ARROYO CHUB
Gila orcutti (Eigenmann and Eigenmann)

Status: High Concern. The arroyo chub is vulnerable to extinction in its native range in the next 100 years. However, populations exist outside the native range and are regarded as generally more secure (e.g., those in the Santa Clara and Ventura River basins) (J. O'Brien, CDFW, pers. comm. 2013).

Description: Arroyo chubs are relatively small fish. Adults can reach lengths of 120 mm SL but are typically 70-100 mm long. They are sexually dimorphic. Males have larger fins than females and develop tubercles on the upper surface of the pectoral fins during breeding (Tres 1992). Both males and females have thick bodies, large eyes, and small mouths. Pharyngeal teeth arrangement can vary but is generally closely spaced with a formula of 2,5-4,2. Fin ray counts are 7 and 8 for anal and dorsal fins, respectively. Gill rakers number from 5 to 9. The lateral line is straight and complete, with 48-62 scales extending to the caudal peduncle. Their body color varies from silver or grey to olive-green on the dorsum, white ventrum, and a dull grey lateral band (Moyle 2002). Larvae and juveniles from the Los Angeles and Santa Ana River drainages are described in Feeney and Swift (2008).

Taxonomic Relationships: Arroyo chub are morphologically and genetically very distinct, reflecting their long evolutionary isolation (Miller 1945a). Both *Gila orcutti* and Yaqui chub (*G. purpurea*) belong to the subgenus *Temeculina* (Miller 1945a). Both species are part of a group of related *Gila* species in the American southwest (Simons and Mayden 1998). Arroyo chub hybridize readily with two other cyprinids native to California: Mohave tui chub (*Siphatales mohavensis*) and California roach (*Lavinia symmetricus*) (Hubbs and Miller 1943, Greenfield and Greenfield 1972, Greenfield and Deckert 1973). The systematics of North American Cyprinidae are complex (La Rivers 1962, Simons and Mayden 1998) and still require further investigation and clarification.

Life History: Arroyo chubs spawn primarily in June and July, but can breed more or less continuously from February through August, as the eggs of females ripen in small batches (Tres 1992). During spawning, a group of males pursue a ripe female and rub their snouts against the area below the female's pelvic fins, stimulating egg release. More than one male may fertilize the eggs as they are being laid (Tres 1992). Embryos adhere to plants, rocks, and debris and hatch in 4 days at 24 °C. After hatching, fry remain attached to or in the substrate for several days and swim to the surface, presumably to fill the swimbladder, once the yolk sac is absorbed (Tres 1992).

Arroyo chubs in the Santa Clara River are about 60 mm SL after their first year and grow about 10 mm each year after, reaching 80-90 mm SL by their fourth year (Tres 1992). Females can begin reproducing after the age of one year. Females generally grow larger than males after their second year. The life expectancy of arroyo chubs is 1-4 years.

Arroyo chubs are true omnivores that feed on algae, insects, and small crustaceans, but they apparently prefer to feed on algae. In one study, algae made up most (60-80%) of the identified stomach contents (Greenfield and Deckert 1973). They also feed extensively on the roots of a floating water fern (*Azolla*), which is generally infested with nematodes (Greenfield and Greenfield 1972).

Habitat Requirements: Arroyo chub are physiologically adapted to survive in habitats with low oxygen concentrations and wide temperature fluctuations, conditions common in southern coastal streams (Castleberry and Cech 1986). They are found in habitats characterized by slow-moving water, mud or sand substrate, and depths greater than 40 cm (Wells and Diana 1975). However, they have also been found in pool habitats with gravel, cobble and boulder substrates (Feeney and Swift 2008, J. O’Brien, CDFW, unpublished data, 2006-2012). They are most common in streams with gradients of less than 2.5% slope (Feeney and Swift 2008), where water temperatures range from 10 to 28 °C (J. O’Brien, CDFW, unpublished data). Thus, Deinstadt et al. (1990) found them in only small numbers (compared to rainbow trout) in the West Fork San Gabriel River, above Cogswell Reservoir where water was cool in summer (maximum temperatures <22°C) and gradients were mostly >4%. Most spawning occurs in habitats with low velocity, such as pools or edge waters, at temperatures of 14- 22 °C. In Big Tujunga Creek, chub utilize multiple habitats and substrates and are found in pools, runs, riffles, and edge-water over substrate ranging from sand and silt to boulders. However, they are most abundant in low gradient pools and flat-water habitats with gravel and sand substrate that support at least some aquatic/emergent vegetation (J. O'Brien, CDFW, unpublished data, 2009). Juveniles spend their first 3-4 months in the water column, usually in habitats with still water and vegetation or other submerged cover (Tres 1992).

Distribution: Arroyo chubs were once found only in the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita rivers and in Malibu and San Juan creeks (Wells and Diana 1975), in southern California. Introductions expanded their distribution into the Santa Ynez, Ventura, Santa Maria, Cuyama, Santa Clara, and Mojave River systems and other smaller streams (e.g., Arroyo Grande Creek) (Miller 1968, Moyle 2002). Arroyo chub were introduced into the Mojave River from the Los Angeles River basin (Hubbs and Miller 1943). The northern-most population was the result of an introduction into Chorro Creek, San Luis Obispo County (Moyle 2002). Other introductions were not successful (e.g., from San Luis Rey River to Rio San Tomas in Baja California; Miller 1968). Absent from much of their native range, arroyo chubs were abundant only in the upper Santa Margarita River and its tributary De Luz Creek, Trabuco Creek below O'Neill Park, and San Juan Creek (San Juan Creek drainage), Malibu Creek (Swift et al. 1993), and the West Fork of the upper San Gabriel River below Cogswell Reservoir in 1990 (J. Deinstadt, CDFW, pers. comm. 1990). Today they are also abundant in Big Tujunga Creek and middle Santa Ana River tributaries, between Riverside and the Orange County line (J. O’Brien, CDFW, pers. comm. 2012). They are apparently present in low numbers in Pacoima Creek above Pacoima Reservoir, Sepulveda Flood Control Basin, Los Angeles River drainage (Swift et al. 1993).

Several hundred arroyo chub were relocated from Big Tujunga Creek to a restored section of the Arroyo Seco below Devils Gate Dam in 2008 (J. O’Brien, CDFW, pers. comm. 2009). Since 2008, they have also been documented in the headwaters of the San Jacinto River, near the USFS Cranston Station on the mainstem, and Indian Creek on the Soboba Indian Reservation (S. Loe, pers. comm. 2009). They have been found in recent years up to the North Fork and South Fork confluence in the mainstem San Jacinto River and have been found up the South Fork to near the Lake Hemet Dam (G. Abbas, pers. comm. 2009). Arroyo chub also occur in Topanga Creek, Arroyo Simi, and Bear Creek (San Gabriel Drainage) (J. O'Brien, CDFW, stream survey reports and CNDDB, 2009). In 2009, they were abundant below and immediately above Big Tujunga Dam in Big Tujunga Creek (J. O'Brien, CDFW, unpublished data). Surveys in 2010 indicate a much lower abundance of chub in Big Tujunga Creek due to impacts from flooding and debris flows associated with the 2009 Station Fire (J. O'Brien, CDFW, pers. obs.). A small population of arroyo chub was salvaged from Big Tujunga Creek in October, 2009 and held at the Riverside-Corona Resource Conservation District in Riverside. These fish were returned to Big Tujunga Creek during the summer of 2010. Surveys in 2011 and 2012 detected an abundant chub population in Big Tujunga Creek, below Big Tujunga Dam, and in Malibu Creek, above and below Ringe Dam (J. O'Brien, CDFW, unpublished data).

Arroyo chub have been found in large numbers within Cogswell Reservoir and immediately above the reservoir in the West Fork San Gabriel River but are much less abundant below Cogswell Dam (J. O'Brien, CDFW, unpublished data). They also occur in the North Fork and East Fork of the San Gabriel rivers, where their distribution has changed little since the early 1990s (J. O'Brien, CDFW, pers. comm. 2011). Chub occur below Morris Dam on the San Gabriel River but are uncommon (J. O'Brien, CDFW, pers. obs.). Chub are the least abundant, and have the narrowest distribution, of the native fishes found in the upper San Gabriel River, which is primarily a high gradient system (O'Brien et al. 2011).

Trends in Abundance: Arroyo chubs are currently abundant in Malibu and Big Tujunga creeks (J. O'Brien, CDFW, unpublished data) and are thought to be abundant at only four other places within their native range: upper Santa Margarita River and its tributary, De Luz Creek; Trabuco Creek below O'Neill Park and portions of San Juan Creek; Malibu Creek (Swift et al. 1993); and West Fork San Gabriel River immediately above Cogswell Reservoir. The decline in arroyo chub abundance has been largely attributed to habitat degradation of low-gradient streams within their native range (Swift et al. 1993). Arroyo chub numbers appear to respond favorably to a decrease in flows in certain drainages (e.g. high gradient streams). From 1986-1990, arroyo chub numbers temporarily increased due to low-water conditions in the West Fork of the San Gabriel River. Numbers decreased again after rains in 1991-1992 but increased in 1993. Arroyo chubs are common and widely distributed in some of the streams into which they were introduced, particularly in the Ventura and Santa Clara rivers. Although a nearly 20 year data gap exists regarding species status, abundance, and distribution, a planned CDFW survey of all endemic populations, along with tissue collections for genetic analyses, is planned to be implemented beginning in 2013 (J. O'Brien, CDFW, pers. comm. 2012).

Nature and Degree of Threats: Although introductions have increased their distribution and abundance, arroyo chub face multiple stressors within and outside their native range from a combination of urbanization and alien species interactions.

Major dams. Most streams containing arroyo chub are dammed and diverted to a large degree. Dams are barriers to fish movement and can result in dewatering of downstream habitats, in both native and non-native streams. Minimum flow releases, however, may actually provide summer habitat for chubs where it was periodically scarce in the past (e.g., West Fork San Gabriel River). It can be expected, however, that as water becomes scarcer (e.g. during drought or due to climate change effects), the impacts from dams will become greater.

Urbanization. Their native range falls largely into the Los Angeles metropolitan area where most streams are channelized, dammed, diverted, and otherwise degraded, leading to a reduction in abundance and distribution and to the fragmentation of populations. Urbanization has especially degraded the low-gradient streams which formerly contained optimal habitat (Swift et al. 1993). Urbanization effects include land use changes as a result of residential and commercial development, stream alterations from bridges, freeways, and channelization, heavy recreational pressure including water 'play' (swimming, pool damming, recreational mining in the Angeles National Forest, as well as trash dumping and pollution from urban runoff.

Some streams within the arroyo chub's native range contain high levels of pollutants from urban run-off that may have adverse impacts as yet unknown. For example, levels of silver, arsenic, chromium, copper, nickel, lead and selenium in Malibu Creek were found to be above thresholds recommended by the State of California for human consumption (Moeller et al. 2003). However, potential impacts to chubs are unknown.

Mining. While hard rock mines in the region are largely a thing of the past, instream placer mining continues in some areas and may disrupt spawning and recruitment on a local scale (J. O'Brien, CDFW pers. comm, 2011).

Transportation. Stream crossings associated with roads have, in many areas, become barriers to upstream migration. Consequently, many populations have become isolated, preventing repopulation of upstream habitats, and some habitats have become inaccessible. Barriers to upstream migrations at stream crossings are common after fires and floods. The activities of various flood control agencies, including ongoing removal of riparian vegetation and diversion of flows, are a threat to the continued existence of remaining arroyo chub populations in the lower foothills (Rodriguez, pers. comm. 2011).

Fire. Hot brush fires are increasingly common within the range of arroyo chubs. While direct effects of fire on chubs are few, fires followed by heavy rain can create debris flows that can reduce chub populations and temporarily degrade habitats. While chubs are adapted to such conditions, increased frequency of severe fires that entirely eliminate large areas of decadent chaparral vegetation, leaving denuded steep slopes of highly friable soils, increases risk of harmful debris flows.

Alien species. Alien species are a continuous and immediate threat. Arroyo chubs in the Cuyama River have hybridized with California roach. Ironically, arroyo chubs introduced into the Mojave River have hybridized with the endangered Mojave chub and are largely responsible for its decline (Hubbs and Miller 1943, Castleberry and Cech 1986). Arroyo chub populations may also be threatened by competition from the alien red shiner (*Cyprinella lutrensis*) and fathead minnow (*Pimephales promelas*) that may exclude them or reduce their numbers from many areas (C. Swift, pers. comm. 1998, 1999, J. O'Brien, CDFW, pers. obs.). Chub numbers are generally inversely correlated to shiner abundance (T. R. Haglund, pers. comm. 1998). Bass (*Micropterus* spp.), green sunfish (*Lepomis cyanellus*) and other predators introduced into streams may also target chub as prey, as they also prefer slow moving habitats (Swift 2005). Declines in arroyo chub abundance in the Santa Ana River has been partly attributed to predation by centrarchids and western mosquitofish (Feeney and Swift 2008). The introduced African clawed frog (*Xenopus laevis*) has also been shown to prey on arroyo chub (Lafferty and Page 1997).

	Rating	Explanation
Major dams	High	Dams alter flows, impair sediment recruitment and create barriers that fragment chub populations (J. O'Brien, CDFW, pers. comm. 2011)
Agriculture	Low	Agriculture historically altered streams but has been largely replaced by urbanization
Grazing	Low	Historically altered streams but has been replaced by urbanization, except at higher elevations
Rural residential	High	Rural development is rapidly expanding in range; substantial habitat alteration and degradation
Urbanization	High	Urbanization and all its associated stressors (stream channelization, pollution, water diversion, etc.) alter habitat throughout its range
Instream mining	Low	Recreational mining alters habitat and likely disrupts spawning and recruitment
Mining	Low	No known impact, but present
Transportation	Medium	Road, railroads etc. are along most streams with chubs
Logging	n/a	
Fire	Medium	Native range extremely prone to catastrophic fire and debris flows
Estuary alteration	n/a	
Recreation	Medium	Recreational use of streams (dam and impoundment building, swimming, bathing) is heavy in some areas, potentially altering habitats but effects are localized
Harvest	n/a	
Hatcheries	n/a	
Alien species	High	Negative interactions with alien species are an immediate threat to most populations

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of arroyo chub in their native range in California. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact to the taxon under consideration. Certainty of these judgments is high. See methods section for descriptions of the factors and explanation of the rating protocol.

Effects of Climate Change: Because arroyo chub are adapted to survive in low oxygen conditions and wide temperature fluctuations, increases in temperatures associated with global climate change may not harm them as much as species with narrower environmental tolerances (Castleberry and Cech 1986). However, arroyo chub appear to be sensitive to changes in hydrologic conditions, especially changes in flow. Predictions for flows in California are for higher flows in the winter and drier conditions in the summer and fall (Hayhoe et al. 2004, Stewart et al. 2005, Anderson et al. 2008). Arroyo chub abundance has been shown to decline in high flows (wintertime scenario) and increase in low flows (summer and fall scenario). Although arroyo chub appear to thrive under low water conditions and are adapted to "flashy" flow conditions, climate change may result in streams that go dry in low gradient reaches during the driest months. Therefore, arroyo chub populations may readily adapt to global climate change conditions (increases in temperatures) but only when surface flows are maintained. Fish assemblages in southern California appear to be more responsive to local hydrologic conditions than small changes in land use (Brown et al. 2005), yet another reason for climate change to be considered in restoration and management planning. Moyle et al. (2013) rated arroyo chub as less vulnerable to effects of climate change than many fishes but noted that impacts associated with climate change were likely to contribute to its overall decline.

Status Determination Score = 2.1– High Concern; 3.1 – Moderate Concern when populations outside native range are considered (see Methods section Table 2). The high concern score applies to the remaining populations within its native range. The score increases to 3.1 if introduced populations are considered (Table 2; numbers in parentheses), making it a species of moderate concern.

Despite being locally abundant in some streams, some populations of arroyo chub in their native range are in danger of local extirpation due to the increasing effects of urbanization in the Los Angeles, Orange, and San Diego metropolitan regions. Interactions with non-native species, exposure to pollutants, and continued habitat degradation result in arroyo chub populations that are not secure, despite being widely distributed. The many introduced arroyo chub populations provide some security from species extinction but most of those face threats as well, especially from other alien species. The fact that the range of the arroyo chub coincides with some of the most densely inhabited parts of California, with a rapidly growing human population, means its future may never really be secure.

The American Fisheries Society considers arroyo chub to be Vulnerable, because of habitat destruction and other factors (Jelks et al. 2008). NatureServe ranks arroyo chub as Globally Imperiled because of its limited range. It is managed by the U.S. Forest Service as a Sensitive Species.

Metric	Score	Justification
Area occupied	3 (4)	Arroyo chub are locally abundant but the area occupied within its native range is limited
Estimated adult abundance	2 (4)	Abundance is often low within native range but higher in streams to which they have been introduced
Intervention dependence	2 (3)	Populations within native range will need to be actively managed in order to ensure recovery
Tolerance	4 (4)	Tolerate low oxygen conditions and highly variable temperatures but are sensitive to changes in flows
Genetic risk	1 (3)	Hybridization with other species and low population sizes threaten genetic integrity
Anthropogenic threats	1 (2)	Alien species and urbanization are major threats (Table 1)
Climate change	2 (2)	Changes in flows threaten population stability
Average	2.1 (3.1)	15/7 (22/7)
Certainty (1-4)	3	Peer reviewed literature on biology is limited

Table 2. Metrics for determining the status of arroyo chub, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. Numbers in parentheses are for all chub populations, including those outside the native range. See methods section for further explanation of scoring procedures.

Management Recommendations: Arroyo chub population surveys should be conducted at least biannually in their native range and every five years at all known sites, in order to monitor the status of this species. Within its native range, streams should be managed in a manner that favors native fish survival and reproduction, including active removal of non-native species. Restoration of highly degraded streams can help provide arroyo chub with more favorable stream habitats. For example, channelized streams can be reconfigured so that slow water habitats can redevelop and fine sediment can be retained. Levees can be set back to allow reconnection to the floodplain and meanders to develop. "Daylighting" streams can redirect water to above ground surfaces so that stream function can be reestablished. An example of such restoration is Arroyo Seco, into which arroyo chubs were reintroduced in 2008 (http://www.arroyoseco.org/casrp.htm).

A number of streams and stream reaches should be designated as native fish streams/refuges and managed for their natural flows and fauna. Restoration of urbanized streams will favor populations of other native species such as the Santa Ana sucker, unarmored threespine stickleback, southern steelhead, and Santa Ana speckled dace (Swift et al. 1993). The best candidate for a "native fish management stream", at present, is the upper San Gabriel River basin (J. O'Brien, CDFW, pers. comm. 2011).

Arroyo chub seem to be as efficient as the introduced western mosquitofish (*Gambusia affinis*) in controlling mosquitoes, so their use for mosquito management within its range should be encouraged where genetically appropriate (Van Dam and Walton 2007). Vector Control agencies are currently working with CDFW on a plan, beginning with pilot projects in Riverside and Orange counties, to study the use of arroyo chub in lieu of mosquito fish in appropriate habitats.

Much is still unknown about the arroyo chub. Future studies should focus on: abundance and distribution of populations within its native drainages, genetic population structure, age and growth and other basic life history parameters, describing taxonomic relationships with closely related genera, describing habitat requirements and environmental tolerances for specific developmental stages, and identifying areas with highest potential for restoration and reintroduction. The genetic and conservation relationships among populations inside and outside the native range should be investigated to determine the best overall conservation and genetic management strategies.

Figure 1. Distribution of arroyo chub, *Gila orcutti* (Eigenmann and Eigenmann),in California. Note: distribution in the Ventura River is not indicated on map.