Status and Distribution of fishes in the Santa Margarita River Drainage

By

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Table of Contents

Introduction

The Santa Margarita River is one of the largest coastal rivers in southern California and remains one of the least impounded systems in this ecoregion, draining parts of both Riverside and San Diego counties. Large segments of the river are in relatively undeveloped private and public holdings that have insulated the drainage against many of the effects of urbanization. However, this is changing as rapid urban development of the upper watershed takes place. Major threats from urbanization include pollution through runoff, reduction of the riparian zone, increased channelization, and aggressive water use. In contrast to the upper watershed, the lower watershed, defined as the river and all tributaries below the confluence of Temecula and Murrieta creeks, remains relatively well protected by public and private reserves as well as the Marine Corps Base Camp Pendleton. An additional threat to the watershed is the spread of exotic species. The exotic riparian plants Tamarisk and Arundo are present throughout much of the watershed and will continue to pose serious habitat issues into the foreseeable future. Exotic fish and other animal species are also widespread with crayfish and bullfrogs competing with and preying on the already beleaguered native fish and amphibian populations still present in the watershed. An as yet unknown threat to native amphibian populations is nitrate pollution from adjacent agricultural lands. With agriculture as one of the primary land uses in the watershed, this risk will need to be assessed soon. Rapid human population increase in the upper third of the basin will also result in increased nitrate levels through sewage effluent released into the river.

In its present state the river supports only one of the four freshwater fish species native to the system, namely the arroyo chub, *Gila orcutti*, a small cyprinid minnow. The other three species, the partially armored threespine stickleback, *Gasterosteus aculeatus microcephalus* (Family Gasterosteidae), the Pacific lamprey, *Lampetra tridentata* (Family Petromyzonidae), and the steelhead trout, *Oncorhynchus mykiss* (Salmonidae), have not been recorded in 20-40 years. However, there is excellent potential for re-establishment through deliberate re-introduction or possibly natural re-colonization by two of these three species, the steelhead trout and Pacific lamprey, if conditions were improved for them. The necessary prerequisite for habitat restoration is comprehensive surveying and assessment of the existing fish fauna and associated habitat to form a basis for long-term conservation planning for the drainage.

We comprehensively surveyed the drainage for three years with the objective of exhaustively establishing the extent of the distribution of native and exotic fish species. We also sampled a subset of stations along the main river successively in order to document annual changes. During this time potential sites for re-introduction of native fishes were also explored. This report summarizes three years of work from Fall of 1997 to Spring of 2000, including the information provided in previous reports to the Nature Conservancy (Fisher and Swift 1998; Swift, Warburton and Fisher 1999).

Description of the Drainage

The Santa Margarita watershed drains approximately 1922 km^2 of land. Almost all of this area is underlain by weathered granite of the southern California batholith or the northern part of the Peninsular Range Province (Jahns 1954; Norris sand Webb 1990). The lower (western) half of the stream has transversely cut from east to west through the coastal Elsinor Mountains which run from north to south and has one large tributary, De Luz Creek that enters from the northeast and also drains these mountains. The upper half of the drainage is abruptly divided into three major tributaries at the head of the gorge though the mountains in the town of Temecula. At this point Murietta Creek comes in from the north-northwest, Temecula Creek from the east, and Pechanga Creek from the southeast. These three streams originally filled a large, flat alluvial valley covered with extensive riparian gallery forest. These forests were removed by agricultural practices in the early 1900s and the valley is rapidly being covered by the suburban development of the town of Temecula. This upstream valley is bordered to the north by gently rising low, arid hills of the southern end of the Perris Uplands, and on the south by much steeper, abruptly higher, and moister mountains of the northern end of the Agua Tibia Mountains and Anza Upland. Two major dams exist in the drainage on the upstream margins of the alluvial valley. These are Vail dam on Temecula Creek on the wetter south side and Skinner dam on the drier north side (represented by blue areas in Figure #1). Vail Lake is fed by the Temecula Creek drainage and Lake Skinner receives water from the Colorado River (California Water Project). Aside from these two open bodies of water, only occasional farm ponds occupy the drainage. Downstream of Temecula the drainage is physically undisturbed and remains in natural condition. It is channelized within the Temecula area, and relatively intact upstream of the town of Temecula.

The gradient of the main river and tributaries begins low near the coast and rises rapidly up to the top of the gorge, and leveling off again through the Temecula Valley. Tributaries from the south like Pechanga, Long, Cottonwood, and Arroyo Seco canyons rise much faster than streams from the north like Santa Gertrudis, Tucalota, Wilson, Tule and Warm Springs creeks. However, these latter creeks all possess “stair stepped” topography of dry courses through long flat alluvial valleys alternating with short, steep, rocky stretches. Some perennial water flow often occurs in these short, steep areas, apparently because ground water is forced to the surface. Although usually fishless, these locations provide important habitat for native amphibians and reptiles. Only in their uppermost reaches do these northern tributaries increase in gradient and loose their stair-step morphology. In several major tributaries, spectacular falls mark the upstream limit of fish distribution.

Water flows at the top of the gorge varied widely based on seasonal rainfall. On average, flows during our collections ranged between 2 and 5cfs (Cubic Feet Per Second). The maximum recorded during our study was in 1998 when El Nino rains created flows of up to 4500cfs. The main river flows continuously to the lagoon on the coast only during the rainy season, usually drying up near the mouth of De Luz Creek and the crossing of Basilone Road on Marine Corps Base Camp Pendleton as rains subside. The largest tributary, Temecula Creek, was also usually dry from below Lake Vail to just above the top of the gorge in Temecula where it re-emerges a kilometer or so upstream of the mouth of Murietta Creek. Temecula Creek has an average flow of 2.3cfs above Lake Vail, and reached 400cfs during El Nino. Murietta Creek had open water only in the lower 5km before meeting Temecula Creek at the mouth of the gorge. Murrieta possessed flows averaging 2.4cfs, with El Nino flows reaching 440cfs. All tributaries upstream of the gorge are intermittent most of the year and the extent of perennial water in these areas is covered in the Results section. Essentially, southern tributaries upstream of the gorge have enough flow to support fish whereas most northern tributaries are much drier and ephemeral. Northern tributaries support fishes only rarely and native fishes occur only in lowermost Murietta Creek and in a few isolated localities farther upstream in Murietta Creek.

The vast majority of the substrate in the drainage was mud and sand or rocks, boulders, and bedrock. Intermediate sized substrate, namely gravel and cobble, were rare or absent. When present this intermediate sized substrate was mixed with 20 to 80 percent finer material, usually sand. The lower gradient parts of the streams near the coast or in alluvial valleys was sand or mud and much of the gorge was bedrock, boulders, or rocks with sand between or intermixed.

Full aquatic and marginal emergent vegetation varied considerably with the season. In the first year much of the lower gradient, sandy and muddy portions of stream were virtually choked with sedges (*Sparghanium*), tules (*Scirpus*), and cattails (*Typha*) after several low rainfall years. The extreme winter flows experienced during the second year of this study (the 1997-1998 rainfall year, Figure #7 and Pictures #1-2) severely denuded much of the stream margins and the vegetation had only partially re-invaded by the third year. The areas that were dominated by bedrock and boulders, particularly in the gorge, had less of the marginal emergent vegetation originally and changed less due to the high flows. The large deep pools in these areas were more dominated by algae that re-grew on an annual cycle. What is probably a typical cycle of denudation followed by re-growth was magnified by the strong El Nino storm events.

The lagoon of the Santa Margarita River varies from about 3 to 6km in length depending on the degree of closure by the sand bars at the mouth of the river. The lagoon is partially or completely closed for most of the dry months and depends on the winter rains to force open the sand bar. The lagoon will be fully tidal for a few weeks or months, depending on the duration of storms, and only partially tidal or non-tidal for most of the year. This variation means salinity can vary from fresh to marine depending on the season and degree of inflow and mixing. Isolated areas subject to evaporation can even become hypersaline. The lagoon was from 20 to 500 meters wide and on average 1.5 meters deep or less. Usually, a relatively narrow channel existed that remained deeper than 1.5 meters.

Little or no attached vegetation occurs in the lagoon, and the lower two-thirds were surrounded by pickleweed (*Salicornia*) flats. The upper third was margined by sedges, willows, and Arundo. For descriptive purposes the lagoon can be divided into three parts, the first of which is coastal, or west of the adjacent railroad and Interstate 5 bridges. This region extends to the beach and the ocean. The middle third begins upstream, or east of these bridges and extends to the bridge of Stuart Mesa Road. The final third exist farther upstream from Stuart Mesa Road to a small hill in the middle of the flood plain locally called the blockhouse. For many previous years the extreme upper limit of tidal effects was about to the blockhouse. El Nino flows of 1998 increased sediment deposits in the upper lagoon, and pushed the tidal effects downstream to the vicinity of Stuart Mesa Road. By late 1999 tidal influence was penetrating upstream to near the blockhouse again. At both bridge areas, the lagoon is narrowed by the elevated levees supporting the roads and railroads, and some rip-rap has been placed to protect the upstream sides of the ends of the bridges. Otherwise the lagoon and wetlands are in relatively natural condition, although a long southern extension near the ocean has been obliterated. Historically, that extension ran south, reaching almost to the San Luis Rey River mouth in the early 1900's, according to early USGS topographic maps.

Methods

The fieldwork for the Santa Margarita river survey took place during 1997, 1998, and 1999. The three field seasons began in late fall or early winter, just prior to winter rains. This time was chosen in an effort to detect perennial sources of water as well as measure fish distributions at their most restricted levels. In 1998 and 1999 an effort was made to sample areas not visited in previous surveys as well as to return to several stations along the main river in order to track year to year changes. A total of 130 stations or field sites were visited with varying degrees of effort depending on the size of the stream and whether water was present (Figure #1).

The 1997 collections were made from October 18th to December 15th and included 88 stations.

The 1998 collections were made mostly from August 31st to November 23rd, except for three collections: on April 10th in the upper lagoon, and on May 8th both at the crossing of Rifle Road on the main river near the airport and at the falls on Roblar Creek all on the Base. The September to November collections entailed 16 field days and 41 field stations. Some of these were repeated collections at sites visited the previous year. Additional information on upper Arroyo Seco was obtained by Alex Vejar, California Department of Fish and Game in April of 1999. Three stations on the lower river and lagoon were part of a study on the tidewater gobies on the Base by Swift and Holland (1998) and subsequent collections by them.

The 1999 collections were taken from July 14th through December 17th and included 59 stations, again with some repeated collections at previous sites. One final survey of the lagoon was done on April 20th 2000.

The primary survey method was quantitative seining (Meador et al. 1993) along 100m sections of the river channel while visually surveying the channel between stations. Stations were set at approximately equal distances. Usually 8 or more seine hauls were taken with a seine 5.2 by 1.8 meters with 3mm mesh (17 by 6 feet with one eighth inch mesh). Visual records were also made both within and outside of transects. In a few small streams a seine 3 by 1.2m with 3 mm mesh (10 by 3 feet with one eighth inch mesh) was used. On average eight to ten non-overlapping hauls were taken. Two people seining sampled all types of habitats within the 75-100m length of stream at the station and Camm Swift participated in all the transect stations. The seine was dragged through open areas, and in obstructed or densely vegetated areas, the seine is used to enclose an area, which was then disturbed to drive out the fishes. Voucher specimens of all fish species were taken and representative material was deposited in the Natural History Museum of Los Angeles County. Common and scientific names for fishes follow Swift et al. 1993, for amphibians and reptiles we follow Fisher and Case 1997, and a list of all species detected in both the estuary and river are listed in Table #3.

The majority of fish caught were released alive after being identified, counted, and measured or sizes estimated. Seines were also utilized in qualitative exploratory surveys of tributaries not previously sampled. In the estuary several net sizes were employed depending on channel depth and width up to a maximum size of 37.5 by 3.6 meters with 3.8 centimeter mesh in the wings and 13 millimeter mesh in the 3.6 by 3.6 meter bag (125 by 12 feet with 1.5 inch mesh in the wings and half inch mesh in the bag). Length and width of seine hauls, deepest and average water depth, and associated aquatic vertebrates and invertebrates were recorded.

In addition to recording the fish species present at every site, the following habitat features were recorded.

Vegetation: The estimated percent coverage of both rooted and floating aquatic plants and vegetative type i.e. Green hair algae, Chara, Watercress.

Bottom: The estimated percent composition of the submerged stream substrate type i.e. Rock, sand, gravel was estimated with the criteria of Flossi et al. (1999).

Shore: The estimated percent composition of substrate and vegetative type of the exposed bank as well as percent cover when appropriate.

Current: A qualitative description of water flow through the area sampled, ranging from trickle/none to fast

Turbidity: The estimated water visibility in centimeters of the area sampled prior to sampling.

Width: The average width in meters of the stream channel sampled.

Depth: The average stream channel depth in centimeters/meters and the capture depth when appropriate.

Temperature: Water temperature in the area sampled.

Road crossings of dry/ephemeral tributaries were visited in the upper watershed, while wet/perennial tributaries were hiked until the upper limit to upstream migration by fishes was evident.

Photographs were taken of several field stations in the main river during annual sampling visits in order to track habitat changes from year to year. When available, a hand-held GPS receiver was employed to record coordinate locations of field stations. Others were mapped by on site reference to United States Geological Survey (USGS) 7.5 minute quadrangle maps and corresponding topography. All field stations were eventually assigned a coordinate location and unique flag number before being plotted on a GIS map of the watershed showing all drainage channels. Stream flow data were taken from USGS sources as well.

Additional personnel involved in the field collections are noted in the acknowledgements section.

Results

Description of fish habitat in the system

After three years of fieldwork, all possible native fish habitat was examined in the drainage except for the upper portion of Pechanga Creek on Pechanga Indian

Reservation. Some small sections of Cottonwood, Arroyo Seco, and Long Canyons were not directly examined, but lay between sections that were fishless and the likelihood of fish populations was remote. A few upstream sections above obvious major barriers to fishes were not examined.

Cottonwood Creek

Cottonwood Creek was surveyed from its mouth in Temecula Creek upstream for about 7-8km on October 6th, 1998 (Stations 65-66). It was dry for the first 5-6km. upstream, then sections with intermittent water alternated with dry sections for another 2-3km upstream to a spectacular vertical rock barrier about 15-16m high. Several 1-5m falls or drops without water were impassable to fish. One section about 1km long has narrow vertical walls only 15-25m wide, which shades the water and created average water temperatures ranging from 13-18 degrees centigrade. A total of 1-1.5km of wetted stream was estimated to be present with several large holes up to 2 m deep interspersed through the length of the stream. Water was very clear and visibility was excellent. Several holes and intermittent shallow areas were seined and no fish were seen or taken anywhere in this canyon. The uppermost 0.5km of stream below the highest barrier reached consists of a series of large pools separated by lesser barriers that would have stopped most fishes, although in some cases the smaller barriers may have been passable by steelhead. Later we examined upper Cottonwood Canyon (October 19th, 1998) and found a similar pattern of surface flow interspersed with dry areas, but lacking the high barriers found in the lower reaches. No fish were taken upstream of the barrier. The wetted areas both above and below the largest barrier held large populations of both native species of tree frog (Pacific tree frog, *Hyla regilla,* and canyon tree frog, *Hyla cadaverina*). A few of the largest pools, again both upstream and downstream of the barrier contained southwestern pond turtles (*Clemmys marmorata*) and garter snakes (*Thamnophis hammondi)*.

Arroyo Seco

Lower Arroyo Seco (examined on September 22nd, 1998, Station 67) was also dry for a long distance up from Lake Vail, about 9km upstream of the lake (about 0.7km up from the trailhead of the campground at Hwy 79) or about 1.5km South of Hwy 79. Shallow standing water was found in the stream bottom for about another 1.3km. For the next 3km, 5 to 6 wet stretches alternated with dry ones. The wet areas were 200-500m long as were the dry stretches. Fifteen to twenty deeper pools were noted over 0.5m deep and up to 0.8m deep throughout the stretch. In the uppermost section examined, 3-4km above the campground, 2-3 stretches of a few hundred meters appeared more permanent with extensive lush herbaceous vegetation, but with very small flows, 0.3-1.0m wide, and to 20cm deep at the deepest. In the whole length of stream above the campground, several drops or falls exist that would not be passable by anything but steelhead. Larger pools were usually inhabited by ten to fifteen green sunfish, and tree frogs of both species were abundant. There was a strong tendency for the larger pools to contain sunfish but to have few or no tadpoles. These pools were characterized by abundant green algae. Shallower pools without green sunfish often had tens and sometimes hundreds of tadpoles and were relatively algae free. One southwestern pond turtle was seen in a large hole about 3 km upstream of the campground.

Long Canyon

Long Canyon (also called Smith Canyon locally) was examined on November 7, 1997 (Station 63), and differed from the Arroyo Seco and Cottonwood canyons in that it had permanent water flowing in its lower reaches where it entered Temecula Creek which was also flowing in this area. About 30 arroyo chubs were taken in Temecula Creek above a diversion about 100m upstream of the mouth of Long Canyon and no other fish species were seen. Arroyo chubs inhabited the lower Long Canyon Creek for about 2.8km upstream, where low barriers more than 0.3-0.4m high, apparently prevented the upstream movement of smaller fish. Larger arroyo chubs and green sunfish penetrated another 0.5km farther upstream to higher barriers over 0.5m or so. In the last few pools containing arroyo chubs only larger chubs seemed to coexist with green sunfish. This was also true in a few pools farther downstream. The green sunfish may have eliminated the smaller size classes of chubs, otherwise common in many areas both up and downstream. The green sunfish were only found in this uppermost 1.0km and were larger (greater than 100mm SL). No evidence of recent reproduction, namely small fish, was noted whereas they were common in Arroyo Seco. Water temperatures were mostly 9-12 degrees in Long Canyon, probably too cold for spawning by green sunfishes. It is possible that these green sunfish migrated up to this point and were concentrated below the impassable obstruction. Many tree frogs of both species (*H.cadaverina, H.regilla*) and about 6 southwestern pond turtles as well as at least one two-striped garter snake were seen. A 18-20m high barrier was reached about 5.0km upstream that certainly stops all fish. Since there were no fish in the pools leading up to this area, it is very unlikely fish occur above the falls. Only a moss-covered trickle of water came over this cliff during our visit. All three tributaries of Long Canyon Creek above the barrier were examined on October 20th, 1998 and all were dry at the crossing of Cutca Trail. The largest tributary, located against the northeastern side of Palomar Mountain, was about 4 times larger than the other two tributaries. It had a small flow upstream of Cutca Trail but was fishless. We examined about 1km of stream in the larger tributary upstream of the trail. It divided into two forks about 2.5km upstream of the trail. The southern of these two forks held only a few small pools of water and no surface flow. Several temperatures taken were 9.5-10 degrees C. An additional tributary of Long Canyon is shown on the map farther to the southwest, draining Palomar Mountain. However, being above the barrier in the lower stream it is undoubtedly fishless as well.

De Luz Creek

De Luz Creek was one of the largest and most unimpacted tributaries and was examined several times at several locations (Stations 42-49,80,89,95). Historically this tributary held steelhead (Lang et al. 1998). In De Luz Creek, the upstream extent of arroyo chubs and a few exotics like green sunfish and largemouth bass was about 1.5km north of the junction of De Luz and Del Rio roads (Station 49). All size classes of chubs were present, with the larger chub being concentrated in the largest holes while the smaller size classes were widely scattered in the slower flowing sections of the stream. Over 80% of the stream bottom was gravel and boulders, and larval *Taricha* occurred in the uppermost few hundred meters of the stream inhabited by arroyo chubs. Farther downstream arroyo chubs occurred in all areas with surface flow, at about 0.3km upstream of the Riverside County line, at the De Luz Road crossing at mile 12.0, and at another De Luz Road crossing at mile 11.5, as well as the De Luz School crossing of the creek. These latter four stations (43-46) held arroyo chubs in 1997 also. More water and a larger number of chubs were present in 1998 than in 1997 (Figure #7). De Luz Creek is a major lower tributary entering the main river from the northeast. Three localities need to be distinguished in relation to the name "De Luz", namely the creek, De Luz Ford, a crossing on the main Santa Margarita River, a short distance upstream of the mouth of the creek, and De Luz Road Crossing which is about 6 km upstream of the ford near the upper boundary of Marine Corps Base Camp Pendleton.

Sandia Creek

Sandia Creek was examined in 1997 and in 1998 (Stations 50-53) and arroyo chubs extended about 1.2-1.5km upstream of the entrance of Martin Fleming Ranch (Station 52). Large adult chubs were present in the upper half of this stretch, which alternated from rocky runs and pools to flat sandy stretches. From the Martin Fleming Ranch downstream it is largely sandy to the mouth in the Santa Margarita River. At the ranch and at the mouth of the stream in the river only smaller chubs were taken, probably due to the lack of larger, deeper holes. Above the steep barrier to upward migration, several large holes contained yearling largemouth bass, which were probably deliberately introduced into man-made ponds upstream rather than produced by adults spawning in this stream which appears too small to support spawning by largemouth bass.

Rainbow Creek

Rainbow Creek was examined during all three field seasons (Stations 54-56). The lower 1km or so of Rainbow Creek had abundant arroyo chubs with some green sunfish and black bullhead. The upstream limit of arroyo chubs in this stream came before the upstream limit of green sunfish and mosquitofish, and below a barrier about 15m high. This barrier was about 2.7km upstream from the crossing of Willow Glen, or 4.5km upstream from the mouth in the river, and about 6-7km downstream from the I-5 crossing. About 2.0km up from Willow Glen we found arroyo chubs penetrating about 100m upstream into a small steep tributary entering from the north. Green sunfish dropped out about 1.0 km upstream of this tributary. Only mosquitofish were seen or taken above this barrier and no native fishes were found above this point. The more upstream range of green sunfish and mosquitofish inn his tributary indicates that a source of them probably exists upstream and not that they can surmount the barrier that stops arroyo chubs. Historical records from the University of Michigan document stickleback inhabiting this stream in the vicinity of Hwy 395 near I-5. No crayfish were taken in Rainbow Creek, and both species of tree frogs were common.

Stone Creek

Stone Creek was collected three times (Station 57-58, on August 31st, September 21st and November 23rd, 1998) and was devoid of fish above a low barrier (0.7m) that lies about 0.5km upstream of where this tributary joins the Santa Margarita River. For about another 0.6km upstream of this point only crayfish, aquatic insects, tree frogs and their tadpoles were found in the stream and its two branches. Two other collections in the lower 50m of this stream above the Santa Margarita River took only small arroyo chubs. This lower area is shallow and did not support green sunfish. The water in the creek was 14-16 degrees centigrade, usually cooler than the river in the daytime. This temperature difference probably inhibits reproduction, but not invasion, by green sunfish.

Temecula Creek

This creek was sampled several times at its two widely separated sections of permanent water, namely just above the gorge in Temecula and about 4km upstream of Lake Vail (Stations 35-37). Arroyo chubs were common at several locations in Temecula Creek above Lake Vail, but only above a concrete drop structure at Hwy 79. Below this structure, a barrier to upstream migration to most fishes (but perhaps not large salmonids), an assortment of exotics were taken. A few green sunfish and black bullhead were taken farther upstream but were not abundant.

Murietta Creek

Murietta Creek was also collected several times at three locations upstream from its mouth (Stations 59-61). A beaver dam lies on Murietta Creek just above its mouth in the Temecula Creek, this latter is the name for the main stream above the confluence with Murietta Creek. The stream was shallow and sandy, and contained mostly arroyo chubs and mosquitofish. At a gauging station about 1.2 km upstream of the mouth, arroyo chubs were present below a large beaver dam in the small sandy stream, amongst boulders and bedrock. Larger pools contained abundant green sunfish and mosquitofish as well as a single black bullhead. Shallow, flowing areas of the stream contained groups of up to 10 arroyo chubs. In 1997 and 1998 the Rancho California Road crossing of Murietta Creek (Station 60) was sampled and an assortment of exotics were caught, with a few arroyo chubs taken in 1997 only. At Station 61 about 3km farther upstream at the crossing of Winchester Road mostly mosquitofish were taken. At this upstream site the flow is much reduced, shallow and virtually all effluent fed. The stream was dry a few hundred meters farther upstream.

Santa Margarita River

The main Santa Margarita River was sampled from about 8km upstream from the ocean, an area of the river at the new crossing of Rifle Road (on May 8th, 1998; Station 5, based on Swift and Holland 1998) upstream to the top of the gorge in Temecula for a total of 35 stations. During the Rifle Road collections, the flow was still relatively high and the two culverts created two falls about 50cm high at their lower end. Small YOY striped mullet and largemouth bass were found both above and below the culverts. About fifteen YOY yellowfin gobies were taken only below the culverts, apparently unable to surmount the falls at the culverts. Apparently the largemouth bass were spawned upstream and some passed over the falls; the mullet were able to jump the falls or came upstream before the culverts were built a few days before; and the yellowfin gobies were unable to surmount the falls and came up after they were put in place.

Most of the stations in the main river from the De Luz Ford area (about 0.5km upstream of the mouth of De Luz Creek in the river) on the Base to the top of the gorge in

Temecula (at the mouth of Murietta Creek) were examined and collected in all three years. At least 90% of the actual wetted portion of the river was visually examined in this section. Upstream of Temecula Gorge we only re-sampled two localities on Temecula Creek and its tributaries, namely the vicinity of the mouth of Long Canyon noted above, and at the Hwy 79 crossing of the creek above Lake Vail.

In 1997 arroyo chubs were in low numbers in the main river, usually only near the mouths of tributaries. In 1998 populations of arroyo chubs occurred widely the main river drainage from De Luz Ford to the top of the Gorge. Chubs were absent in the first 5.5-6km upstream of the ford, or about half the distance to the De Luz Road crossing (about where the river flows out of Section 15[T:9S, R:3W]). Arroyo chubs were common in the river from this point to about 100m above the De Luz road crossing. All other fishes were scarce in this area, including mosquitofish in 1998. A few stretches in the upper one third of this area, within 3km or so of De Luz Road had enough gravel to be suggestive of possible steelhead spawning areas. The gravel beds contained some sand during our visit in November, but sand content was probably reduced during the higher flows early in the year. In 1998 we observed about 10 striped mullet in a small, isolated oxbow (5 x 15 meters, to 1.5 m deep) about 1km upstream from De Luz Ford. This oxbow also had bluegill, largemouth bass, and carp. On September 21st, 1998, about 10 similar sized mullet were taken 100-200m downstream of the De Luz Road bridge along with abundant chubs of all sizes, carp, black and yellow bullheads, and one small individual each of largemouth and redeye bass. This is the most upstream record of striped mullet in the river and the most downstream record of redeye bass known to us.

Arroyo chubs were also abundant about 2km upstream of this crossing; about 150 of all sizes were seen in about 200m of stream in 1998. The stream was relatively shallow and sandy and with abundant chubs from the De Luz Road crossing upstream through Section 12, or at least to the mouth of Sandia Creek.

The stretch of river from the mouth of Rainbow Creek upstream to the mouth of Stone Creek contained many wide sandy stretches with occasional holes holding 20-50 arroyo chubs. The upper half of the stretch was more vegetated and rocky, possessing deeper holes and chubs were rare or absent. About one third of this stretch was well vegetated with tules and/or cattails. About 0.7-1.5km upstream of the mouth of Rainbow Creek, three to four beaver dams blocked and ponded the stream. About 30 carp, 120-150mm SL, and five to ten green sunfish were seen in this ponded area. Farther up and about 1.5km downstream of the mouth of Stone Creek, one large bouldery pool 1.5m deep had about 300 half-grown bullheads and about 50 carp. Just downstream of this pool in shallower sandy runs with smaller holes, 50-100 arroyo chubs were observed. No redeye or largemouth bass were seen until the large rocky hole in the river just upstream of the mouth of Stone Creek. Earlier in the year (September), we took carp, black bullhead, black crappie, bluegill, mosquitofish, and redeye bass in this hole. Mosquitofish were more common in this area than farther downstream.

Upstream of the mouth of Stone Creek in 1998, arroyo chubs were absent until the river entered the gorge, and only a few carp, green sunfish, black bullheads, and mosquitofish were observed. In September one to five redeye bass juveniles were seen in almost every hole, for an estimated several hundred between Stations 26 and 30. No largemouth bass were observed and several hundred bullheads, mostly YOY were seen. Of the 150-200 bullheads actually seined, all were black bullheads. About 1.5-2.0km downstream of the pipeline crossing in the San Deigo State University Reserve, arroyo chubs were encountered, and they were present all the way up to the pipeline area, except in a few larger holes with exotics fish species. Redeye bass were common all the way up to the pipeline, but only about one twentieth the numbers of black bullheads and green sunfish. Eighty to ninety percent of each species were YOY, from about 50-120mm SL. Arroyo chubs continued to be abundant in the lower gradient region upstream of the pipeline. One green sunfish with a melanistic black caudal fin was captured, being similar to one seen but not captured the previous year in the same area. No exotic fishes were seen above the pipeline area until the deep pool at Station 33 where two bright yellow (xanthic) arroyo chubs were taken. Here exotics were present again, except for the redeye and largemouth bass. Chubs were common all the way to the gauging station at the top of the gorge. Black bullheads, green sunfishes and mosquitofish declined in abundance with increased distance upstream from the pipeline (Stations 31-35). No basses were seen in this whole stretch and several gaps or falls in bedrock areas may be partial or complete barriers to upstream movement by the basses as well as other species. One large beaver dam existed about 0.5 km downstream from the top of the gorge. Bullfrog tadpoles were observed in most, if not all of the larger slower flowing holes.

At the gauging station at the top of the gorge (Station 35) large numbers of fishes were concentrated in the deep hole below the concrete apron crossing the stream on 8 September. One seine haul up through this hole, about 10 X 2 m and to 90 cm deep took about 1000 arroyo chubs, 150 YOY black bullheads, 58 green sunfish, and only 4-5 mosquitofish. About 60% of the bullheads were examined and they were all black bullheads. During about 15 minutes of observations, 100-120 YOY green sunfish, along with at least one each of arroyo chub, mosquitofish, and black bullhead, occupied a shallow concrete shelf below the steeper fall of the apron of the gauging station. About 50 small sunfish were observed to try and swim up the shallow overflow on the apron that was only about 5 to 10 mm deep. The water was equally shallow on the shelf below the apron lateral to the main flow where they lay on their sides, only barely covered by the water. They obviously were trying to migrate upstream and had a very difficult time. Only one of the fish noted making the attempt actually made it to the upstream side of the apron, and those trying were extremely exposed to predation. On a later visit (November 23) no evidence of this migration was apparent and a similar haul below the barrier netted about 300 chubs, 20 mosquitofish, 20 green sunfish, and 1 black bullhead. Chubs extended above the apron upstream to the mouth of Murietta Creek, about 100-150 m upstream of the gauging station.

Santa Margarita Lagoon

The lagoon was sampled six times from 1997-2000, namely on November 24th 1997, April 10th and September 1st 1998, July 14th and December 14th 1999, and on 20 April 2000. Usually samples were distributed over much of the lagoon with small to large seines and additional visual observations. A variety of typical estuarine species were taken (Table #3). On 10 April the sample was restricted to the vicinity of the I-5 crossing when the freshwater outflow was strong and little salinity existed. The overwhelmingly dominant fish in this latter collection were small yellowfin gobies. About 300 of them were taken in only 3 or 4 hauls of the net. Many seemed opaque as if they were dead before being seined. Only about ten other small fish were taken in the seine including diamond turbot, California killifish, striped mullet, arrow goby, and a single large bluegill sunfish. An additional 30 or so large mullet were observed jumping in the lagoon. On September 1, 1998, the first records for the longfin goby, striped bass, grey smoothhound, and slough anchovy were made. Large numbers of yellowfin gobies were taken, the same year class as the abundant young taken the previous 10 April in the lagoon and on 8 May upstream at Rifle Road (Station 3). They were 15 to 25 mm long in April, 75 to 100 mm long in May, and by September they were 150-200 mm long. In all other lagoon collections, yellowfin gobies were rare or absent, as well as during previous years collections (Swift et al 1994; Swift and Holland 1998). On 20 April 2000, 50 tidewater gobies were taken along the south shore of the lagoon from the I-5 bridge upstream for about 300 meters. This is the first record of this federally endangered species from the lagoon since the early 1990s (Swift and Holland 1998).

Table #3
Species detected in the Santa Margarita River drainage

Estuary

Exotic Species

Striped Bass	*Marone saxatillis*
Yellowfin Goby	*Acanthagobius flavimanus*
Mosquitofish	*Gambusia affinis*

Native Species

Topsmelt	*Atherinops affinis*
Arrow Goby	*Clevelandia ios*
Northern Anchovy	*Engraulis mordax*
California Killifish	*Fundulus parvipinnis*
Longjaw Mudsucker	*Gillichthys mirabilis*
Diamond Turbot	*Hypsopsetta guttulata*
Cheekspot Goby	*Ilypnus gilberti*
Staghorn Sculpin	*Leptocottus armatus*
Striped Mullet	*Mugil cephalus*
California Halibut	*Paralichthys californicus*
Shadow Goby	*Quietula y-cauda*
Bay Pipefish	*Syngnathus auliscus*
Longfin Goby	*Ctenogobius sagittula*
Tidewater goby	*Eucyclogobius newberryi*

River

Exotic Species

Common Carp	*Cyprinus carpio*
Mosquitofish	*Gambusia affinis*
Black Bullhead	*Ameiurus melas*
Yellow Bullhead	*Ameiurus natalis*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Redeye Bass	*Micropterus coosae*
Largemouth Bass	*Micropterus salmoides*
Black Crappie	*Pomoxis nigromaculatus*

Native Species

Arroyo Chub	*Gila orcutti*
Striped Mullet	*Mugil cephalus*

Discussion

Three years of collections from the Santa Margarita River drainage has provided a comprehensive, up to date assessment of the distribution and relative abundance of the freshwater and estuarine fishes. The fortuitous occurrence of a record El Nino rain year, followed by an equally prominent La Nina event, has presented an additional opportunity to document the effects of these extreme weather phenomena. Our effort on the river and its tributaries also benefitted from the work of Swift and Holland (1998) on the lagoon and by Lang et al. (1998) on steelhead.

The arroyo chub was the only one of the four native freshwater fishes recorded from the drainage that we found still present. The tidewater goby and the striped mullet are estuarine species that utilize only the lower parts of freshwater systems as a nursery area. Since the drainage is artificially dry just above the lagoon most of the year this function is limited today, but was probably more prevalent historically. The California killifish is the only other native estuarine species that may invade the lower stream, but we did not take it above the tidewater areas, also probably partly due to the artificial lack of freshwater flow most of the year. Historical records exist for the steelhead, stickleback, and lamprey but they have been extirpated since at least the 1940s (Lang et al. 1998; Swift et al. 1993). The latter three still occur both to the north and to the south of the drainage and the stickleback should be considered for reintroduction. The steelhead and lamprey are anadromous (migrating in from the ocean to spawn) and would reinvade of habitat conditions improved enough for them.

Arroyo chubs clearly became more abundant in the main river channel from Station 13 to the top of the gorge following the El Nino rains that heavily scoured the vegetation from the drainage (Picture #1-2). The chub appeared to be excluded by redeye bass since where one was abundant, the other would be rare or absent in the main river. Although redeye bass are known from small streams in their native Alabama and Georgia (Etnier and Starnes, 1993), they have not invaded the tributaries to the main river, and could not be found in the upper 1.5 to 2 km of the river in the gorge. Thus, while the redeye bass obviously prey on chubs, they seem to do so only in a limited area that is apparently optimal for them in the middle gorge area, from about the mouth of Stone Creek upstream to the pipeline crossing in the reserve. Chub were able to colonize successfully after El Nino because the exotic fish species had been severely depleted, but our 1997 collections showed that after several low rainfall years, emergent vegetation increases considerably and largemouth bass, green sunfish, and black bullhead are also abundant. These all provide additional predation pressure on arroyo chubs in addition to the redeye bass. We recorded 9 exotic species in the river and 2 in the lagoon, which were yellowfin goby and striped bass. Thus there is a strong dichotomy between the river and lagoon, the former is overwhelmingly dominated by exotic species and the latter by native species. Three species of exotic species were abundant and widespread, western mosquitofish, green sunfish, and black bullhead. These are species that are adapted to similar habitats in the Midwestern United States and establish permanent reproducing populations in southern California coastal streams (Swift et al. 1993). Fortunately two other exotic cyprinid species common in many other southern California coastal

Picture #1, Santa Margarita River (Station #24) in 1997

Picture #2, Santa Margarita River (Station #24) in 1998

drainages, red shiners and fathead minnows, were not recorded from the Santa Margarita and apparently are absent. They have ecological requirements similar to the arroyo chub and could compete with this native species. Both red shiner and fathead minnows are less tolerant of high flows and breed at higher temperatures than the arroyo chub, and the naturally cool tributaries of the Santa Margarita might deter the success of these two exotics in the system. The warming effect of the existing beaver ponds would be favorable for these two exotic species. The other exotic species are much less common and more dependent on artificial impoundments or the largest pools in the river for their continued existence, such as largemouth bass, channel catfish, golden shiner, bluegill, black crappie, and yellow bullhead. We did not record channel catfish or golden shiners but recent records exist for the lower river and Lake O'Neill (Lang et al. 1998). The potential exists for additional exotics that we did not record but that probably occur in Lake Vail and Lake Henshaw upstream.

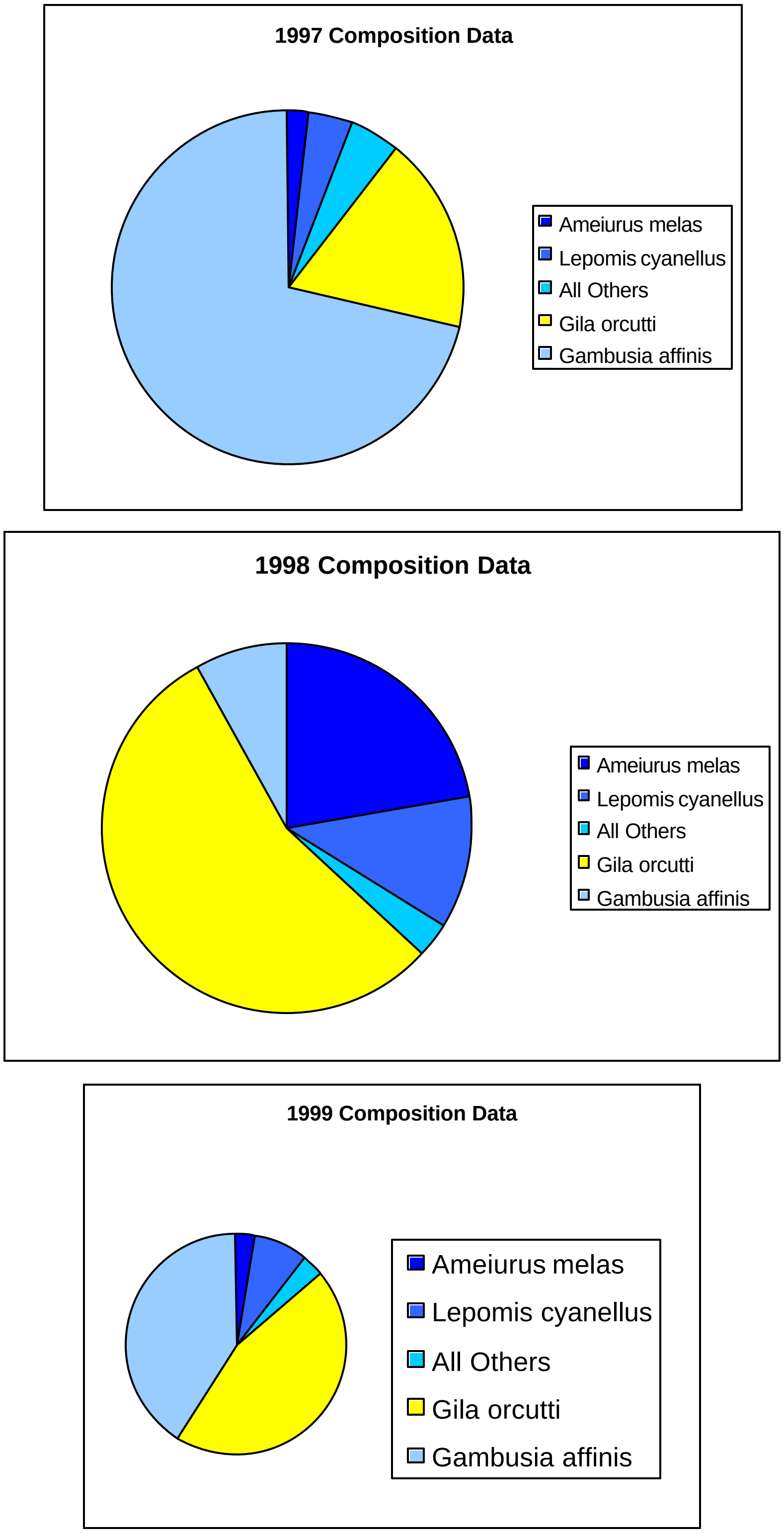
In addition to providing habitat for exotic predators, another effect of the increased vegetation is to increase the depth of the stream channel in the lower gradient portions of the river downstream of the mouth of Stone Creek to the De Luz Ford on the Base. As the vegetation encroaches into the flat sandy stream channel the flow is narrowed and deepened to the benefit of the larger exotic species. Water depths range from 30 to 60 centimeters. Right after El Nino, many of these channels were wider, shallower (5-20 centimeters) and bordered by watercress. This provided ideal habitat for arroyo chubs, but it was generally too shallow for the larger green sunfish, largemouth bass and black bullhead. Larger pools in these areas often lacked arroyo chubs but harbored exotic predators.

The numbers of exotic species were reduced in most areas of the river in 1998 as compared to 1997 (Figure #8). Largemouth bass and mosquitofish were found in reduced numbers compared to 1997 surveys. No largemouth bass were seen until late in the sampling period when one was captured in the main stream below the De Luz Road crossing. In contrast to the above-mentioned exotic species, black bullhead and redeye bass appeared in increased numbers in 1998. This was due in part to the seasonally earlier collection period when larger numbers of smaller bullheads were still present. The red eye bass were represented largely by YOY, which were seen in the gorge area from the mouth of Stone Creek (end of Stagecoach Road) upstream to just below the pipeline crossing below the SDSU Field Station.

El Nino Effects

It is presumed that high flows created the changes in faunal composition observed during the 1998 field season. The stream was flushed out and much marginal vegetation was removed (Pictures #1-2). A long stretch of the stream from the De Luz Road crossing upstream to the mouth of Rainbow Creek was largely open to the sun and flat, whereas the year before much of it had been hidden in dense sedges, tules, and cattails. This was true upstream to the end of Stagecoach Road as well. Farther upstream in the gorge area, the shoreline was less changed because the bedrock had not supported as much vegetation the year before. However, the upper most 1-2km below the top of the gorge was sandier and with a lower gradient. It resembled the downstream areas in having been largely denuded of marginal stream vegetation. These denuded areas held abundant arroyo chubs in contrast to their general absence in 1997. In the case of the

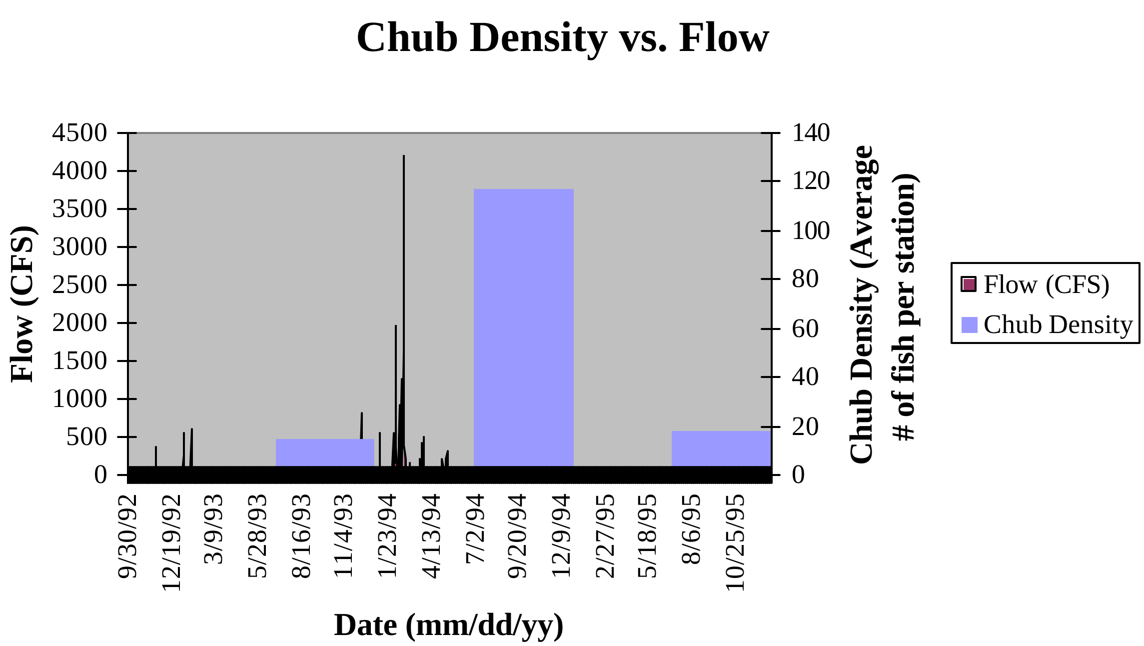
Figure #8 Species Composition by Year



uppermost gorge reach, only low numbers of mostly large fish were found in 1997 while in '98 over 1000 juvenile chub were found in a single hole. This strongly suggests that the success of the exotics is dependent on deeper water with abundant cover. When years of low flows allow the vegetation to encroach on the open flat channel, the water is channeled and deepened, favoring the exotics.

Arroyo chub populations were found to be much higher in the 1998 field season as compared to 1997. The chub's distribution throughout the river appeared to have expanded as well. Observations taken earlier in the year showed YOY chub appearing in March throughout the gorge, and it is assumed, throughout the drainage. As water levels and flow dropped off later in the season, YOY chub only persisted in those areas where the presence of exotics was either minimal or absent. There was a strong correlation between the success of chubs within a specific area and its habitat type. Chub persisted in shallow riffles free of exotics that had been scoured of vegetation by high flow events caused by El Nino rainfall. They benefited greatly from changes in habitat brought on by these scouring events. A combination of increased habitat quality and reduced predator populations seems to be the reason their numbers increased in the 1998 season. Field observations have shown that exotic species have a negative impact on the chub, with only the largest size classes being able to persist when exotic species were present. The strong correlation between the chub's success and extirpation of exotics in certain areas strongly supports the use of high flow events, either natural or artificial as a tool for restoration in this watershed. By increasing the magnitude and frequency of scouring events it may be possible to remove some exotics from the watershed entirely.

Figure #7



The one exotic thought to be most likely to decimate the chubs, redeye bass, also seemed to be favored by the flushing out of the river. Our preliminary results indicate that both species benefit and that exotic control efforts need to be directed at other species and at the habitat conditions that favor them. While the large pools seem to favor green sunfish and largemouth bass, they often posses a thermocline 1-1.5m below the surface. The surface water was 18-22 degrees centigrade, where as the lower levels were about 14 to 16 degrees C. These two exotics should favor shallower, warmer pools with the upper temperature range. This also implies that the long ponded areas 1-2m deep created by beaver dams might do much more for the exotics than natural bedrock holes. However, these deep holes may favor the redeye bass, which prefer cooler water than largemouth bass. The heavy El Nino rains also reduced the extent of beaver ponding in the drainage. In addition some of the beaver dams are built on top of natural ponding barriers in the stream so they just increase the size of natural ponds rather than affecting established stream channel.

Black bullheads were the second exotic species that appeared in increased numbers in 1998. In '98, hundreds of YOY fish in schools were observed in larger holes and beaver ponds of the gorge area. In 1997 bullheads were seldom seen unless flushed from under vegetation during seining. In a few of the largest holes, schools of adult fish, along with carp could be seen. However, this was only observed in five or six holes throughout the gorge area in 1997, whereas in 1998 schools of small black bullheads were in virtually every hole and easy to see. The reasons for this change are not clear, but perhaps reduction of the number of adults, abundant before the strong winter flushing, enabled the new year class to respond in dramatic fashion. Yellow bullheads seemed to be adversely affected as they were not taken at all in the gorge. While not as noticeable as the three other exotics that declined in numbers, the yellow bullhead population was definitely reduced. Brown bullheads have been reported from the Santa Margarita River (Cooper et al. 1973) but we did not take any, we carefully examined all the fish we caught and they were black bullheads. As noted by Swift et al. (1993) and Etnier and Starnes (1993) the consistent field and laboratory separation and identification of these two bullhead species is one of the most difficult among North American freshwater fishes. Thus historical records undocumented by specimens should be carefully considered (Dill and Cordone 1998).

Barriers to migration

One set of stair-step falls in the gorge seemed to be a barrier to upstream migration of fish, since many small individuals were concentrated just below this falls. Several other sites in the gorge both above and below the Field Station were identified as being potential partial barriers to upstream migration by fish. For many of these, higher flows would provide alternate paths around the barrier and allow migration during rainy periods. The gauging station at the top of the gorge is definitely a barrier to small fishes, and their difficulty in overcoming that barrier during low water was directly observed. Higher winter flows probably allowed larger fish to surmount the barrier, but it is probably a substantial, if not complete, barrier to upstream movement of arroyo chubs. Two other such barriers noted on the main river within Camp Pendleton are at the newly constructed Rifle Road and the diversion dam near Lake O'Neill. This latter may have been a barrier to steelhead in the past, but is supposed to be modified seasonally to allow them to pass today (Lang et al. 1998). Considerations of migration by both large and small fishes should be integrated into all construction projects on the river and its tributaries (Warren and Pardew 1998).

Potential Steelhead habitat

Steelhead habitat for rearing is present at several sites in the drainage; upper De Luz Creek from about the De Luz School upstream to the upper limit of accessible flow, about 11-12km; Sandia Creek from its mouth in the river upstream about 4-5km; Rainbow Creek in its lower about 5km; Stone Creek for about 2km up from the mouth; and the main river from about the De Luz Ford on the Base to the top of the gorge, about 32km. An additional few kilometers may be accessible in Pechanga Creek, which is as yet unexplored. Upstream of the gorge the stream dries for too long or is inaccessible behind Lake Vail. Even if this upper river was restored, only the lower 2-3km of Long Canyon and about 15km of Temecula Creek proper would be available to steelhead. The other tributaries, such as Arroyo Seco and Cottonwood Canyon, are too dry or have natural barriers to access of headwater areas. The main Temecula Creek down to the top of the gorge was probably a major rearing and spawning area for steelhead before 1900.

The capabilities for holding and rearing steelhead appear adequate in the Santa Margarita drainage, but spawning habitat is much scarcer and needs to be accurately surveyed. Lang et al. (1998) note that filling in with sediments has obliterated areas identified in the past as spawning areas in De Luz Creek. The only area with spawning potential noted by our surveys are in Roblar Creek below the barrier falls about 1.5km above its mouth in De Luz Creek and in the main river in the first 3km below the crossing of De Luz Road. These areas show some development of the appropriate sized gravel (about 15-60mm in diameter) needed for steelhead spawning. Such gravel beds also need to be at least 15-20cm deep, have 5% or less of finer sediments or plant material, and occur in cool flows, 48-52 degrees F. for at least a month for successful hatching of young steelhead. In addition the alevins require another two to three weeks at these temperatures to grow and emerge from the gravel (McEwan and Jackson 1996; Flossi et al. 1999). The gravel we observed was located in substrates at least half or more sand. The gravel proportion may have been greater earlier in the year, during stronger flows, with the sandier component filling in as flows dropped off in spring and summer. A winter survey needs to be done to verify if better conditions occur transiently at these sites. Lang et al. (1998) indicated that fires in the drainage led to the stream channels filling with fine sediments and it may take years of flushing to bring back the gravel beds and other habitat features that will support spawning by steelhead. Short term loss of steelhead, on the order of 3-5 years, and their subsequent return have been documented by the California Department of Fish and Game in several streams, perhaps most recently by Maurice Cardenas and Mark Capelli in the Arroyo Sequit drainage of the Santa Monica Mountains National Park. The fact that lower Roblar Creek often dries up in the summer is not fatal, since observations in other areas have shown that intermittent streams can function as spawning areas if enough flow exists for eggs to hatch and juveniles to grow and migrate downstream to permanent stream or even coastal lagoon habitat that will sustain them. Such reproductive strategies were probably relatively more important in a southern stream like the Santa Margarita River where upstream areas are less able to support juvenile fish on a year round basis. However, the extended drying out of the lower Santa Margarita River renders this option difficult for the young steelhead to accomplish, and argues for maintaining more perennial flow in the lower river and De Luz Creek as was historically available from the early 1900s and earlier.

Potential Stickleback habitat

The vast majority of substrate noted during our surveys has been bedrock, boulders, or sand. Very little mud or other organic substrate was present and then only in distinct backwaters that are not common in the drainage. Rock predominates in most parts of the gorge, usually accompanied by high gradient flows and is associated with deep holes. Where the gradient is lower, sand predominates. These lower gradient areas are optimal for threespine stickleback, formerly native to the drainage. Shallow, sandy runs with marginal herbaceous vegetation like watercress are good habitat for stickleback. They would do well in the margins of larger holes, but do not tolerate many exotic predators, and like the chubs would be restricted if these predators were in high numbers. The historical museum records of stickleback from the drainage are from the lowermost river near the lagoon, upper Rainbow Creek from near the I-5 crossing (at or near the crossing of the old Hwy 395) and the Temecula area. This means that originally they were found throughout the gorge, at least as downstream migrants even though the gradient is too high for them in much of the gorge. The same is true on Rainbow Creek where they were undoubtedly upstream of the barrier noted above, but probably inhabited the whole stream down to the main river. From a criterion of physical habitat condition, including the presence of year round flow, the following areas appear appropriate for permanent stickleback populations today: the main river at the upper end of the lagoon; main river from the De Luz Ford upstream to about 3km below the De Luz Road Bridge; the main river from about 1km above the top of the gorge to about 2km below; Temecula Creek from the Hwy 79 crossing upstream to about 2km downstream of Oak Grove Ranger Station, including the lower 1.5-2km of Long Canyon; Rainbow Creek for about 2km above and below I-5; De Luz Creek from about De Luz School upstream to the barrier about 4.5 km; and Sandia Creek from the mouth about 4km upstream to the barrier. These areas seem to have water most of the year and the main management problem would be removal of exotics. Some of these habitats could be expanded with more permanent water, such as lower De Luz Creek and the main river from the De Luz Ford downstream to the lagoon. Pollution probably has to be controlled in upper Rainbow Creek since sticklebacks were once there but have since been extirpated. Temecula Creek upstream of Hwy 79 is probably the best current transplantation site since it possesses a good volume of water, exotic species are not abundant, water quality seems better than downstream (arroyo chubs still live there), and a barrier just below Hwy 79 prevents upstream invasion by exotics from Lake Vail. The main threats to populations in this area are probably appropriation of surface water and agricultural and mining contamination. We observed one diversion just above the mouth of Long Canyon and others may exist.

While the presence of beaver ponds to slow the water flow (thereby locally reducing the gradient) could be interpreted as favorable to stickleback, this would only be the case if the exotics were absent. In addition, the beaver dams cause increased water temperatures that would be detrimental to the stickleback. Threespine stickleback have thermal requirements higher that rainbow trout but lower than arroyo chub (Swift 1989) and would do better in the cooler flowing waters of the natural stream. Stickleback were undoubtedly numerous in the large slowly flowing, algae filled pools in the gorge before the advent of exotic species. In any case the necessity to limit or exclude beaver ponds as favoring exotic predatory exotic species overrides any consideration of possibly increasing habitat for stickleback that do now currently inhabit the drainage.

Many other water quality issues probably affect the fishes but are poorly understood. However, urban and surburban runoff are going to increase as well as sewer effluent for the next few tens of years. Beyond that time it is conceivable that water will again be in short supply and instream uses will have to compete with other uses. The effects of the amount and quality of this water should be assessed for its effects on the native fishes downstream. Beaver dams also affect water quality and the temperature effects were noted above. In addition, many nutrients and other suspended materials are filtered while the water passes slowly through the impounded portions of the stream. On a couple of occasions within the first kilometer below the top of the gorge we observed turbid river water entering the upper end of a beaver pond and much clearer water leaving the lower end. The precise effects of this filtering is not known, but considerable nutrients must be stored in the ponds until the winter storms remove them in wholesale fashion to the lower coastal plain, lagoon, or all the way to the ocean.

Status of the estuary

Only one native estuarine species, the tidewater goby, has been extirpated in the drainage for several years, and its recent return documents that it can occasionally recolonize habitats that are close to existing populations (within at most 10 kilometers [Lafferty et al. 1999a,1999b]). Swift and Holland (1998) have documented some re-colonization of small lagoons on the Base by this species. However, it had not been able to re-colonize the Santa Margarita estuary after last being recorded in 1991. This is in spite of several thorough surveys and the occurrence of a population of tidewater gobies about 1km north of the Santa Margarita at the Cockleburr Lagoon. Since the physical nature of the Santa Margarita estuary is relatively good and all other native species expected are present, some as yet poorly understood factor has made it impossible for tidewater gobies to re-colonize until very recently. Exotic species are probably the main suspects, particularly largemouth bass, sunfishes and yellowfin gobies. All but the yellowfin gobies were abundant in the upper estuary where the tidewater gobies used to occur. The yellowfin gobies documented invading upstream in the spring of 1998 (Swift and Holland 1998) were almost twice as large as adult tidewater gobies, and undoubtedly prey on them if given the chance. However, the large number of yellowfin gobies appeared to have been in response to the El Nino conditions, and they have always been very rare in the lagoon before and since.

Until this reappearance of tidewater gobies, the Santa Margarita Lagoon was a good candidate for artificial re-introduction of them if progress could be made on removing exotics. Since very large numbers of tidewater gobies exist in some of the other lagoons, a re-introduction could be made to save these fish if French Lagoon threatened to dry up as it has in the past. The fish could then be monitored to determine if they survived for the long term or if they disappear. It now seems likely that a one-time event eliminated them earlier and that they now have become reestablished. The species became reestablished after the strong rebound of a La Nina winter that possibly improves the chances of gobies recolonizing. Perhaps previously re-colonization from the ocean has been inhibited for some reason. Exotic control by El Nino and additional efforts in the lower river (Dan Holland, pers. Comm.) possibly improved the chances of success for invading tidewater gobies. Increasing freshwater inflow to the river during the dry season and thereby increasing the lower salinity brackish zone favored by tidewater gobies may also help. This flow increase would also enhance steelhead habitat as well.

In addition to habitat for the federally endangered tidewater goby, the lagoon is valuable as nursery habitat for California halibut, a valuable commercial and sport species of flatfish (Haugen 1992). It is dependent on coastal protected wetlands for the first two to three years of life and we took this species in the lagoon (mention numbers?). We also recorded abundant populations of arrow, shadow, and cheekspot gobies that are known to figure prominently in the diet of young California halibut (Haugen 1992?). Young topsmelt are also abundant in the spring and they figure prominently in the food of the federally endangered least tern that nests on islands in the lagoon (Patricia Baird and Camm Swift, unpublished research). Diamond turbot, deepbody anchovy, bay pipefish, shiner surfperch, and staghorn sculpin are all marine species that depend on the lagoon as a nursery area. Finally six species are almost completely dependent on the lagoon for their complete life cycle, the three gobies mentioned above, the longjawed mucdsucker, the tidewater goby, and California killifish. A whole suit of estuarine organisms is still relatively intact in this lagoon, and it is large enough to maintain most of them.

The lagoon is one of the few remaining in all of California with a complete suite of native bay gobies interacting over ecological time. Much of the integrity of the estuarine system relies on input from upstream. Farther north where streams are more permanent (as the Santa Margarita once was [Baumgartner 1989]) tidewater gobies typically use the lower several kilometers of low gradient streams as nursery areas (Swift et al 1997). Today the tidewater gobies are more restricted to the upper end of the lagoon. The other three species are more marine and extend into the lower lagoon, arrow shadow, and cheekspot gobies have always been rare in the upper two-thirds of the lagoon upstream of the Interstate 5 and railroad bridges. Several other estuarine species, deepbody anchovy, bay pipefish, yellowfin croaker, queenfish, grey smoothhound, butterfly ray, round sting ray, bat ray, and shiner surfperch were also limited to the lower third of the lagoon. Some of these suffer mortality if the salinity gets too low; a mass mortality of gray smoothhound was observed by Chris Bandy (pers. Comm.) in 1996. Swift and Holland (1998) observed mass mortality among bubble snails, razor clams, and bay gobies due to a combination of a winter influx of freshwater and/or concomitant severe lowering of the lagoon water level. Topsmelt and California killifish are more uniformly distributed throughout the lagoon. Western mosquitofish are also throughout the lagoon but were uncommon in the lower two-thirds of the lagoon.

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