Exhibit 4

SPECIES NAME AND GROUP DESIGNATION

Common Name and Scientific Name: arroyo chub (*Gila orcutti*) (Eigenmann and Eigenmann 1890)

Status: **State:** Species of Special Concern
Federal: None

GROUP DESIGNATION AND RATIONALE

Group 2

The arroyo chub is distributed within two watersheds, the Santa Ana and Santa Margarita watersheds. It occurs in several locations within these watersheds. Although the preferred habitat, open water and emergent vegetation in lower gradient streams with sand or mud substrate, is located in numerous areas within the Plan Area, only six drainages currently support populations of the arroyo chub. These locations comprise the Core Areas for the species and include the Santa Margarita River, De Luz Creek upstream of the De Luz Post Office, lower Sandia Creek, Murrieta Creek near its mouth at the Santa Margarita River, Cole Creek between the confluence of Murrieta Creek and the edge of the Conservancy property, and Temecula Creek upstream of Vail Lake. Within the Santa Ana River, the species Core Area occurs from the Riverside and San Bernardino county line downstream to the Prado Dam (Swift 2001). Because it requires specific well known habitat conditions and occurs in few Core Areas within a larger habitat category, the arroyo chub will require conservation on a landscape level as well as on site specific considerations for the known Core Areas as a Group 2 species.

SPECIES CONSERVATION OBJECTIVES

The species-specific conservation objectives developed for this species are based upon the best available scientific information at the time of MSHCP preparation. Pursuant to *Section 5.0* which includes Management, Monitoring and the Adaptive Management Program, the MSHCP's mitigation requirements will be monitored and analyzed to determine if they are producing the desired result. Based upon this information, the following species-specific conservation objectives will be adjusted if appropriate, as new information is gathered during Plan implementation. The Adaptive Management Program will be used to identify alternative strategies for meeting the MSHCP's

general biological goals and objectives and, if necessary, adjusting future conservation strategies according to the information received.

Objective 1

Include within the MSHCP Conservation Area, 4,580 acres of habitat that provides potential spawning and foraging opportunities for the arroyo chub in the Santa Ana and Santa Margarita watersheds.

Objective 2

Include within the MSHCP Conservation Area, the suitable Core Areas for the arroyo chub in the Santa Ana watershed. Conserve the natural river bottom and banks, including the adjacent upland habitat where available to provide shade and suitable microclimate conditions (*e.g.*, alluvial terraces, riparian vegetation) of the Santa Ana River from the Orange County and Riverside County line to the upstream boundary of the Plan Area.

Objective 3

Include within the MSHCP Conservation Area, the suitable Core Areas and available adjacent habitat for the arroyo chub in the Santa Margarita watershed. Conserve the natural river and or creek bottom and banks up to an elevation of 400 meters in the reach of the Santa Margarita River in the Plan Area, and in De Luz Creek and its tributary downstream to the County line, in upper Sandia Creek downstream to the County line, in Murrieta Creek from Winchester Road to near its confluence with the Santa Margarita River, in Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property and in Temecula Creek from Long (Smith) Canyon just below the falls near the County line downstream to a concrete drop structure at Highway 79 (upstream of Vail Lake).

Objective 4

Within the MSHCP Conservation Area, the Reserve Managers responsible for the areas identified in the Santa Margarita watershed will assess the range of chub movement in the watershed and the need for connectivity and identify measures to restore connectivity to be implemented as feasible.

Objective 5

Within the MSHP Conservation Area, the Reserve Managers responsible for the areas identified in Objectives 2 and 3 will assess threats to the chub from degraded habitat (*e.g.*, reduced water quality, loss of habitat, presence of non-native predators and vegetation); identify areas of the watershed that are necessary to successful spawning of the chub, identify areas for creation of stream meanders, pool riffle complexes and reestablishment of native riparian vegetation as appropriate and feasible and identify and implement management measures to address threats and protect critical areas.

SPECIES CONSERVATION ANALYSIS

Conservation Levels

For the purpose of the conservation analysis, potential habitat for the arroyo chub within western Riverside County was identified as open water channels and emergent vegetation areas or lower gradient stream sections within the Santa Ana watershed and Santa Margarita watershed and specific tributaries to the main drainage. Additional vegetation types adjacent to the streams were included as buffer habitats essential to maintaining the ecological integrity of the freshwater systems. Additional habitats included riparian forest/woodland/scrub habitats, oak woodland and forest, Riversidean alluvial fan sage scrub, grassland, coastal sage scrub and agricultural lands. These habitats were included in the analysis for a width of approximately 1,300 feet centered on the channel of the Santa Ana River. Also included in the area of the Santa Ana watershed conserved for the arroyo chub are the main tributaries for a distance of at least 0.5 miles upstream from the confluence of the tributary with the Santa Ana River. These tributaries include Sunnyslope Creek, Mount Rubidoux Creek, Arroyo Tequesquite, Anza Park Drain, Evans Lake Drain, Temescal Creek and Aliso Creek. The elevation included in the analysis extended to 400 meters above median sea level (AMSL); elevations above this point were considered to be typical of higher gradient steam sections unlikely to support any life stage of the arroyo chub. For the Santa Margarita watershed, these habitats were included in the analysis for a width of approximately 600 feet centered on the main channel of the Santa Margarita River and the tributaries including De Luz Creek and its tributary downstream to the County line, upper Sandia Creek downstream to the County line, Murrieta Creek from Winchester Road to near its confluence with the Santa Margarita River, Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property, and Temecula Creek from Long (Smith) Canyon just below the falls near the County line downstream to a concrete drop structure at Highway 79 (upstream of Vail Lake). These drainages within the Santa Margarita watershed are included within the Proposed Constrained Linkages 11, 12 and 13 with average widths of 380, 700, and 980 feet respectively. The Santa Margarita River is located

within Existing Core G and the eastern reach of the Temecula Creek is located within Proposed Core 7.

Based on these habitats, the Plan Area supports approximately 5,100 acres of potential habitat for the arroyo chub. *Table 1* shows the conservation and loss of potential habitat for the arroyo chub. Overall, approximately 4,580 acres (90 percent) of potential habitat in the Plan Area will be conserved in Criteria Area or existing Public/Quasi-Public Lands. This includes a total of 100 percent of the open water and freshwater marsh within the Santa Margarita watershed and 97 percent of the open water and freshwater marsh habitat within the Santa Ana watershed. The open water areas not included within the Santa Ana watershed included small ponds or water bodies that are isolated from the main channel of the river but that are located within the area analyzed for conservation for the species.

In addition, the wetland habitats policy described in *Section 6.1.2* of the *MSHCP, Volume 1* provides for conservation of wetlands which provide habitat for this species through avoidance and minimization. Mitigation for impacts to wetlands shall be incorporated in accordance with the "No Net Loss" policy of federal and state wetland regulations. The proposed mitigation shall be directly related to the functions and values of the wetland as related to this species and result in equivalent replacement.

The conservation of core populations includes the Santa Ana River, including the Sunnyslope Creek, Lake Evans Drain, Arroyo Tequesquite, Anza Park Drain, Temescal Creek, Aliso Creek, and Mount Rubidoux Creek tributaries, from the county line downstream of Prado Dam to the upstream boundary of the County line. Definable core population locations are also located within the Santa Margarita watershed including the mainstem of the Santa Margarita River, in De Luz Creek and its tributary downstream to the County line, in upper Sandia Creek downstream to the County line Murrieta Creek from its mouth upstream to Winchester Road, Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property and Temecula Creek from Vail Lake upstream to Long Canyon. All of these conserved core populations include the stream channel itself with its associated open water and emergent vegetation, as well as riparian and other habitats analyzed for a 1,300-foot area centered on the main channel of the river for the Santa Ana River and a 600-foot area centered on the main channel of the river for the Santa Margarita River.

Additional conservation measures for the arroyo chub include an assessment of the barriers to fish movement and identification of measures to restore connectivity if feasible. Conservation measures also will include an assessment of threats to the arroyo chub, identification of areas that are necessary for spawning, identification of areas for the creation of stream meanders, creation of pool riffle complexes, and establishment of native vegetation.

TABLE 1
SUMMARY OF HABITAT CONSERVATION
ARROYO CHUB

Vegetation Type	MSHCP Plan Area (Acres)	Within MSHCP Conservation Area: Criteria Area[1] (Acres)	Within MSHCP Conservation Area: Public/ Quasi-Public (Acres)	Within MSHCP Conservation Area: Total Within MSHCP Conservation Area (Acres)	Outside MSHCP Conservation Area: Rural/ Mountainous (Acres)	Outside MSHCP Conservation Area: Outside MSHCP Conservation Area (Acres)	Outside MSHCP Conservation Area: Total Outside MSHCP Conservation Area (Acres)
Santa Ana River Watershed							
Water	200	20	170	190	0	10	10
Freshwater marsh	100	30	70	100	0	0	0
Riparian habitat, Riversidean alluvial fan sage scrub, and coastal sage scrub adjacent to the channel	3,570	360	2,830	3,190	0	380	380
Subtotal Santa Ana River Watershed	**3,870**	**410 (11%)**	**3070 (79%)**	**3480 (90%)**	**0 (0%)**	**390 (10%)**	**390 (10%)**
Santa Margarita Watershed							
Water	50	50	0	50	0	0	0
Freshwater marsh	30	30	0	30	0	0	0
Riparian habitat, Riversidean alluvial fan sage scrub, and coastal sage scrub adjacent to the channel	1,150	690	330	1,020	90	40	130
Subtotal Santa Margarita River Watershed	**1,230**	**770 (63%)**	**330 (27%)**	**1,100 (90%)**	**90 (7%)**	**40 (3%)**	**130 (10%)**
TOTAL	5,100	1,180 (23%)	3,400 (67%)	4,580 (90%)	90 (2%)	430 (8%)	520 (10%)

[1] Acres refer to Additional Reserve Lands to be assembled from within the Criteria Area.

The Reserve Managers responsible for the areas identified in Objectives 2 and 3 will assess the threats to the sucker due to degraded habitat and implement management measures to address the threats and protect critical areas. Restoration of potential habitat areas through enhancement of existing habitats, removal of non-native vegetation, instream habitat modifications in tributaries that provide potential spawning and nursery habitat, and planting of stream side native riparian trees and shrubs may improve and restore the habitat for the Santa Ana sucker.

MSHCP Conservation Area Configuration Issues

Conserved tributaries (*e.g.*, Sunnyslope Creek or Murrieta Creek) are contiguous with the conserved portions of the main river channels (*i.e.*, both the Santa Ana and the Santa Margarita River). The arroyo chub requires lower flow tributaries of high quality water and as such, the MSHCP Conservation Area will provide adequate habitat linkages between the main Santa Ana River channel and tributaries and between Temecula Creek and the Santa Margarita River. Based on this information, the MSHCP Conservation Area will contain the major known Core Areas for the species within western Riverside County. Within the Santa Margarita River, this includes the mainstem of the river from the junction with Rainbow Creek upstream to junction with Murietta Creek, Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property, Temecula Creek from its mouth (Vail Lake) upstream to Long Canyon (locally known as Smith Canyon) just below the falls near county line (including the Wilson Miller Creek tributary), and Murietta Creek downstream of the Winchester Road crossing in Temecula to its junction with the Santa Margarita River. Within the Santa Ana River, the MSHCP Conservation Area will include the mainstem of and tributaries to the river from Riverside and San Bernardino County line downstream to the Riverside and Orange County line below Prado Dam.

Conservation Summary

In summary, conservation for this species will be achieved by inclusion of at least 4,580 acres of suitable Conserved Habitat including the occupied habitat (water and freshwater marsh) and adjacent buffer and streambank (includes a variety of habitats) within the MSHCP Conservation Area. All of the known and potential locations, refugia, and spawning areas are included within the MSHCP Conservation Area. In addition, Objectives 4 and 5 will provide assessment of barriers and threats to the arroyo chub by the Reserve Managers and will identify measures to be implemented if feasible.

INCIDENTAL TAKE

About 520 acres (10 percent) of potential habitat for the arroyo chub will be outside the Criteria Area and Public/Quasi-Public designations and individuals within these areas will be subject to consistent

with the Plan. A total of 10 acres (3 percent) of the open water habitat within the Santa Ana River will be outside the Criteria Area and Public/Quasi-Public designations. These open water areas are currently unsuitable areas of isolated ponds that are not connected to the Santa Ana River but are located within the area analyzed for conservation of this species. Other upland and adjacent areas within the Santa Ana River watershed that are not conserved include adjacent habitat within the Green River Golf Club, an upland area within the Silver Lakes areas and and upland area between Mission Boulevard and Rancho Jurupa Park where the adjacent habitat area narrows. None of the stream channel reaches of the Santa Ana River are outside of the MSHCP Conservation Area. None of the open water or emergent vegetation within the Santa Margarita River and its arroyo chub occupied tributaries is located outside the Criteria Area and Public/Quasi-Public designations. Other upland and adjacent areas within the Santa Margarita River watershed that are not conserved include adjacent habitat within De Luz Creek which averages narrower than the 600-foot area analyzed for conservation. This drainage averages approximately 380 feet in width within the MSHCP Conservation Area. De Luz Creek drainage is conserved, however the buffer of upland habitat is narrower than most of the other drainages within which the arroyo chub occurs. None of the Core Areas, spawning areas, dispersal, or refugia areas are outside of the MSHCP Conservation Area for either watershed. It should be noted that wetland habitats located outside the MSHCP Conservation Area would be subject to the wetland policy presented in *Section 6.1.2* of the *MSHCP, Volume I.*

The of the chub is difficult to quantify because larva and adults are quite small in body sizes, finding a dead or impaired specimen is unlikely, the species occurs in habitat that make detection difficult and losses may be masked by fluctuations in abundance and distribution during the life of the permit.

Data Characterization

Data reviewed includes the California Natural Diversity Database (CNDDB) and the University of California, Riverside, GIS database, and available literature.

There are eight records for the arroyo chub in the UCR location database ranging in date from 1974 to 1999. All of the records are for the Santa Ana River. However, other investigators report locations within the Santa Margarita River Watershed as well as the Santa Ana River Watershed.

The quantity and scope of the available literature for the species is moderately high, including descriptions of general biology for the species, recent locational information within several historically occupied watersheds, edaphic factors limiting the species distribution within portions of the watersheds, current habitat conditions, as well as general and specific management recommendations.

Habitat and Habitat Associations

The arroyo chub is adapted to surviving in the warm fluctuating streams of the Los Angeles Plain. They prefer slow moving or backwater sections of warm to cool streams with substrates of sand or mud (Moyle 1976a). The depth of the stream is typically greater than 40 centimeters (Moyle 1976a).

Biogeography

The native range of the arroyo chub includes the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita rivers and also Malibu and San Juan creeks (Wells and Diana 1975). This species is common at three localities within its native range, namely the upper Santa Margarita River and its tributary, De Luz Creek; Trabuco Creek below O'Neill Park and San Juan Creek drainage; and Malibu Creek. It is present, but scarce in Big Tujunga Canyon (Pacoima Creek above Pacoima Reservoir), and in the Sepulveda Flood Control Basin, Los Angeles River drainage; upper San Gabriel River drainage; and middle Santa Ana River tributaries between Riverside and the Orange County line (Swift *et al.* 1993).

Introduced populations occur at Santa Maria-St. Inez, Mojave, Santa Clara, and Cuyama river drainages, and a portion of San Felipe Creek (Miller 1968; Moyle 1976b; Bell 1978; Sigler and Sigler 1987; Page and Burr 1991). Within the literature, there is some disagreement regarding the extent of this species' native distribution. Miller (1968) and Bell (1978) conclude that the Santa Clara population is probably introduced while Moyle (1976b), and Page and Burr (1991) indicated that this population is native. Fish fossils at Rancho La Brea, including arroyo chub (Swift 1989) indicate local, permanent stream conditions, and not stream transport from distant mountainous areas.

Known Populations Within Western Riverside County

The arroyo chub is known to occur in the Santa Ana River from the County line (approximately Riverside Avenue) downstream to approximately Van Buren Boulevard, primarily within the willow forest area two to three kilometers upstream of Prado Dam (Swift 2001). Temescal Creek reportedly contained a large population of arroyo chubs; however, sampling conducted from 1997 onward within the creek yielded only a few fish (Swift 2001). Therefore, the stream may no longer support a population large enough to be considered a Core Area. It is abundant at only a few widely scattered locations within the Santa Margarita River watershed where both permanent water and low numbers of exotic predators occur (Fisher and Swift 1998). These locations include the Santa Margarita River mainstem from Murietta Creek downstream to Rainbow Creek, in Murrieta Creek downstream of the Winchester Road crossing in Temecula downstream to the junction with the Santa

Margarita River, in Cole Creek upstream of its confluence with Murrieta Creek and the boundary of Conservancy property (Robert Fisher 2002, pers. comm.), in Temecula Creek from Long (Smith) Canyon just below the falls near the County line downstream to a concrete drop structure at Highway 79 (upstream of Vail Lake), in upper Sandia Creek downstream to the County line, and in De Luz Creek and its tributary downstream to the County line (Swift et. al. 2000). The arroyo chub has been documented in the past in lower Temescal Creek (Robert Fisher 2001, pers. comm., Swift 2001), and may still occur in San Jacinto River (Fisher and Swift 1998); however, it has not been documented in either drainage recently.

Biology

Genetics: The increase in fragmentation of the remaining population causes a loss of genetic variability and results in higher vulnerability to random events, environmental factors, and inbreeding which may allow increased expression of deleterious genes. Small populations cannot respond successfully to environmental stressors when genetic variability is reduced (Moyle 1976a). Several documented barriers to annual upstream migration of the arroyo chub exist within both the Santa Ana and Santa Margarita Rivers, potentially reducing gene flow between refugia populations within the watersheds. Swift (2001) notes that the Prado Dam in the Santa Ana River may present a genetic barrier if reproduction of native fish species does not occur below the dam, since several impassable upstream barriers prevent any fish below the dam from returning to reproducing populations upstream. Although the arroyo chub may have several refugia populations within portions of a creek in perennial water areas, there may be annual gene flow between these populations, making the maintenance of the intermediate creek stretches important for long-term persistence of the species (Fisher and Swift 1998).

Diet and Foraging: The arroyo chub is omnivorous, feeding primarily on algae (Greenfield and Deckert 1973), but also ingesting other plants, aquatic insects and their larvae, small crustaceans, and feeding extensively on roots of a floating water fern (*Azolla*) infested with nematodes (Moyle 1976a).

Reproduction: Arroyo chubs are fractional spawners that breed more or less continuously from February through August, although most spawning takes place in June and July (Tres 1992). Most spawning occurs in pools or in quiet edge water, at temperatures of 14 to 22 degrees Celsius during March and April (Moyle *et al.* 1995). Larger fins distinguish males from females, and when breeding, males develop a prominent patch of tubercles on the upper surface of the pectoral fins (Tres 1992). Egg release is initiated by the male rubbing his snout against the area below the female's pelvic fins. Once released, eggs may be fertilized

by more than one male. Chubs attach their eggs to trailing vegetation in flowing water, at least in captive situations (Tres 1992). After four days (at 24 degrees Celsius) embryos hatch, with larvae about 4 to 6 millimeters long when they emerge (Swift 2001). After hatching, the fry spend the first three to four months in quiet water, in the water column and usually among vegetation or other flooded cover. They begin to reproduce at the age of one year. Age and growth in arroyo chubs remains to be thoroughly investigated, but Moyle (1976a) reports that they seldom exceed 75 mm. Tres (1992) found that arroyo chubs live three to four years.

Survival: Castleberry and Cech (1986) demonstrated in laboratory studies that this species is physiologically adapted to survive hypoxic conditions and the wide fluctuations in temperature common in south coastal streams. They are adapted for surviving the warm fluctuating streams of the Los Angeles Plain which historically shifted naturally between muddy torrents in the winter and clear intermittent brooks in the summer (Moyle 1976a).

Dispersal: Natural dispersal is typically up- or downstream as conditions and suitable habitat permit, and is typically facilitated by flooding events (Moyle 1976a). Fisher and Swift (1998) noted that arroyo chub dispersal within the mainstem of the Santa Margarita River appeared to increase dramatically after El Nino rains produce flood waters that heavily scour the vegetation within the drainage, widening channels and reducing channel depths, creating habitat conditions that favor the chub and reduce exotic fish presence. The larvae and juveniles of the species tend to invade standing backwaters and/or disperse downstream from upstream spawning areas within the Santa Ana River (Swift 2001). Dispersal within both watersheds is currently limited by several large dams that serve as migration barriers. In addition, many tributaries within each watershed are limited to chub occupation by artificial or natural upstream migration barriers (Swift 2001, Fisher and Swift 1998).

Socio-Spatial Behavior: No information is available or was reviewed.

Community Relationships: Arroyo chub prefer low gradient portions of streams with sand and mud substrates, and often spawn in warmer water relative to the Santa Ana sucker. These species tend to complement each other's distributions within the watersheds they occupy, with suckers found in higher elevation, higher gradient portions of the stream and chubs found in lower elevation, lower gradient stream sections (Swift 2001). Mass hybridization between the arroyo chub and the Mojave tui chub have depleted most, if not all, pure stock of tui chub in the Mojave River drainage (Hubbs and Miller 1943; Moyle 1976b, 1976b; Miller *et al.* 1991; Swift *et al.* 1993). Castleberry and Cech (1986) studied the response of arroyo chubs and Mojave tui chubs to abiotic factors. They found that arroyo chubs are more tolerant and respond more appropriately to laboratory conditions simulating stressors of desert rivers than

the tui chubs. This presumably is because they are better suited to habitats such as these, evolving in environments similar to the Mojave River (Eigenmann and Eigenmann 1890; Miller 1942). In contrast, tui chubs, until the late Cenozoic, have evolved in lake environments and are less suited for inhabiting rivers. Arroyo chub were found to be more tolerant of higher temperatures which would occur under low water conditions. They exhibited a large metabolic rate increase following temperature increases which could aid in remaining active and escaping stressful conditions. Moreover, arroyo chub experienced difficulty acclimating to cooler temperatures, while tui chubs showed a greater tolerance for colder temperatures, which is typical of lake dwelling fishes. In the Mojave River environment, in which low water temperatures are transient, this would give the tui chubs a selective disadvantage in relation to arroyo chubs. Castleberry and Cech (1986) suggest that tui chubs persisted in the Mojave River in the absence of a similar fish.

Within the Cuyama River, California roach-arroyo chub hybrids are abundant (Moyle 1976a). High stream flows segregate the two species, the chubs preferring large pools and reservoirs while the roach utilizes riffles and smaller pools. Low flow events force the species together, resulting in hybridization.

Threats to Species

The arroyo chub is currently scarce within their native range because the low-gradient streams in which they do best have largely disappeared. Their native range is largely coincident with the Los Angeles metropolitan area where most streams are degraded and populations are reduced and fragmented (Moyle *et al.* 1995). The potential effects of introduced species, combined with the continued degradation of the urbanized streams that constitute much of its habitat, mean that this species is not secure despite its relatively wide range. The high degree of fragmentation of the remaining populations make the arroyo chub especially vulnerable to random events, environmental factors, and loss of genetic variability. Random events such as floods, fires, variations of annual weather patterns, predation and associated demographic uncertainty, may lead to the demise of the remnant populations in the Santa Ana River and Santa Margarita River watersheds. Threats to the arroyo chub within the Santa Ana River and the Santa Margarita River may be generalized into three categories; habitat based threats (*e.g.*, degradation, fragmentation, destruction), biological threats (*e.g.*, predation, competition), and water quality threats (*e.g.*, temperature, salinity, pollution). Many of the threats are unique to each watershed, whereas others are the result of changes affecting the entire range of the species. Specific threats to the species are discussed below by watershed.

Santa Ana River

Threats to the continued persistence of the arroyo chub within the Santa Ana River are wide-spread and diverse. Habitat-based threats include extensive existing and proposed channelization, hardbank stabilization, flood control projects that directly remove habitat for the chub, modify it to such a degree that the species can no longer utilize it, or fragment the existing areas of occupied habitat within the watershed. The Santa Ana River and tributaries within western Riverside County currently contain miles of rip-rap bank stabilization between Riverside Avenue and the Prado Dam. Swift (2001) documented a portion of Sunnyslope Creek that has been progressively migrating northward due to a capped landfill and associated rip-rap bank stabilization upstream at the present mouth of Arroyo Tequesquite. The river has been diverted to the north by this streambank armoring and is progressively eroding away an existing stream meander in lower Sunnyslope Creek, removing habitat occupied by native fish. Swift (2001) estimates that three to four miles of stream habitat have been removed in the last fifteen years due to intensive flood control projects within the Sunnyslope and Arroyo Tequesquite drainages alone. Bridges and diversions and their associated regular maintenance also negatively affect the species.

The River Road bridge does not span the floodplain of the Santa Ana River and requires regular removal of sand to prevent drifting sand from overwhelming the bridge. Swift (2001) documented sand mining at River Road that restricted the downstream movement of native fish. In addition, the diversion downstream of River Road reduces the amount of water in the river by one-half (Swift 2001), reducing instream habitat quantity within the river for native fish and creating a one-way flow of fish through culverts. Abundant predatory fish species moving from ponds are also a significant threat in this area of the Santa Ana River. Extensive cement channelization, rip-rap bank stabilization, construction and maintenance of diversions and drop-structures has been implicated as a key factor responsible for the decline of freshwater fishes native to the Los Angeles basin (USFWS 2000).

Instream migration barriers in the form of culverts, drop-structures, and dams pose a serious threat to the Santa Ana River population of arroyo chubs. Dams and other barriers isolate and fragment fish populations, and likely have resulted in some populations being excluded from suitable spawning and rearing tributaries (USFWS 1999). Swift (2001) documents two major instream migration barriers within the Santa Ana River; the Prado Dam outlet, which contains rapid flow over a laminar concrete surface and the diversion dam just downstream of River Road, which allows water to pass downstream through culverts with 40 to 70 centimeter falls at their downstream ends. In addition, all tributaries to the Santa Ana River between Riverside Avenue and the Prado Dam (excepting the seep under Market Street Bridge and Mt. Rubidoux Creek) are limited upstream by artificial barriers, consisting primarily of unpassable culverts or concrete-lined channels (Swift 2001).

An additional habitat-based threat to the species within the Santa Ana River includes the spread of invasive giant reed (*Arundo donax*) and tamarisk (*Tamarix* sp.) throughout the watershed. These plants tend to create large monocultures of emergent vegetation and habitat areas suitable to exotic predatory fish by gradually increasing water depth, lowering flow gradients, covering spawning gravels or cobbles, and out-competing emergent vegetation beneficial to the arroyo chub and other native fishes.

The primary water quality threat to the arroyo chub in the Santa Ana River in western Riverside County is the long-term security of base flows within the river downstream of the Rapid Infiltration and Extraction Plant (RIX) outlet. The flow within the river is subject to frequent drops downstream of the Rialto Drain and the RIX plant, which are the origination sources of flow for the river below the Seven Oaks Dam in San Bernardino County. Swift (2001) indicates that every few weeks the flow drops by more than 50 percent for a few hours or more during maintenance and Clean Water Act (CWA) requirements, dramatically reducing the shallow water habitats favored by native fishes downstream to Riverside Avenue and potentially limiting the number of fish that may inhabit the upstream areas of the river. A portion of these flows may be subject to sale in the future, potentially reducing the flow volume available to the arroyo chub in the river. In addition, water pollution from non-point sources including heavy metals, high-levels of bacteria, and low levels of protozoa and viruses has been identified as a potential threat (Egan *et. al.* 1992).

Biological threats to the species in the Santa Ana River include high levels of predation by exotic and introduced fish, as well as competition with non-native fish species. Swift (2001) notes that arroyo chub were absent from lower gradient habitats with softer substrates downstream of Van Buren Boulevard that would otherwise have been appropriate for them. This absence of chubs is correlated with an abundance of predatory fish species including green sunfish, largemouth bass, back bullhead, and mosquitofish (Swift 2001). The greatest predatory effect of these species is in the lower two-thirds of the river where habitat conditions are most favorable for arroyo chub, as well as the exotics. In addition, arroyo chub were observed in standing backwaters within the watershed, where habitat conditions strongly favor exotic predators (Swift 2001). Competition may also be a significant issue for chubs, especially with fathead minnows, and tilapia, all of which have ecological requirements similar to those of the arroyo chub (Swift *et. al.* 2000).

Santa Margarita River

Habitat-based threats to the species within the Santa Margarita River differ markedly from those in the Santa Ana River, primarily because the majority of the watershed below Vail Lake is intact, with minimal physical disturbance of the floodplain and tributaries (Fisher and Swift 1998). However, significant threats to arroyo chub habitat within Western Riverside County include hardbank

stabilization, the channelization of a portion of Temecula Creek within the city of Temecula, and the proposed channelization of approximately eleven miles of Murietta Creek. These flood control measures have removed or threaten to remove existing arroyo chub habitat. Although the chub is relatively widespread throughout the watershed, it is abundant in only a few locations that contain both perennial water and few predators. Thus, removal of those habitats that contain these conditions may negatively affect the species abundance and distribution throughout the watershed. In addition, several barriers to upstream fish migration occur within the watershed, including a concrete drop structure at Highway 79 upstream of Vail Lake on Temecula Creek, and the gauging station at the top of the gorge in Temecula (at the mouth of Murietta Creek) (Fisher and Swift 1998). These structures, in addition to many tributaries that contain seasonally dry conditions limit the distribution of the species within the watershed.

Additional habitat-based threats to the chub include invasive giant reed (*Arundo donax*) and Tamarisk (*Tamarix* sp.), which are encroaching on streambanks throughout the Santa Margarita River watershed and channelizing flows in low gradient drainages to the benefit of exotic predators, reducing the amount of shallow water habitats available for the arroyo chub (Swift *et. al.* 2000). Also, as urbanization increases within the upper portions of the watershed, threats such as reduction of the riparian zone and aggressive water use threaten to diminish available habitat areas for the chub (Swift *et. al.* 2000).

Water quality threats within the Santa Margarita River watershed include increased amounts of nitrates from sewage effluents and agricultural runoff (Swift *et. al.* 2000). Biological threats to the chub in the watershed are significant due to the presence of several predatory exotic species including redeye bass, largemouth bass, black bullheads, green sunfish, and mosquitofish. Redeye bass appear to be excluding arroyo chub from portions of the river mainstem that are optimal for the bass, but the species does not appear to have invaded any of the tributaries. The remaining species prey on the chub in deeper, warmer waters throughout the watershed, often excluding smaller size classes of chub through predation. In contrast to the Santa Ana River, the chub may benefit from the apparent absence of two competitor cyprinid species including red shiners and fathead minnows within the Santa Margarita River (Swift *et. al.* 2000). Chubs generally decline when red shiners become abundant (Moyle *et al.* 1995). However, an additional threat unique to the Santa Margarita watershed is the presence of beavers, which are creating ponded conditions within the drainage that may be adversely affecting the chub by promoting warm, deep water habitats that favor exotic predatory fish.

Special Biological Considerations

Arroyo chub are now considered scarce within their native range, because they prefer lower gradient streams that have largely disappeared. The majority of the arroyo chub population occurs within areas of large human populations associated with the Los Angeles metropolitan area, and consequently should be monitored closely (Moyle 1976a).

Dams and reservoirs greatly reduce the natural variability in environmental conditions, resulting in the domination of non-native fish faunas (Moyle 1976a; Herbold and Moyle 1986; Moyle and Light 1996). High disturbance systems support groups of species that would probably not coexist under natural conditions. For example, 3-4 species of predatory bass commonly live within reservoirs on California rivers, while rarely are more than two species found together in natural systems (Moyle and Light 1996). Cornell and Lawton (1992) argue that ecological communities are rarely saturated with species, thus, even complex systems may be invaded relatively easily. Successful invasions are most likely to occur when native assemblages have been temporarily disrupted or depleted (Moyle and Light 1996). The match between an invader and the hydrologic regime seems to be the most important factor in determining the success of an invasion, rather than the biotic resistance (Moyle and Light 1996; Case 1991). However, most invasions do not result in direct extirpation, except in the case of piscivores, or when invaders can hybridize with native species (Moyle and Light 1996). In relatively unmodified streams, such as Deer Creek (Tehama County), the natural hydrologic regime prevents repeated invasions of nonnative fish (Moyle and Light 1996).

Management considerations for the arroyo chub should include careful consideration of several factors that appear to be influencing the population demographics of the species within both the Santa Ana and Santa Margarita watersheds. Preservation of existing connected habitat areas for the species within the mainstem of the rivers and their associated tributaries, as well as restoration of additional habitat areas within the mainstem of the rivers and any appropriate tributaries to promote the maximum genetic flow and widest distribution possible for the species is paramount.

To support preservation and restoration activities, accurate characterization and mapping of seasonally restricted habitat areas and migration barriers within each watershed should be conducted, as should identification of tributaries and mainstem areas that provide the most appropriate spawning, rearing, and adult foraging habitats for arroyo chub. The various ownerships and management regimes of the lands that surround and contribute to the ecological integrity of the arroyo chub instream habitat also need to be taken into consideration. Management activities should target reduction or removal of exotic predatory fish species, especially within areas of potential habitat for the arroyo chub, and consider the effects that other non-native species such as beaver, crayfish, and African clawed-frogs may be having on the species. Management considerations

within the Santa Ana River must also account for the presence of the Santa Ana sucker. The Santa Ana sucker generally prefers habitats with steeper gradients and faster flows than the arroyo chub, so they complement each other's distributions in the watershed. Saiki (2000) states that a stepwise multiple regression analysis of the biological variables from his study of the Santa Ana Sucker within the San Gabriel and Santa Ana Rivers indicates that the relative abundance of arroyo chub is directly correlated to and is a predictor of Santa Ana sucker abundance.

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