui Chub should be similarly treated. The predicted hotter and drier future climate, paired with an ever-increasing human demand for water resources in the Owens Basin, strongly indicates that aquatic habitats must be carefully protected if the Owens Tui Chub is to persist within its native range. Given the area’s history of

water exportation and competing demands for remaining water supplies to meet agricultural, municipal, recreational, and ecological needs, future climate warming and increased variability and extremity of weather patterns will undoubtedly exacerbate existing challenges.

B. Degree and Immediacy of Threats

Numerous threats exist that may negatively affect the persistence of Owens Tui Chub; however, as noted, hybridization with non-native Lahontan Tui Chub has led to near extinction of the species. In addition, historically extensive aquatic habitat alteration and destruction has contributed to their endangered listing status by eliminating possible refuge locations and greatly reducing their abundance. Ongoing threats include: potential introduction of nonnative species into refuge habitats; climate change; increasing demand for municipal and agricultural water supplies; isolation and potential impacts from genetic drift, differentiation, or bottlenecks; reliance of some populations on managed water supplies and routine removal of emergent vegetation in very small or artificial (or both) refuge habitats; and stochastic events that may reduce or eliminate small, isolated, populations. However, the degree and immediacy of these threats is unknown.

VI. MANAGEMENT AND RECOVERY

A. Impact of Existing Management Efforts

Management and recovery efforts directed toward Owens Tui Chub have been hampered by the lack of suitable habitat for their expansion, coupled with the widespread presence of hybrid tui chubs in the Owens Basin. However, some actions have been undertaken to benefit Owens Tui Chub and maintain their existing populations. Regular and ongoing habitat maintenance and population monitoring are key management elements for Owens Tui Chub. Existing monitoring is outlined below (Table 1).

i. Maintain existing habitats:

   a. Intermittent aquatic vegetation removal is required and performed at Mule Spring, Hot Creek Headwaters (CD Spring), and Little Hot Creek.

   b. Routine management of water quantity and water quality occurs at Mule Spring and White Mountain Research Center.

ii. Population reestablishment:

   a. Toikona Tui Chub were restocked to the White Mountain Research Center “Lawn Pond,” following extirpation in 2010.

iii. Maintain updated genetic information:

   a. A genetic evaluation of existing populations was contracted by the Department with the UC Davis Genomics Variation Laboratory (Benjamin and Finger 2016). This evaluation updated and expanded upon the findings of a previous genetic study (Chen et al. 2007). The 2016 study determined the chub population in AB Spring (part of the Hot Creek Headwaters refuge) was introgressed and provided updated management recommendations related to protecting existing genetically pure

Owens Tui Chub populations, including a recommendation to eradicate introgressed fish from AB Spring due to its proximity to CD Spring.

Table 1. Ongoing monitoring schedule for Owens Tui Chub (source: N. Buckmaster and S. Parmenter, CDFW, 2020).

Population	**Monitoring Effort**	**Responsible Agency**	**Known threats**
Mule Spring	Quarterly visual surveys	CDFW and Bureau of Land Management	Cattail encroachment Plugging of supply and outlet water pipes
White Mountain Research Center (WRMC) Ponds	Monthly checks	WMRC Staff and CDFW	Water Supply
Owens Gorge	Irregular - distribution survey planned for Fall 2020	CDFW	Unknown
Hot Creek Headwaters	Annual Visual Surveys	CDFW	Hybridization, vegetation removal, geothermal development
Little Hot Creek	Annual visual surveys. Population estimate planned for 2020	CDFW Inyo National Forest	Drought
Sotcher Lake	N/A	CDFW Inyo National Forest	Recreational fishery

B. Recommendations for Management Activities and Other Recommendations for Recovery of the Species

The principal management needs to protect and prevent further declines of Owens Tui Chub are:

1. Continue to maintain existing habitats:
    a. Perform ongoing habitat maintenance and emergent vegetation control.
    b. Establish partnerships with other agencies to ensure all refuge populations and their habitats are appropriately monitored, in accordance with Table 1.

2. Develop a genetics management plan:
    a. Perform research, as needed, to inform the management plan with the latest genetic information available. Utilize the plan to develop and direct future population mixing or establishment of new populations in refuge sites.

3. Evaluate new habitats for potential to support Owens Tui Chub and protect their genetic integrity:
    a. If one or more suitable habitats is/are identified, establish a new population in accordance with the genetics management plan and develop a subsequent monitoring plan.

VII. RECOMMENDATION TO THE COMMISSION

Pursuant to Fish and Game Code section 2077, the Department has prepared this Five-Year Species Review, based upon the best scientific information available to the Department, to determine if conditions that led to the original listing are still present. Based on this Five-Year Species Review, the Department recommends no change to the status of Owens Tui Chub on the list of endangered species at this time.

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B. Personal Communication

E-mail message from Bjorn (Peter) Erickson (USFWS) on July 22, 2019, indicating the Owens Tui Chub federal 5-year review will not be initiated until their FY 2021.

Multiple e-mail exchanges with Nick Buckmaster and Steve Parmenter (CDFW, Inland Deserts Region). Various dates, 2019-2020.

C. Other

N/A

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Appendix A. Historical (1913) map of a portion of the Owens Basin, featuring extensive wetland complexes associated with the Owens River and representing likely Owens Tui Chub historic habitats. Note the now dry Owens Lakebed is not shown and was probably a considerable proportion of their overall historically occupied habitat.