SOUTHERN STEELHEAD *Oncorhynchus mykiss* HABITAT SUITABILITY SURVEY OF THE SANTA MARGARITA RIVER, SAN MATEO, AND SAN ONOFRE CREEKS ON MARINE CORPS BASE CAMP PENDLETON, CALIFORNIA.

(Dan Ryan in 1939, with two steelhead taken from San Mateo Creek)

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
COASTAL CALIFORNIA FISH AND WILDLIFE OFFICE
ARCATA, CALIFORNIA

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PREPARED FOR:

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MARINE CORPS BASE
CAMP PENDLETON

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DISCLAIMER

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EXECUTIVE SUMMARY

A comprehensive literature search for records of Southern California steelhead trout, *Oncorhynchus mykiss* was conducted for the following streams; Santa Margarita River, San Mateo, San Onofre, Las Flores, De Luz, Cristianitios, Talega, Pilgrim, Sandia, Rainbow, Murrieta, and Temecula creeks. Sufficient data exists to indicate southern steelhead populations historically occurred on San Mateo Creek through the late 1940's, and that the Santa Margarita River populations appeared to have declined prior to this. The best historical records for Base streams are from San Mateo Creek and its tributary Devils Canyon, followed by De Luz and San Onofre creeks. Steelhead populations in San Diego County have been extirpated and their known distributions in North America freshwaters have shifted northward from the Santo Domingo River in northern Baja California, to Malibu Creek in Los Angeles County.

An extended dry cycle from the mid 1940's through the late 1970's, and concurrent urban and agricultural growth in the lower alluvial valleys of the Santa Margarita River, San Mateo and San Onofre creeks, overtaxed the groundwater resources of these streams. There were extended periods in the mid 1950's, when stream flows were insufficient to reach the ocean during the historical wet months February through April. This severely limited the opportunity for upstream and downstream migration of adult and juvenile steelhead. Landlocked steelhead were likely extirpated due to competition, increased fishing pressure, disease, and/or predation following plants of hatchery trout for put and take fisheries, and the introduction of exotic predatory game fish. The introduction of exotic fish species in southern California started in the late 1940's, with the boom of dams and water diversions.

Based on the available literature, southern steelhead are relatively adaptable, able to survive in modest habitat and withstand higher stream temperatures and lower dissolved oxygen concentrations than their northern counterparts. Basic habitat requirements cited were adequate spawning gravel for adults, and areas of perennial flow or intermittent flow associated with pools and vegetative cover for over-summer juvenile rearing. Rainbow trout have been observed surviving water temperatures as high as 29°C, but prolonged exposure to temperatures greater than 25°C would likely be lethal. In intermittent streams, trout will tolerate low dissolved oxygen in order to escape high water temperatures. Large or deep thermally stratified pools likely provided the best opportunity for juvenile survival and growth, however, shallow pools associated with coldwater seeps or springs were also used. Adults spawned upstream soon after winter/spring flows breached the sand bar, and juveniles emigrated the following winter. Estuary/lagoon rearing was beneficial, but may not have been essential due to rapid in-river growth potential. The best steelhead habitat on Base occurs within the upper San Onofre Creek drainage. Roblar Creek, possesses spawning but limited rearing habitat. The Santa Margarita River and San Mateo Creek provide a corridor to upstream habitat off-Base. Spawning and rearing habitat occurs on San Mateo Creek and Devils Canyon within the Cleveland National Forest.

INTRODUCTION

Southern California steelhead trout, *Oncorhynchus mykiss* are a unique anadromous form of rainbow trout that have been almost eliminated from most of its historical range (Moyle 1991; Nehlsen, Williams and Lichatowich 1991; Swift 1993; Titus 1994). Southern steelhead is a name applied to populations of winter-run steelhead managing to persist in a few streams south of San Luis Obispo, CA. The principal self sustaining populations of southern steelhead are: 1) Malibu Creek, Los Angeles County; 2) Ventura River, Ventura County; 3) Sespe and Santa Paula creeks in the Santa Clara River drainage, Ventura County; and 4) the Santa Ynez River, Santa Barbara County. The combined total of these populations are estimated at less then 500 adult fish (Titus 1994).

According to the National Marine Fisheries Service (NMFS 1995) a salmon population or group of populations is considered "distinct" and hence a "species" under the Endangered Species Act if it represents an evolutionarily significant unit (ESU) of the biological species. There is both geographic and genetic evidence that southern California steelhead constitute a distinct ESU. The geographic boundaries of this ESU extend from the Santa Ynez River to Malibu Creek, however, in years of substantial rainfall spawning steelhead have been found as far south as the Santa Margarita River (SMR)(NMFS 1995). Historically, the southern range of steelhead extended as far south as the Rio del Presidio, Mexico (CDFG 1996a).

In 1995, the U.S. Fish and Wildlife Service, Coastal California Fish and Wildlife Office (CCFWO) entered a multi-year, three phase fishery investigation of southern California steelhead habitat on Marine Corps Base, Camp Pendleton (Base). This investigation was to determine the historical status of steelhead in the streams on Base, and the current suitability of these streams as migratory, spawning and rearing habitat. Phase I involved a comprehensive literature search documenting the historical presence of southern steelhead on Base, conducting stream surveys for the presence of southern steelhead on Base, inventorying habitat available to steelhead on Base, and locating migration barriers on the Santa Margarita River. Phase I began in May 1995. An amendment to Phase I, expanded the literature search and surveys to include San Mateo Creek (SMC) and its tributaries. Phase II, was conducted in conjunction with Phase I in 1995 and completed in 1996. Phase III was added in 1996 to include San Onofre Creek (SOC) with work to be completed in 1997.

The cumulative effects of drought, groundwater pumping, frequent fire, military training, agricultural activities, exotic fish, and shrinking estuaries have lead to the extirpation of Base steelhead populations. SMC is looked upon by (San Diego) anglers as having the best potential for restoration as a steelhead stream. Recent reports of steelhead straying into SMC continue to fuel hopes that this population can be reestablished.

STUDY AREA

The study area encompasses some of the last remaining undeveloped open space along the southern California coast. Camp Pendleton is located along the southern California coastline approximately 84 kilometers (km) north of San Diego (Figure 1). The boundaries of the Base enclose approximately 50,586 hectares of a variety of habitats including; coastal strand, salt water estuary/freshwater marsh, riparian woodland, coastal sage scrub, oak woodland/savannah, annual and perennial grassland, and chaparral. The climate is characterized as Mediterranean having warm, dry summers, moderate winters, and frequent fog. Temperatures are moderate, with an average monthly maximum of 23°C. The coldest month is January and the warmest is September. Temperatures rarely reach freezing and few days exceed 32°C. Precipitation averages 34.5 cm (13.6 inches) per year, with most (84%) occurring between November and March. January is the wettest month, while July is the driest (USFWS 1995a).

The Santa Margarita River watershed comprises approximately 1,191 km^2 and is one of the larger river basins on the southern California coastal plain. The upper watershed is typically composed of steep and rocky terrain with intermittent valleys. The lower watershed is characterized by a wide, sandy flood plain with braided low-flow channels overlying a groundwater aquifer. The major tributaries to the SMR within the Base boundaries are De Luz and Roblar creeks (Figure 1). Flow in the mainstem SMR has been partially regulated since November 1948 by Vail Lake on Temecula Creek, and since 1974 by Skinner Reservoir. The Rancho California Water District also supplements low summer flow with 3.0 cfs of treated wastewater into the SMR via Murrieta Creek (Jenz, pers. comm. 1997).

The SMR flows to the Pacific Ocean beginning during the winter months through late spring. The remainder of the year flow is entirely subsurface downstream of Fallbrook to the head of the estuary. Surface flow is diverted on Base to refill Lake O'Neill and/or nearby groundwater recharge basins. Since 1962, 84% of all diversions have occurred during the months January through March (USFWS 1993).

The San Mateo and San Onofre creek watersheds are two of the few streams in southern California that are not dammed. SMC flows 35 km from its headwater in the Cleveland National Forest (CNF) to the ocean just south of the city of San Clemente. The total watershed is approximately 355 km^2 and lies in mostly undeveloped areas of the CNF, northern portion of the Base, and ranch lands of southern Orange County (Woelfel 1991). The San Onofre Creek watershed is completely encompassed within the Base boundaries, and like the Santa Margarita River and San Mateo Creek, is a source of potable water for the Base. San Onofre Creek has four upper subunits: Jardine Canyon, 8 km^2, North Fork, 20 km^2, Middle Fork, 30 km^2, and the South Fork 24 km^2. Two small lakes, Case Springs, approximately 50 acre-feet storage capacity, and Little Case, approximately 25 acre-feet storage capacity, flow into the North Fork of San Onofre Creek.

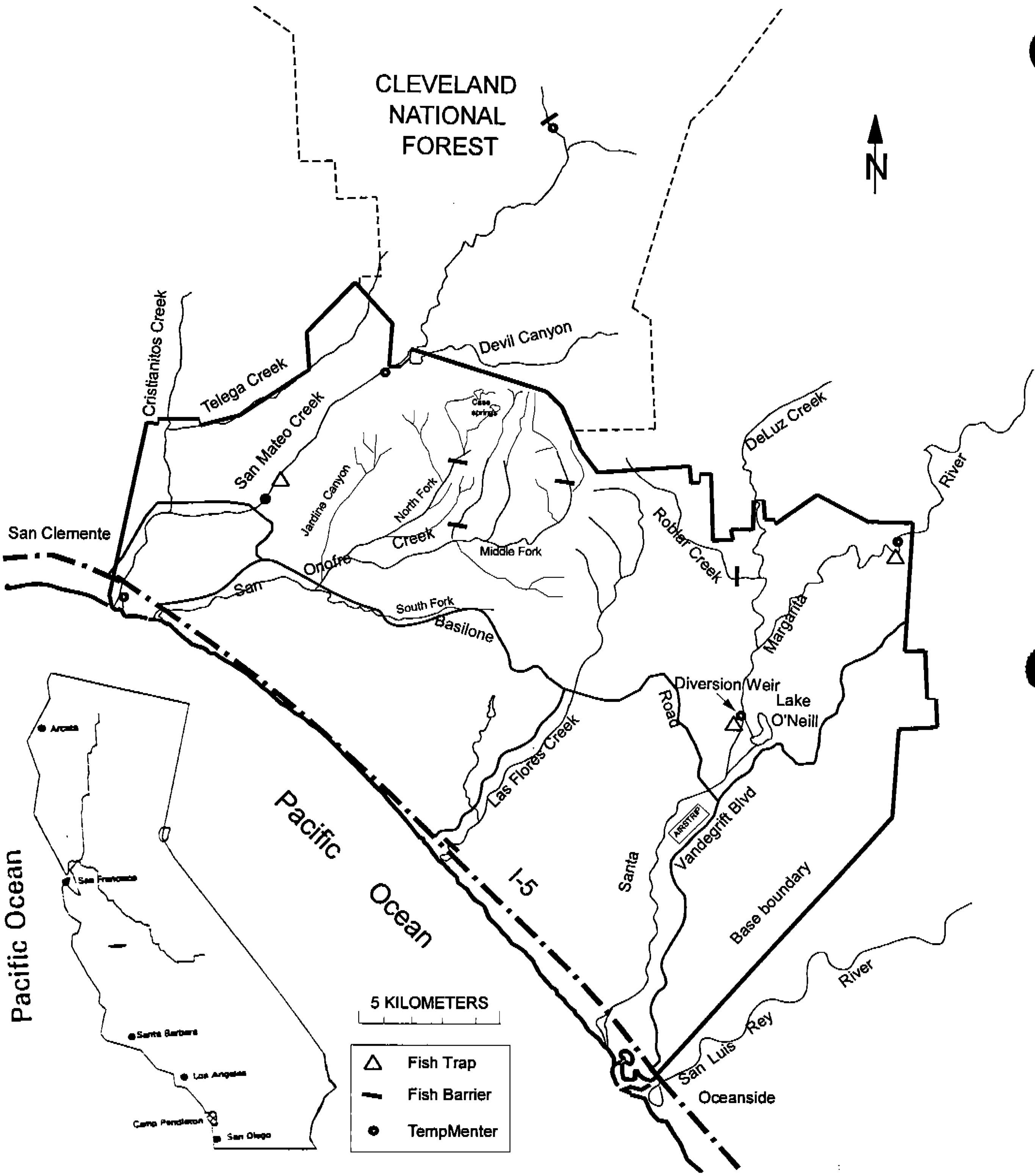


Figure 1. Base streams and major roads, TempMentor locations, trap sites, and barriers to steelhead.

METHODS

Literature Review:

A comprehensive literature search for records of salmonids was conducted for the following streams; SMR, SMC, SOC, Las Flores, De Luz, Cristianitios, Talega, Pilgrim, Sandia, Rainbow, Murrieta, and Temecula creeks. Phone interviews, letters, and library database searches for pertinent journal articles were conducted. Phone conversations were documented and cited as personal communications (pers. comm.). A time-line was derived summarizing all literature reviewed and where possible, included the location, year, number and age of steelhead or rainbow trout for each of the major watersheds. A complete list of reference contacts and sources are included as Appendices A and B.

Stream Flows and Water Temperature:

Historical stream flow by month for periods of record from United States Geological Service (USGS) gauge station 11046300 (upper SMC near San Clemente), were provided by Camp Pendleton's Water Resources Office. Daily USGS stream flow data for gauge stations in the SMR, SMC, and San Luis Rey River were downloaded from USGS via the Internet.

Daily water temperature data in two hour increments was collected using Ryan TempMenters (Trademark name). Each TempMenter was enclosed in a weighted 15.2 x 61.0 cm steel or PVC housing and secured to a boulder, tree, or bridge abutment with 0.09 mm aircraft cable. Three TempMenters were placed in SMC on Base during the spring of 1995 and included a site in the estuary (upstream side of center railroad bridge abutment), middle SMC (shaded pool habitat 100 m upstream of the San Mateo road bridge) and upper SMC (riffle habitat approximately 50 m upstream of USGS gauge station near the eastern Base boundary with the CNF (Figure 1). Additional SMC water temperature data was provided by a CDFG TempMenter located above Fishermans Camp and below a barrier falls in CNF. SMR TempMenter sites included a pool directly downstream of the Lake O'Neill diversion weir and in a run approximately 100 m downstream from the De Luz Road Bridge near Fallbrook. Temperature data was downloaded approximately every six months with a laptop computer.

Habitat Inventory and Fish Surveys:

Survey crews included personnel from the USFWS, CDFG, California Conservation Corps (CCC's) and Americorps volunteers. CDFG involvement led to the subsequent use of the CDFG habitat typing format defined in the California Salmonid Stream Habitat Restoration Manual (Flosi and Reynolds 1994) (Appendix D). Habitat unit measurements and related physical characteristics where made within the wetted stream channel. Hip-Chains (a string driven gauge worn at the hip), fiberglass measuring tape and range finders were used to measure habitat unit lengths. Coleman range finder model 123X and 620 were used to measure distances less than 30 m and between 15-180 m, respectively. Average widths of the wetted perimeter were measured to the nearest whole unit and depths to the nearest tenth of a unit. Positions were located on 7.5 minute USGS maps (1:2400 scale).

A random stratified sampling method (Hopelain 1994) was used to expedite sampling. Each first occurrence of a given habitat type (n) was measured for length, mean width, mean depth, maximum depth, substrate composition and vegetative cover. These parameters were not measured again for the same habitat type until the n+x unit was tallied, with x representing a randomly generated number between 1 and 10. The targeted sampling rate was 20%. CDFG has since adopted a 10% sampling rate as standard procedure (Downie, CDFG, pers. comm. 1996).

Habitat typing was conducted on the SMR on May 3, and May 5, 1995. Soon after beginning it became evident that habitat on the SMR was homogenous. As a result, three 100 m sections from three reaches were taken, representing the first 24.5 km. Reach 1 began immediately upstream of the railroad bridge up to the Basilone Road Bridge. Reach 2 began from the Basilone Bridge to the confluence of De Luz Creek. Reach 3 began at the De Luz Creek confluence to km 24.5. Habitat above km 24.5 to the De Luz Road Bridge (Reach 4) was more heterogenous and the habitat was typed using CDFG protocol. De Luz Creek was habitat typed in five reaches on May 4 through May 8, 1995, and Roblar Creek, a tributary to De Luz Creek, was habitat typed in two reaches up to a barrier falls (1.4 km) on May 7, 1995, using CDFG protocol.

With the exception of the stream reach encompassed within Range 313, SMC was habitat typed in nine reaches from the estuary to km 32 (the barrier falls within the CNF), from May 1 to May 12, 1995. Range 313A access was restricted in 1995 and was habitat typed in March 1996. The mainstem SOC and South Fork SOC were habitat typed in April 1996. Habitat typing of San Onofre Canyon inside the Whiskey Impact Area was attempted in April, 1996. Due to time constraints, habitat typing within the Whiskey Impact Area was pared down to only include pool habitat. This enabled a larger proportion of the stream to be surveyed. The first pool and each additional nth pool encountered was measured for length, depth, and water temperature, with n a random number between 1 and 10. All uniquely deep pools not chosen randomly were also measured for length, depth, water temperature and dissolved oxygen (surface and bottom). Habitat typing surveys conducted in September 1996 and March 1997, included the Middle and North Fork of SOC below Case Springs; and Devil Canyon, and utilized the abbreviated (pool only) format.

Inriver direct observation, and snorkeling for fish were conducted simultaneously with habitat typing whenever possible. Electro-fishing surveys using a Smith-Root Model-12 backpack electro-shocker were conducted in the fall of 1996 and spring of 1997. Electro-fishing was effective only at depths less than 1 m, and thus two 1.8 x 1.0 m seines easily carried in backpacks to remote locations were also used. Walking staffs used to measure stream depths were inserted into panel seams to direct seines through the water. Electro-fishing surveys were conducted on the SMR below the diversion weir and the confluence of De Luz Creek; SMC directly above the estuary and in perennial pools upstream of the USGS gauge station; Devil Canyon; Mainstem SOC and North Fork SOC below Case Springs; and Pilgrim Creek from the Naval Weapons Boundary downstream to the horse stables. Habitats were typically 20-50 m long and less than 1 m deep. All fish collected were identified to species, measured and tallied, and non-native fish were removed from the stream. SMC was also snorkel surveyed in the spring of 1997, from Fishermans Camp downstream to the USGS gauge station near the boundary between the CNF and the Base.

A frame-net trap was used on SMC for two-week periods in May 1995, and April 1996. Traps were used to augment direct observation, electro-fishing, seining, and snorkel surveys for fish. The SMC trap was located approximately 8.0 km upstream of the estuary (Figure 1). A second frame-net trap was used for one week on the SMR in 1996, 50 m downstream of the Lake O'Neill diversion weir. Use of the SMR frame-net was discontinued after a week due to excessive sand accumulation. Each frame-net frame measured 3.0 x 1.5 m and was anchored perpendicular to the stream by rope and fence stakes. Each frame supported a 6.1 m tapered net (5 mm diameter mesh) that intersected and directed flow into a live box (0.9 x 0.6 x 0.3 m) secured at the terminal end of the net (Figure 2). Approximately 80-90% of the stream flow was diverted into the net and live box by a rock weir built upstream of the net opening. Stream inflow was buffered inside the live box by a V-shaped baffle creating an area of slower water for captured fish to rest. Rocks were placed in each live box to allow fish to hide and floating wood boards provided refuge for toads and frogs. A hinged wooden lid provided access through the top of the live box to remove contents. An inclined-plane trap was used in 1996 on the upper SMR near Fallbrook,

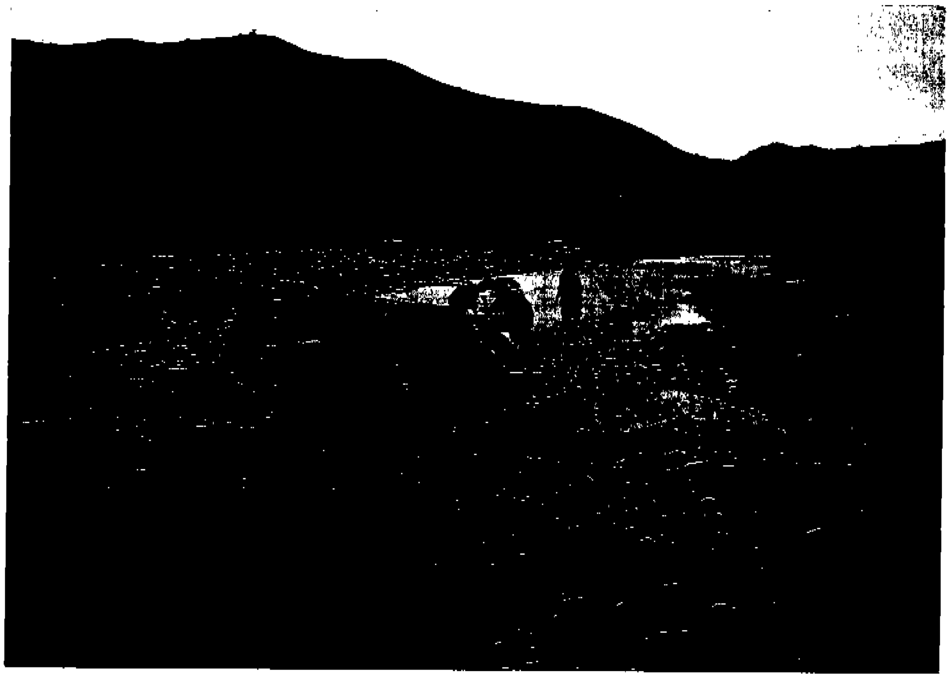


Figure 2. Frame-net trap in operation on San Mateo Creek, May 1995.

approximately 100 m downstream of the De Luz Road Bridge. This trap sampled 50-75% of the stream and used a live box identical to the frame-net traps. All traps fished 24 hours/day and were checked and cleaned each morning. Captured fish were identified to species, measured for fork length (mm) and released approximately 30 m downstream. Amphibians were identified to species and released. The USFWS did not operate a trap in 1997, however, CDFG operated a downstream migrant trap on the SMC between the estuary and the I-5 Bridge from March 6-28, 1997. We present their results in this report.

Two nylon beach seines (30 x 1.5 m and 9 x 1.8 m) with 5mm diameter mesh were used to seine for juvenile steelhead in the estuaries/lagoons. The two seines were used separately and in unison when the larger net was needed to form a barrier. All captured fish were netted and placed in a bucket or plastic garbage can filled with ambient water. Buckets and cans were aerated using a compressed air tank and air-stones or battery operated aerator and air-stones while fish were identified, measured and tallied. All fish were returned alive back into the same location.

Water Quality and Macroinvertbrates:

Water quality measurements were taken in 1996, in lagoons and inriver locations on the SMR, SMC, SOC, and the Case Springs area. In the spring of 1997, water quality sampling occurred both on and off Base, and additional water quality parameters measured included total dissolved solids (TDS), conductivity, NO_3 and NH_4. A Hach Model 44600 water quality kit, Hach Model 43800 pH meter, YSI Model 51B dissolved oxygen and water temperature meter and a YSI Model 33 S-C-T salinity meter were used. Measurements were taken during daylight hours at the waters surface and bottom, approximately one meter from shore.

Eight water quality sites were selected on the SMR with aquatic macroinvertebrates collected at six sites. Three sites corresponded with previous aquatic insects sampling (Hunsaker 1992) and seven were previously sampled for water quality (Cadmus 1992). Water quality and macroinvertebrate sampling on SMC and SOC were conducted below wastewater facility discharge points and at upstream locations on and off Base. Aquatic macroinvertebrate sampling occurred from mid to late March, 1997 to identify food items availability for both adult and juvenile steelhead.

Macroinvertebrate sampling procedures followed California adaptations of the National rapid bioassessment protocol (Plifkin et al 1989). Sampling consisted of agitating substrate for two minutes at the bottom, middle and top of riffle habitat units respectively, using a 500μ kick-net. Collected insects were transferred into pre-labeled jars containing 95% ethanol. Kerosene was added to expedite the death of large beetles. All samples were transferred to the Arcata lab to be sorted, identified to family, and tallied. Published keys used to identify insects included Merrit and Cummins (1988) and Usinger (1956). Individual insect families were placed into labeled vials containing 70% isopropyl alcohol for permanent storage.

Photographs of barriers, large pools and trap locations were taken using a Minolta Weathermatic 35/50 mm camera, and located on a USGS map. Special use permits were obtained from Camp Pendleton Environmental Security and California State Parks. Escorts through impact areas and firing ranges were provided by Explosive Ordinance Disposal (EOD) personnel.

RESULTS

Life History and Habitat Requirements:

Nomenclature/Taxonomy/Range:

Scientific name . . . . *Oncorhynchus mykiss*
Former scientific name . . . . *Salmo gairdneri* Richardson

Class . . . . Osteichthyes
Order . . . . Salmoniformes
Family . . . . Salmonidae

Historical range: At sea, from northern Baja California to the Bering Sea and Japan (Fry 1973; Barnhart 1986).

Populations may be anadromous, resident, or a mixture where the two forms presumably interbreed. Although they comprise the same subspecies, the different forms have unique common names: the anadromous form is called steelhead; the resident form is simply called rainbow trout. Both forms may exist in the same stream system, and in some instances may be physically discrete from one another due to an impassable barrier to upstream migration (Titus 1994).

Historical data depicting life history for southern steelhead in San Diego County is poor. Natural trout in southern California are not distinct enough to separate from other coastal rainbow trout, and there is no difference genetically between steelhead and coastal rainbow (Nielsen pers. comm. 1996). The timing for life history stages (i.e. adult migration and juvenile emigration), were ascribed to Base streams based on the timing of life history stages of viable steelhead runs on Malibu Creek and the Santa Clara River, and CDFG stream surveys (Table 1).

In streams south of San Francisco Bay, all steelhead are assumed to be winter run fish (Titus 1994) and adult steelhead enter freshwater after winter storms breach sand bars allowing open access to the river. Emigration in Malibu Creek occurs December through April (Table 1). Peak spawning activity occurs mid-February to mid-March, in the upper mainstream or tributaries having suitable spawning gravels and cool well oxygenated water (CDFG 1996a). Redd location commonly occurs at the top of a riffle or downstream edge of a pool where current velocity increases (Barnhart 1990). A female digs a redd (gravel nest) approximately 1.2 x 3.0 m, using 0.64 to 13.0 cm gravel. Female steelhead can lay between 500 and 3,100 eggs (USFWS 1984), and depending on water temperatures in the gravel, hatching occurs in approximately 30 days. Alevins emerge from gravel four to

Table 1. Life history periodicity of southern California steelhead.

LIFE STAGE	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Adult migration								XXXX				
Spawning								XXXX				
Incubation / Emergence [1]												
Juvenile Rearing												
Juvenile Emigration										XXXXX		

XXXX Indicates Peak Activity

[1] Rearing Depicted for 0+, 1+ and 2+ Fish

SOURCES:

NMFS 1994. Steelhead life history on Malibu Creek

(Shawn Chase, pers. comm.1997) Steelhead adult migration and juvenile emigration on the Santa Clara River, 1994-1996.

CDFG 1932-1952. San Mateo Creek Field surveys (1946, 1947, 1950).

six weeks after hatching. Alevin/fry move into shallow protected stream margins and begin to establish and defend feeding locations (Shapolav and Taft 1954). Juveniles move progressively into riffles then runs and pools as size increases (Barnhart 1986). A physiological and morphological change, enabling juveniles to emigrate from a freshwater to the marine environment is referred to as smolting. Indications of smolting are silvery coloration, faded parr marks and loose scales. Smoltification is primarily size dependant and related to increases in the photoperiod and water temperatures.

Juvenile steelhead at the southern end of their range grow more rapidly then their more northern counterparts, and emigrate after one to two years in freshwater (Moore 1980). This trend is primarily due to longer growing seasons, higher water temperatures and higher productivity in southern streams. In Malibu Creek, sixty percent of the juvenile steelhead smolts were one year old (yearlings) (Chase, pers. comm. 1997). Juvenile steelhead usually reach a length of 160 mm before they began to smolt (USFWS 1984). A larger smolt has a higher chance of surviving to reproduce. Smolts emigrate during periods of higher flow, generally December through May (Table 1). In the Santa Clara River, the majority of steelhead emigrated as yearlings in April and May (Chase, pers. comm. 1997).

Similar trends occurred for steelhead in Arroyo De la Cruz in San Luis Obispo County CA, where fry resided in the perennial stream reach for one growing season (Jones and Stokes Associates 1986). In response to increased winter/spring flows the following year, juvenile steelhead emigrate from the perennial reach to the lagoon. Some of these fish, which may have attained a critical length necessary to make changes for survival in salt water (Wagner et al. 1963), continue to the ocean if the bar is open. Some fish remain in the lagoon for one or more growing seasons before entering the ocean. In Arroyo De la Cruz, the majority of smolts sampled in October 1985 in the lagoon were between 150-160 mm, and would enter the ocean as age 2+. As a general rule, age 2+ smolts constituted a significant proportion of returning adults in Arroyo De la Cruz, since ocean survival is generally correlated with size and duration of freshwater residence of smolts (Wedemyer et al. 1980, cited in Jones and Stokes Associates 1986).

Estuaries generally are rich in food sources which promote faster growth rates then in a freshwater environment. In the ocean, steelhead feed on a variety of organisms, especially juvenile greenling, squids, and amphipods. In California the average length of steelhead after two years in the ocean is 59 cm (Withler 1966, cited in Barnhart 1990).

Historical Flows:

Santa Margarita River:

Flow on the SMR is currently recorded at 15 USGS stations within the basin, however, only three gauge stations have operated continuously since 1923, and one since 1930. The four stations are 1) Murrieta Creek at Temecula Creek, gauge 11043000 (430); 2) SMR at Temecula, gauge 11044000 (440); SMR near Fallbrook, gauge 11044500 (445); and 4) SMR near Yisodora, gauge 11046000 (460) (Figure 3). The period from 1923 to 1947 represents the extent of the historical record prior to the building of the first major dam in the upper SMR watershed. The Santa Margarita became a regulated river starting in 1948, with the completion of Vail Dam. Skinner Reservoir, formed by the damming of Tucalota Creek, became the second major regulatory entity in 1974.

Flows in the SMR were lowest from 1948 to 1979. Drought conditions persisted throughout most of this time resulting in very low flows (less than 300 acre-feet) for gauge stations (430), (440), (445) and zero surface flow at gauge (460) near Yisodora during the historical wet months of January through April (Figure 4). At Yisodora, no surface flow occurred in nine of ten years, from 1955 to 1965. In 24 of 30 years (1948 to 1978), flow at Yisodora would have been insufficient for adult steelhead to migrate upstream or juveniles to move downstream during the historical wet months of January through April (Table 2).

Table 2. Median monthly flow (acre-feet) for Santa Margarita River at Yisodora (1104600) by decade.

Decade	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1920's	396	235	209	540	19	0	0	0	0	0	0	58
1930's	1,954	5,248	3,552	1,152	302	99	30	24	28	87	95	686
1940's	1,637	2,702	2,807	2,100	371	28	0	0	0	0	0	1,633
1950's	0	0	0	0	0	0	0	0	0	0	0	0
1960's	0	0	0	0	0	0	0	0	0	0	0	0
1970's	0	9	175	13	0	0	0	0	0	0	0	0
1980's	1,851	1,942	2,280	1,069	582	148	0	0	0	69	867	1,437
1990's	985	7,162	11,236	2,380	1,323	501	246	134	91	110	148	681

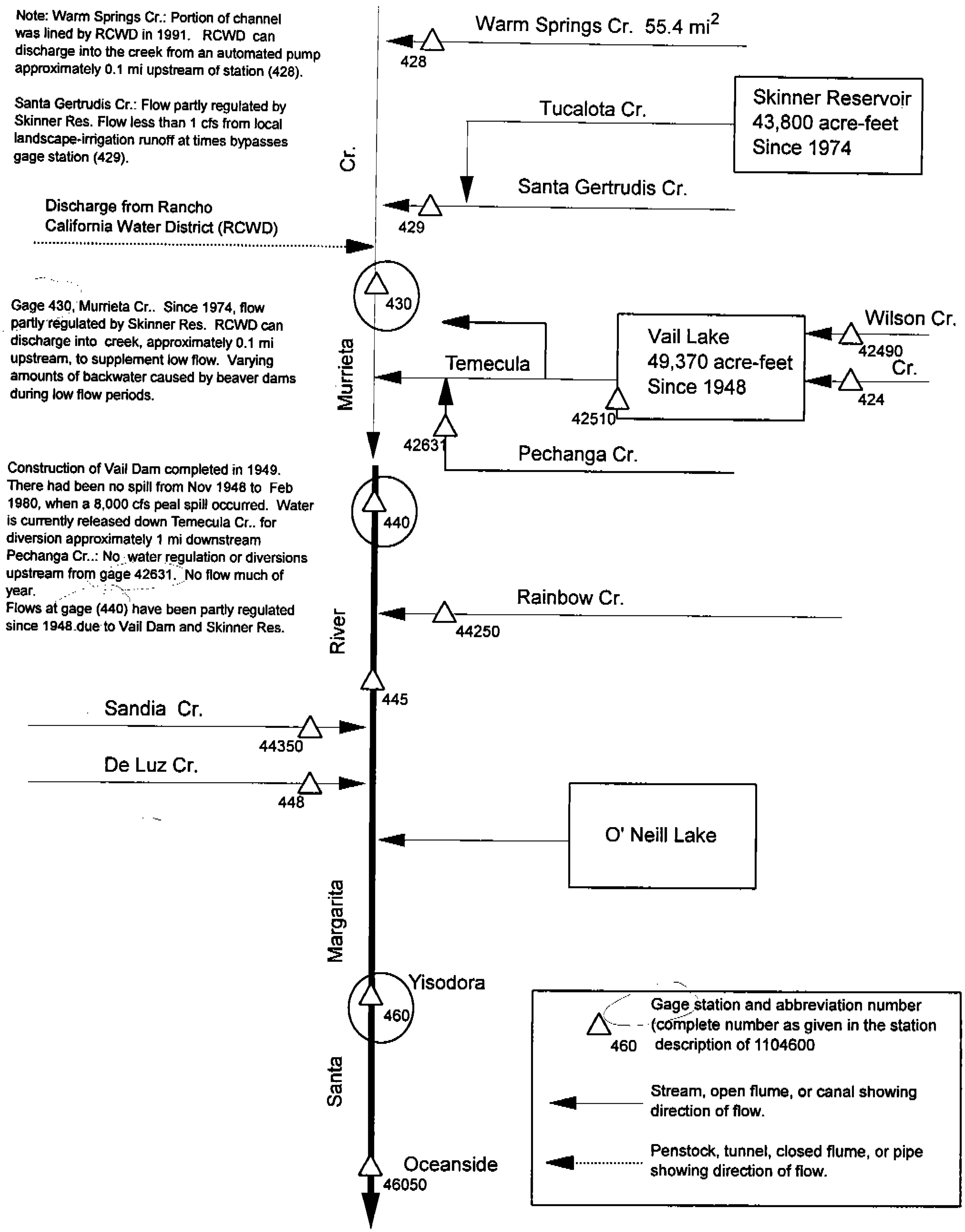


Figure 3. Schematic of the Santa Margarita Basin depicting USGS gauge stations, diversions, and water storage.

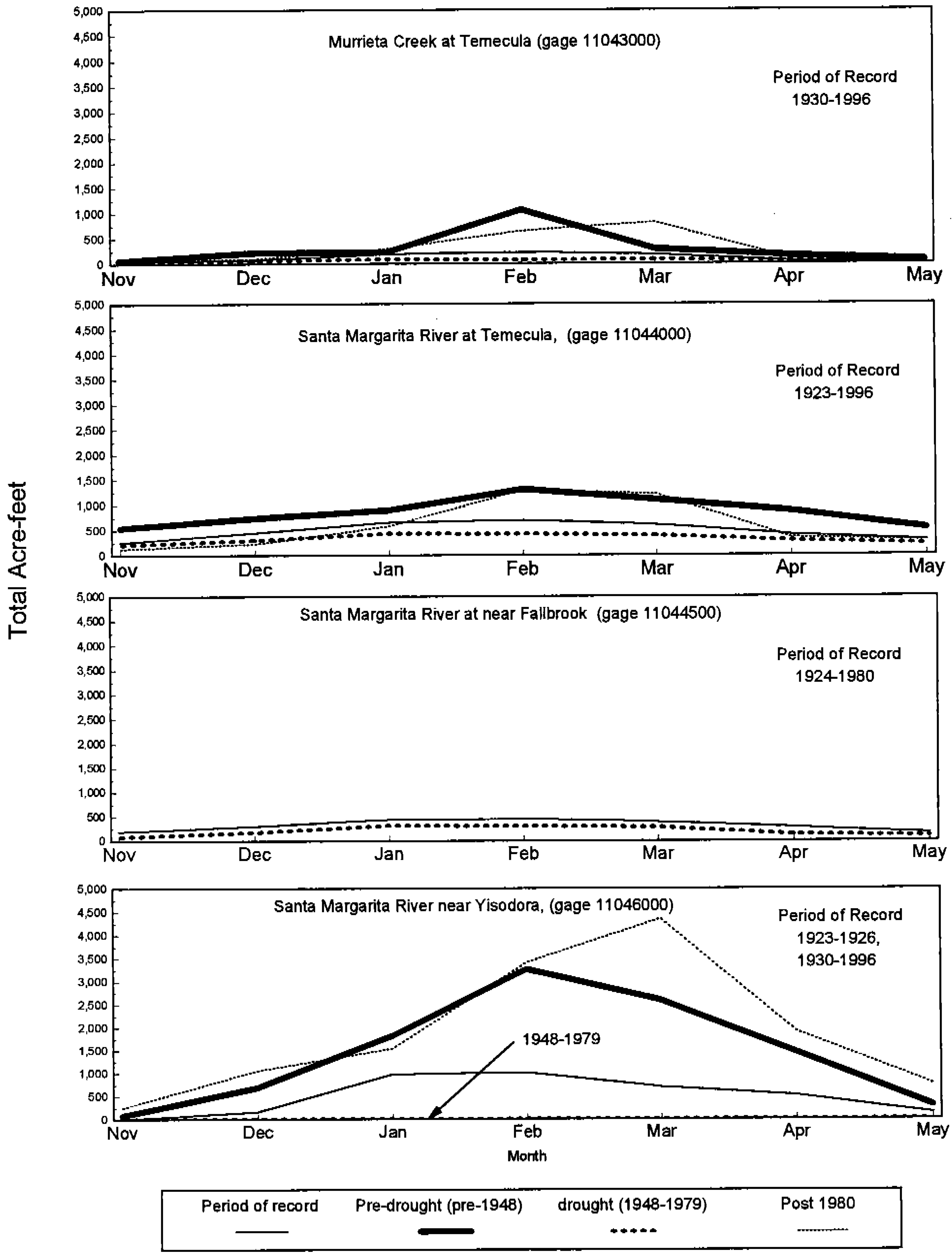


Figure 4. Historic median flow, November-April, for gauge stations 11043000 (430), 11044000 (440), and 11046000 (460).

The lowest gauge stations on the SMR (Yisodora (1104600)) and San Luis Rey River (Oceanside (11042000)) were compared during years of concurrent operation from 1948-1979 (Figure 5). Median flow at both gauges was zero during the months of November to May and this result helped conclude that the newly constructed Vail Dam was likely not solely responsible for zero flow conditions at Yisodora during the 1950's.

With the exception of the years 1987 to 1991, southern California has experienced a relatively wet period beginning in 1978. The years 1980 to 1996 for the SMR and the San Luis Rey rivers, November through May, depict median flows significantly higher than the historical median (Figure 5). Based on this, it is likely that flow conditions post 1980, have been sufficient to support southern steelhead in the SMR.

San Mateo Creek:

Historical flow records for SMC date back to 1947 at the USGS gauge station (11046370) or "lower" station at Camp San Onofre. A second gauge station, SMC at San Clemente (11046300), is located near the eastern Base boundary with the CNF and referred to as the "upper" station. The period of record for the upper station is 1952-1976 and 1989-1996. Like the SMR basin, drought conditions persisted in the late 1940's through the late 1970's, and thus the earliest historic flow records on SMC represent conditions of drought. The upper and lower gauge stations were compared for periods of concurrent operation 1953 to 1976. Peak median flows occurred in March and were less than 300 acre-feet at the upper gauge and about 50 acre-feet at the lower gauge. In comparison, median flow at Yisodora was zero acre-feet during the concurrent time period (Table 3).

The most recent flow records at SMC lower gauge station were recorded from 1983-1985, providing little information about conditions in the 1980's. Flow records from 1990 to present are available for the upper gauge station and are significantly higher then during the 1953-1976 time period. A comparison of post 1990 monthly median flows at the upper SMC gauge and the SMR gauge at Yisodora, show significantly more flow on the SMR (Table 3). The greater flow on the SMR maybe attributable to live-stream discharge from wastewater treatment facilities upstream of the Base.

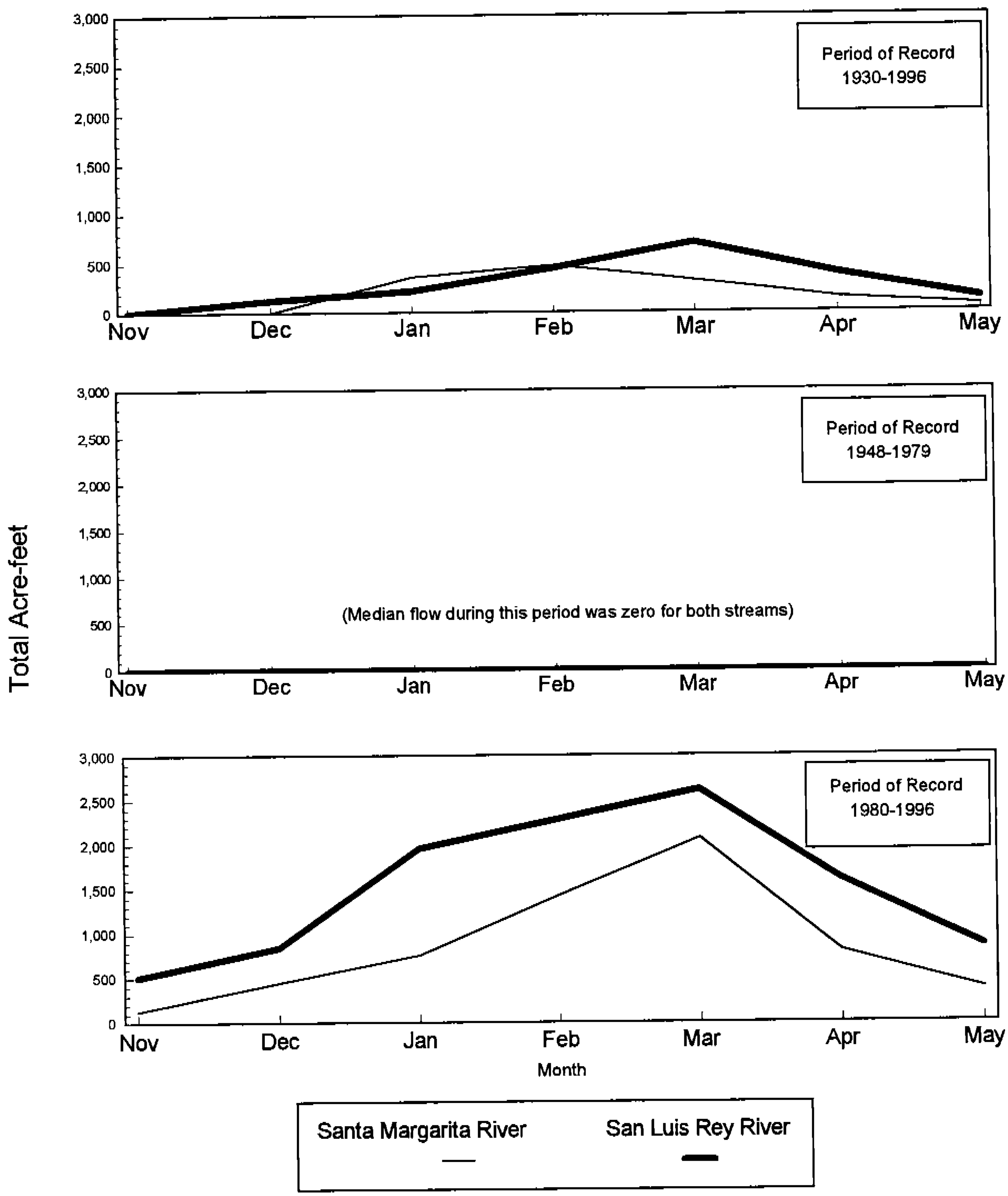


Figure 5. Historic median flow, November-May, for gauge stations 11046000 (Santa Margarita River at Yisodora) and 11042000 (San Luis Rey River at Oceanside) during years of concurrent operation.

Table 3. Median monthly flow (acre-feet) at the upper and lower San Mateo Creek gauges and the Yisodora gauge (Santa Margarita River) for concurrent periods of record.

	Upper gauge		Lower gauge		Yisodora gauge (SMR)	
Month	1947-76	1953-76	1953-76	1990-96	1953-76	1990-96
Oct	0	0	0	0	0	110
Nov	0	2	0	0	0	148
Dec	14	68	0	4	0	681
Jan	199	151	12	36	0	985
Feb	230	1,590	30	47	0	7,162
Mar	284	3,916	31	47	0	11,236
Apr	163	298	7	11	0	2,380
May	63	181	0	3	0	1,323
Jun	7	21	0	0	0	501
Jul	0	65	0	0	0	246
Aug	0	31	0	0	0	134
Sept	0	19	0	0	0	91

San Onofre Creek:

Historical flow on SOC was similar to SMR and SMC. A comparison of the two gauges on SOC (11046200 and 11046250) showed that median surface flow was zero for the twenty-one years (1946-1967) that flow was recorded. After 1967, flow data was only recorded for nine months in 1989 and was zero. Between the two gauges, surface flow decreased, likely becoming subsurface due to the sandy soils and groundwater pumping.

Documentation of Historic Runs:

Southern California:

Steelhead run abundance for southern California streams (pre-1960's) has been estimated at 20,000-30,000 for the Santa Ynez River, 2,000-3,000 for the Ventura River, 7,000-9,000 for the Santa Clara River, and 1,000 for Malibu Creek (NMFS 1995). No estimates were found for any streams south of Malibu Creek. In 1995, CDFG estimated the abundance of southern steelhead south of point Conception at several hundred fish (CDFG 1995).

Some of the earliest recorded notes on the fishes of the Pacific Coast list steelhead, *Salmo irideus*, as occurring from the San Luis Rey River northward (Jordan 1881 in CDFG 1931, Goode 1903, Jordan and Evermann 1923). *Salmo irideus* referred to resident, nonanadromous rainbow trout (Behnke 1992). Carl Eigenmann in 1892 describes *Salmo irideus* as being abundant in the streams rising in Smith Mountain and emptying into the San Luis Rey River. Smith Mountain was found to be synonymous with present day Palomar Mountain (Hubbs 1973a). Miss Rosa Smith's 1880 list of the fishes of San Diego County describe a brook trout, *Salmo irridea*, as being found near Pala on Smith Mountain (San Diego Union 1880).

Research fishery biologist, Orville Ball, interviewed an elder of the Pauma tribe who spoke of annual runs and ceremonies associated with large fish, presumably steelhead, on the San Luis Rey River (Ball pers. comm. 1996). San Diego anthropologist, Dr. Florence Shipek, has also testified before the Indian Claims Commission and the San Diego Regional Water Quality Control Board (SDRWQCB) that the San Luis Rey River did support steelhead runs prior to the construction of Henshaw Dam (1924) and that Native Americans caught steelhead by various means including nets, weirs, and hook and line (Shipek pers. comm. 1997).

A search of the San Diego Historical Society (SDHS) records provided the following reference to trout and salmon in San Diego County. Ruth Held, of the San Diego Historical Society's oral history program, interviewed Mauricio "Sonny" Magante, the leader of the Pauma Valley band of Native Americans on April 25, 1996. Mr. Magante who lived on Palomar Mountain, recalled his ancestors told him salmon used to run up the San Luis Rey River. In the interview, Mr. Magante described how, as a boy, he and friends would catch trout by hand from pools only two to three feet deep in Pauma Creek off Palomar Mountain (SDHS 1996).

A search of the California Academy of Science (CAS) and University of California (Berkeley) fish collection in San Francisco turned up very little. Although most of the early fish records for California were stored here, many were destroyed by the 1906 earthquake and succeeding fire. Existing records are mostly from northern California and Mexico. Only one record of *Salmo gairdneri irideus* (CAS #81111) was found from a San Luis Rey River, no date was given, nor was it clear whether this river was in California or Mexico (CAS 1996). One record of *Salmo gairdneri gairdneri* (CAS #81108) was found from Los Angeles Harbor in April of 1938 (CAS 1996). There were also several jars of *Salmo gairdneri nelsoni,* ranging in size from fry to 300 mm adults (CAS #38-11-1-D) collected by Needham in 1938 from the Rio Santo Domingo in Mexico (CAS 1996).

An account from Dr. Carl Hubbs's early fishery investigations was found in the Scripts Institute of Oceanography Library archives. In 1947, Dr. Hubbs along with Dr. Brody and Carl Johnson found steelhead in the San Luis Rey River up to the Mission, approximately 6.4 km upstream from the mouth (Hubbs 1973b; SDRWQCB 1997). A search of the Scripps Institute of Oceanography fish collection produced 24 records under *Salmo gairdneri* of which only one was from San Diego County and that one was found washed up on Ocean Beach in 1980 (Appendix C). The CDFG, Natural Diversity Database was queried for all records on steelhead in southern California, no steelhead were located. The Humboldt State University Library, one of two repositories in California for data collected by NMFS as a precursor to Federal listing of California steelhead populations was searched, but it did not contain new information.

There are historical accounts of steelhead in San Juan Creek (Orange County), approximately 12 km north of San Mateo Creek. In the report to the Bureau of Fish Conservation, CDFG wardens Mayfield and E.D. Beeman described a survey of San Juan Creek conducted in February, 1940. In a 1 km section of stream, approximately 24 km upstream of the mouth, they found three pair of spawning steelhead (CDFG 1940).

In a discussion with Paul Barret (USFWS, Carlsbad Field Office), biologist Fred Roberts also of the Carlsbad Field Office, recalled that as a young boy he captured juvenile steelhead in March 1968, near the mouth of San Juan Creek. Mr. Roberts kept several of these fish alive in an aquarium for a number of months. After 1974, Mr. Roberts conducted surveys on San Juan Creek and steelhead were not found (Roberts, pers comm. 1997).

<u>Santa Margarita River</u>:

Records pertaining to the historical presence of steelhead on the SMR are not well documented in print and the earliest accounts are largely anecdotal dating back only to 1930's (Table 4). One of the earliest accounts was from a local CDFG warden, E. H. Glidden, who was reported to have rescued adult steelhead weighing up to 5.4 kg trapped in pools during the 1930's or 1940's (Brown pers. comm. 1996). Robert Miller, while working for the University of Michigan Museum of Zoology (UMMZ), collected 27 steelhead fry in April 1939, at the confluence of De Luz Creek (Appendix B-#3).

Allen Brain, a long time resident of De Luz Creek caught in 1943, what he described as a salmon (Figure 6) in De Luz Creek, just upstream of the Fire Station (pers. comm. 1997). As a young boy in the 1940's, Mr. Brain, recalled catching salmon in De Luz Creek by hand and at one point in time chased six to seven fish around in a pool.

Table 4. Santa Margarita River summary of steelhead sightings from literature review.

Year	Month	Location	Numbers	Size/age	Source
late 1930's	May	De Luz Cr.	Unknown	10-12" trout caught	Dan Ryan & John Waters *19
1939	April	Mouth of De Luz Cr.	27	25-50mm fry	UMMZ #132968 * 3
1940's	Summer	Fallbrook	3	5.4 kg adults	CDFG warden (Brown pers. comm.)
1940's		Temecula	1	2.3 kg adult	Jessup pers. comm. 1996
1940's		Upper lagoon	Unknown	Juveniles	Swift 1994
1942	Sept	Fern Cr., trib to De Luz Cr.	many	Rainbow trout	Allen Brain, pers. comm. 1997
1943	Spring	De Luz Cr. Fire Station	6-7 "salmon"	74cm	Allen Brain, pers. comm. 1997
1944		De Luz Cr.	100-200	15cm juveniles	Allen Brain, pers. comm. 1997
1940-1945	Spring	De Luz Cr., Base to town of De Luz	Unknown	Trout to 30cm	Don Rivers, pers.comm. 1997
1950-60's	Spring	Confluence of Sandia Cr.	"many"	Hatchery plants	Don Rivers and Dick O'Brian, pers. comm. 1997
1967	March	Fallbrook	1	38cm adult	Brown pers. comm. 1996
1968		Fallbrook	'many"	Hatchery plants	Brown pers. comm. 1996
1973		Temecula Gorge, SDSU Reserve	0	May be present	CDFG biologist, Larry Botroff *in* Cooper et al. 1973
1973	Jul-Sept	Estuary, mouth of De Luz Cr., and Fallbrook area	0		USMC 1973
1974		3 sites along SMR	0		Swift et al. 1975
1980	Oct	Estuary	0		USEWS 1981
1981	Jan	Estuary	0		USFWS 1981
1983	Dec	Estuary	1	200mm juvenile	Swift letter to USMC 1983
1984		upper SMR	Present	Rainbow trout	USFWS 1984a
1983-84	Spring	Fallbrook, De Luz Rd.	Many	Hatchery plants	Greenwood pers. comm. 1996
1986	June 29	De Luz Rd. Bridge	Unknown	Juvenile trout	Bruce Campbell, SDWQCB 1997
1987	May	Confluence of Sandia Cr.	1	152mm trout	Bruce Campbell, SDFF 1996 *18
1986-89	Winter	Estuary	0		USFWS 1992
1990-91	May/Oct	Estuary	0		Holland 1992
1991	Jun/Aug	4 sites, entire river	0		Chadwick 1992
1991	Sept	8 sites, entire river	0		Hunsaker 1992
1993	Oct/Nov	Estuary	0		Swift 1994
1995	June	Temecula/De Luz Cr.	0		CDFG 1995 stream surveys
1995 - 1997	March April May/Sept	Entire Base, De Luz Cr., Roblar Cr., Rainbow Cr., Sandia Cr.	0		USFWS, this report

*Appendix B

Figure 6. A youthful Alan Brain with salmonids he caught in 1944 and 1945 from De Luz Creek. (Estimated length 74 cm, from photograph).

Mr. Brain also recalled catching a steelhead weighing 2.3 kg, further upstream, above the Fire Station and below the ranch he stayed at near the Riverside County line. Mr. Brain recalled catching rainbow trout (20-30 cm long) in De Luz Creek 3.2 km's above the county line. He also tried catching salmon in the pools on Cottonwood Creek (a tributary to De Luz Creek above the town of De Luz), but was unsuccessful because the pools were too deep. Mr. Brain stated that during his youth large pools on De Luz Creek were common, not filled with sand as they are today. Mr. Brain also described a 68 cm long lamprey *Lampetra* sp., migrating up De Luz Creek in the mid 1930's to early 1940's.

In September of 1942, Mr. Brain's family moved to the Blue Bird Ranch on Fern Creek (a tributary to De Luz Creek). Mr. Brain recalled, "many rainbow trout in Fern Creek at that time". CDFG began stocking trout in Fern Creek in 1941 and it is possible that these fish may have been hatchery fish. CDFG also stocked De Luz Creek from 1941 to 1945 at a location approximately 5.6 km upstream of the De Luz Post Office (Table 5).

Table 5. Stocking record for rainbow trout into the Santa Margarita River.

Date	Month	Location	Number	Hatchery/source
1941	Jan	Fern Cr., trib to De Luz Cr.	3,000	CDFG, Arrowhead Lake *6
1942	Feb	De Luz Cr. above town of De Luz	4,000	CDFG, Fillmore (Hot Cr.) *6
1961	Apr-Jun	Willow Glen Rd. above Fallbrook	5,000	CDFG, Mojave River *8
1962	Feb-Nov	"	12,045	"
1963	Feb-Dec	"	19,150	"
1964	Jan-Dec	"	26,180	"
1965	Jan-Nov	"	29,630	"
1966	Jan-Dec	"	26,680	"
1967	Jan-Dec	"	26,020	"
1968	Jan-Nov	"	24,590	"
1969	Jan-Dec	"	13,160	"
1970	Jan-Apr	"	7,880	"
1971	Feb-May	"	18,540	"
1973	Apr-May	"	4,990	"
1974	Mar-Apr	"	1,950	CDFG, Fillmore *8
1975	Apr-May	"	1,500	CDFG, Mojave River *8
1976	Feb-Mar	"	3,750	"
1978	May	"	2,600	"
1979	Apr	"	2,200	"
1982	July	"	740	"
1983	Apr-May	De Luz Rd. bridge by Fallbrook	Unknown	Greenwood, per. comm. 1996
1984	Apr-May	De Luz Rd. bridge by Fallbrook	Unknown	CDFG, *in* Higgins 1991

*Appendix B

In 1944, Mr. Brain observed what he thought were juvenile "salmon" in pools along De Luz Creek. He described 100-200 fish in each pool that were 15-18 cm long with spots. By 1951, the creeks became dry due to drought and he did not see fish again. Several large forest fires contributed ash and erosion to Fern Creek, destroying trout habitat. Mr. Brain attributed the large amounts of sand and silts in De Luz Creek to the development of avocado orchards around De Luz by the Vail Ranch. He also stated that in 1978-79, 142 cm of rain fell in a short period of time causing erosion of the recently planted hillsides. The result of which was the filling in of De Luz Creek with up to 3 m of sand in places.

In March 1947, Willis A. Evans, Sr., a CDFG fisheries biologist, evaluated the stream condition for continued trout plants. He described the stream as 1.8 m wide, 10 to 15 cm deep, with 3 to 5 cfs (field notes from De Luz Creek, CDFG 1932-1952). He mentioned that for the last two years quite a few fisherman have had just fair luck in the sections stocked. In May 1947, Mr. Evans described the stream as intermittent, 50 cm wide and consisting of small sanded up pools that were unsuitable for trout except during wet years. Mr. Evans thought that the lack of trout might be due to a large fire two years earlier. Although, he had observed a few trout in Fern Creek. Mr. Evans also mentioned that steelhead entered De Luz Creek in wet years and that Arroyo chub *Gila orcutti*, and threespine stickleback *Gasterosteus aculatus* were present.

In early November 1956, Base personnel treated the SMR and its tributaries with rotenone from the Fallbrook boundary downstream to the brackish water in the lower river (USFWS 1993). This treatment occurred at the same time Lake O'Neill was rotenoned to control non-game fish, mainly carp *Cyprinus carpio*. There was no mention of trout having been killed in the treated areas. A citation which was not included in Table 2 because it was not confirmed, stated steelhead trout were observed near the mouth of the SMR as late as 1958 (CCZCC 1975).

Rainbow trout were first planted into the SMR in 1941 and 1942 from the Arrowhead Lake Hatchery and Fillmore Hatchery respectively (Table 5). Rainbow trout tolerant of high water temperatures were imported to California from Mexico in the late 1950's (Needham and Gard 1959). Some of these Mexican trout were placed in the Fillmore State Fish Hatchery and later stocked into both the SMR and SMC. CDFG again stocked hatchery rainbow trout in the SMR from 1961 to 1984. For the twenty year period, an average of 11,600 fish were planted each year. Hatchery plants were deposited into the river east of Fallbrook, at Willow Glen Road and the De Luz Road Bridge. According to Dick Uplinger, hatchery manager at Mojave River, hatchery plants were either stocked in the spring (Mt. Whitney strain), or in the fall (Hot Creek strain) at 9-11/kg (pers. comm. 1996). Using standard length-weight tables (Piper et.al. 1989), these fish would have been 200 to 220 mm long. The literature does not indicate that these fish provided anything other than a put and take fishery or that hatchery plants survived to reproduce naturally.

Local fly fisherman, Jim Brown, described a 380 mm steelhead he caught in the late spring of 1967. The fish was fresh, bright silver with no spots (pers. comm. 1996). He also caught smaller rainbow trout from hatchery plants that were half the size of the steelhead. He fished an area above a riffle containing fist sized cobble near Fallbrook. The year 1967, was one of the few years during the 60's having surface flow at the Yisodora gauge station from February to July (Appendix E-2).

In 1980 and 1981, the USFWS surveyed the SMR estuary for fish species using gill nets, beach seines and dip nets. The estuary was open and gill nets were set at two locations overnight, but no salmonids were captured (USFWS 1981). The USFWS again surveyed the fish species in the estuary during the spring, summer, and winter for each of the years 1986 to 1989, with no salmonids being observed (USFWS 1992). In twelve of the last sixteen years, the SMR estuary has been seined with only one salmonid reported.

In 1983, Dr. Camm Swift, while looking for tidewater goby *Eucyclogobius newberryi*, seined what he thought was a juvenile steelhead in the estuary, but it jumped out of the net before he could positively identify it (Swift 1983). Allen Greenwood (San Diego fishing advocate) recalled catching hatchery planted rainbows above and below the De Luz Road Bridge in 1983 and 1984 (pers. comm. 1996). Hatchery stockings were discontinued in 1984, due to vandalism, trespassing, and a lack of angler access (SDRWQCB 1997).

Hunsaker (1992) set up eight monitoring sites along the SMR for the Eastern Municipal Water District. Fish sampling occurred at four sites above the Base and one site located just above the Lake O'Neill diversion weir. Surveys of these sites found green sunfish *Lepomis cynellus*, arroyo chub, tidewater goby, black bullhead *Ictalurus melas*, mosquito fish *Gambusia affinis*, redeye bass *Micropterus coosae* and carp, with green sunfish being the most abundant (Hunsaker 1992). Hunsaker found green sunfish and annual floods the two most degrading factors for the river. Green sunfish tend to out compete all other fish species. The presence of beaver ponds was also mentioned as contributing to poor water quality conditions and increasing the green sunfish population in the SMR. Beaver were introduced in 1959 by CDFG (Kramer, pers. comm. 1997) and were present in 1991, from

Temecula to the Base. Beaver have been periodically trapped and removed, and floods such as those which occurred in 1993 and 1995, wash out their dams (Buck, pers. comm. 1996).

Chadwick et al. (1992) also set up study sites on the SMR and its tributaries in 1991 to provide biological data for the Santa Ana Watershed Project Authority. Three of their sites were within the boundaries of the Base. Fish species found on Base included arroyo chub, black bullhead, fathead minnow *Pimephales promelas*, green sunfish, mosquito fish, and carp, with arroyo chub being the most dominant. Fathead minnow were the most abundant species found at the site near Lake O'Neill. No rainbow trout were found during this study in the SMR or its tributaries; Rainbow, Murrieta, Temecula and Pechanga creeks (Chadwick et al. 1992).

The upper watershed within the Santa Margarita Ecological Reserve may have been a steelhead spawning area (Cooper et al. 1973). Dr. Paul Zedler, of the San Diego State Biology Department, which manages a field station on the reserve, said that rainbow trout have not been found in the area but may have been present historically (pers. comm. 1996). Larry Botroff, former CDFG biologist, mentioned a historical spawning area for steelhead above the old I-15 Bridge, where Murrieta Creek joins the SMR (cited in Cooper et al. 1973). But the California Transportation Department has since paved over the springs that supplied this area with cold water (Greenwood pers. comm. 1996). In June of 1995, CDFG surveyed the upper SMR watershed including De Luz, Temecula and Murrieta creeks for native fish species and found no trout (CDFG 1995).

In addition to hatchery rainbow trout, other fish were intentionally introduced into the SMR which may have affected the steelhead population (Table 6). A survey of the upper watershed found green sunfish, arroyo chub, brown bullhead *Ictalurus nebulosus*, golden shiner *Notemigonus crysoleucas*, and a few redeye bass (Cooper et al. 1973).

According to a 1964 CDFG press release, redeye bass would not harm the rainbow trout population, being introduced well above the trout planting site. However, these fish were free to move downstream or to be carried by higher winter flows leading to potentially disastrous impacts. Redeye bass ranging from 25 to 205 mm standard length were found to be abundant in the upper watershed (Swift 1975) and juveniles were collected just above the Base in 1991, indicating a self sustaining population (Hunsaker 1992).

Table 6. Additional fish species stocked into the Santa Margarita River.

Date		Location	Number and Species		Origin/source	
1932		Fern Cr. trib to De Luz Cr.	4,000	Brown trout	CDFG, Arrowhead Hatchery	*11
1962	Jul	Temecula Gorge, below I-15	3,000	Brown trout	CDFG, Mt. Whitney Hatchery	*12
1964	May	Temecula Gorge, below I-15	50	Redeye bass	CDFG, Georgia	*13
1968	Jul	slough near estuary, USMCB	500 fry	Largemouth bass	Federal fisheries, Montana	*14
1973	Dec	river above estuary, USMCB	test	Striped bass	CDFG, Bud Young	*15
1974	Jan	slough near estuary, USMCB	220	Coho salmon	CDFG, Oregon	*16
1975	Jan	Stuart Mesa bridge, USMCB	30,900	Coho salmon	CDFG, San Joaquin	*17

* Appendix B

San Mateo Creek:

Historically, SMC may have been one of the most important steelhead spawning streams on the south coast. In the early 1900's, according to newspaper articles and interviews with local residents, trout in San Mateo Creek were abundant and of a larger size then in any of the Orange County streams. Fishermen would hike 16 km into the upper reaches of the stream for the best fishing. Fish in the lower reaches were often described as being full of worms and the fish upstream were thought to be in better condition. SMC adult steelhead ranged from 30-76 cm in length and 3-7 kg in weight (Table 7). For comparison, Malibu Creek, the closest known steelhead population, adults ranged from 61-81 cm in length and weighed from 1-3 kg (NMFS 1994). A little farther north in the Ventura River, adults ranging in length from 35-66 cm were observed milling in the estuary apparently waiting to ascend the river (EPA 1991).

Newspaper accounts from 1916 reported that January, February, and March were the months that steelhead adults migrated upstream, "...thousands go to the headwaters every year and schools of 10 inch fish were observed traveling upstream in San Juan River, Trabuco River and San Mateo Creek" (Appendix B, #1 and #2). The smaller schools of 25 cm fish were probably "half-pounders" or what the locals called "sundowners" (Swift 1993, and Henke pers. comm. 1996). Steelhead returning to the river after less then one year in the ocean are commonly referred to as "half-pounders", a unique life history trait considered limited to northern California and southern Oregon rivers (Kesner 1972). Also the same newspaper articles reported, "...several big fellows are caught each year on the sand bars at the mouths of the creeks. Last year a number of big fellows were caught in the slough at the mouth of the San Mateo" (Appendix B, #1 and #2).

Table 7. San Mateo Creek summary of steelhead sightings from the literature review.

Year	Month	Location	Abundance	Size/age	Source
1900		CNF & Devil Canyon	"some"	38-40 cm adults	Freeman Sr. (Woelfel 1991)
1916	March	upper & lower creek	"plentiful"	Juveniles & adults	Newspapers *1, 2
1928	Summer	landlocked pools in CNF	"several"	30-33 cm adults	Freeman (Woelfel 1991)
1938	Summer	Devil Canyon	"some"	76 cm adults	Freeman (Woelfel 1991)
1930's	April-May	CNF to Base boundary	"3 to 5 a year"	35-40 cm adults	Clemmens, pers. comm. 1997
1930's	Winter	lower creek, riffle areas	"a few"	3-7 kg adults	Havens (Woelfel 1991)
1938		lagoon	"many"	23 cm trout	John Waters * 19
1939	April/May	estuary to I-5 bridge	191	2.5-7.6 cm juveniles	UMMZ 132967 & 132964 * 3
1939		pools above estuary	"many"	76 cm adults	Photo from Dan Ryan * 19
1939	August 7	lower creek pools	9,800	7.6 cm juveniles	CDFG stocking records * 4
1940	February	CNF, ~19 km above estuary	3 spawning	Adults and a few 15cm juv.	CDFG stream survey * 22
		On Base ~2.4 km above estuary	9 females	60-68 cm adults	
1942	May/June	Fishermans Camp to Base	"25+ limits"	25-35 cm trout	John Waters * 19
1946	June 13	lower creek pool	33	Fingerlings to 30 cm	Willard Jarvis * 5
1926-46		"Far up the San Mateo"	"consistent runs"	up to 9 kg adults	E.H. Glidden in Hubbs 1946
1946	Sept 5	lower creek	0	Adults if bar open	CDFG stream survey * 6
1947	Jan. 17	headwaters in CNF	0		CDFG stream survey * 6
1949-50		trapped in gravel pit on Base	"2 per trip"	35-46 cm, " holdovers"	Kramer * 20
1950	Oct. 10	Bluewater Canyon to Base	"abundant"	7-35 cm all ages	CDFG stream survey * 6
1952	July 23	upper creek below the falls	1	17.8 cm rainbow trout	CDFG field notes (P. Douglas) * 6
1960	Spring	pools below Nickel Canyon	several	25-30 cm trout	D. Phifer, pers. comm. 1997
1968	July	upper watershed	0		USFS 1970
1980-84		upper creek pools in CNF		Trout observed	Ken Croker (Woelfel 1991)
1984		Fishermans Camp, CNF	"some"	Small trout caught	D. Phifer, pers. comm. 1997
1986	Winter	Leased farmland, lower creek	3	46-58 cm adults	T. Tanaka (Woelfel 1991)
1987	November	entire creek	0		Woelfel 1991
1988	May/Nov	entire creek	0		Woelfel 1991
1989	August	pool at upper USGS gauge stn.	1	25 cm trout	D. Boyer, pers. comm. 1995
1989	August	estuary	"many"	Fry observed	S. Stromberg, pers. comm. 1996
1989	August	Fishermans Camp, CNF	"some"	38 cm trout	S. Stromberg, pers. comm. 1996
1990	June	entire creek	0		Woelfel 1991, Higgins 1991
1990	September	estuary	0		Holland 1992
1991	May/Oct	estuary	0		Holland 1992
1993	March	lower creek	2	Adults	Sutherland, pers. comm. 1996
1993	Oct/Nov	all estuaries on Base	0		Swift 1994
1994	July 27-28	mouth & below falls, CNF	0		CDFG stream survey *21
1995	May	mouth to falls, CNF	0		USFWS this report
1995	June	Rd. crossing below falls, CNF	0		Giusti, pers. comm. 1996 * 9
1996	April	Base-wide	0		USFWS this report
1997	March	I-5 bridge	0		A. Vejar, pers. comm. 1996
1997	March	mouth to falls, CNF	0		USFWS this report

*Appendix B

Russell Freeman and his father reported catching adult steelhead in the 1920's and 1930's from isolated pools in the upper San Mateo and Devil Canyon (Woelfel 1991). A few adults in the 3-5 kg range were also reported caught by the Haven family in the late 1930's. These fish were caught in the shallow riffle areas of the lower creek.

Between the 1930's and late 1940's, Marion Clemmens a local fisherman, used to hike from Fishermans Camp to the Base boundary once a year fishing the pools along the way (Clemmens, pers. comm. 1997). He recalled catching rainbows 35 to 40 cm long on worms in pools 1.2 to 1.8 m deep. On one such trip he remembered walking up to a group of Marines throwing hand-grenades into a pool. They told him, they were camped up at Case Springs and were getting fish for a fish-fry that evening. The fish that the Marines caught were 20 to 25 cm trout. In the spring of 1949, following the disastrous 1948 Stuart Fire, Mr. Clemmens recalled the creek covered in ash after which he could not find any fish. In May and April of 1939, R.R. Miller, from the University of Michigan, took large samples of juvenile steelhead from the estuary of San Mateo Creek for the museum's zoological collection (UMMZ 1996). The sampled fish were young of the year ranging from 30 to 70 mm long, indicating that reproduction was occurring.

In August 1939, 9,800 steelhead fingerlings were rescued from isolated pools in the lower SMC and planted in the lagoon (CDFG 1932-1952). These fish were estimated to be 76 mm in length based on stocking records found in the survey files. The fact that these last two records occurred prior to the first hatchery stocking (Table 8), and that the fish were small in size indicates reproduction occurring. In February 1940, CDFG wardens Mayfield and E.D. Beeman surveyed Orange and Northern San Diego Counties streams to determine the extent of steelhead runs. In the report to the Bureau of Fish Conservation, Warden Beeman described a survey of San Mateo Creek (CDFG 1940).

> [Coming over from the San Juan Creek, Beeman and Mayfield traveled a fire truck trail off the Artega highway into the San Mateo Creek drainage]...approximately twelve miles from the ocean, after some difficulties getting through stretches of mud and slides. A three mile stretch of stream was carefully checked for steelhead in that area. Three pair of fish were found working one spawning bed, just above Mr. Ford's tin shack, which is the end of the road. I checked the stream a half mile above this spawning bed, but found no signs of spawning, in this area. A few 5 to 6 inch fish. [Warden Beeman surveyed downstream from the Ford Cabin while Warden Mayfield drove the truck. In the two and one-half miles covered before

dusk, no signs of spawning were found. Flow was described as thirty-five second feet of clear water with 54°F at five P.M. They then traveled downstream on the San Mateo Canyon Road.] About a mile and one-half from the mouth of the stream I counted and caught nine females which were all green, and all were measured at twenty-seven inches, except one, at twenty-four inches. A sample of scales was taken from the smaller fish. Due to the fact that the water was so warm, this fish was unable to stand that little handling. She was cut open, and had a large number of eggs in her, but they had not separated as yet. We had nothing to measure the eggs with, but I estimated that she had nearly one quart of eggs. [No food was found in the stomach. The flesh was described as a nice light, reddish color and very firm. Warden Beeman concluded his letter stating that steelhead can enter the San Mateo and San Juan Creeks only when a high tide occurs.]

Table 8. Trout stocking records for San Mateo Creek.

Year	Month	Location	Species	Number	Origin/source
1945	May	USMC corral at eastern Base boundary	Rainbow trout	2,000	CDFG, files * 6
1946	April	USMC corral at eastern Base boundary	Rainbow trout	900	CDFG, files * 6
1950	Unknown	CNF road to falls and Fishermans Camp	Brown trout	Unknown	CDFG, warden *20
1954	April	CNF below road to falls	Rainbow trout	650	Mojave Hatchery * 8
1955	Unknown	"	Rainbow trout	Unknown	"
1956	April	"	Rainbow trout	750	"
1957	Feb-May	"	Rainbow trout	2,200	"
1958	Mar-May	"	Rainbow trout	2,700	"
1959	March	"	Rainbow trout	500	"
1979	Unknown	CNF pools below Nickel Canyon	Brown trout	500	Phifer pers. comm.
1983	June	CNF below road to falls	Rainbow trout	600	Mojave Hatchery * 8
1983-85	June	CNF road to falls and Fishermans Camp	Brown trout	Unknown	Fillmore Hatchery * 23

*Appendix B

In 1942, the marines acquired Camp Pendleton. Fish rescues continued until 1946. In June 1946, Willard Jarvis CDFG senior fisheries biologist, accompanied the USMC horse patrols and observed 24 fingerlings and 9 larger trout (23-30 cm in length) in a man made pool 9 m x 3 m x 1 m (CDFG 1932-1952). Five pools like this had been created in the lower SMC by draglines. The local CDFG warden, E.H. Glidden, reported that steelhead up to 9.0 kg had consistently run far up SMC in the last 20 years (Hubbs 1946).

CDFG stocked approximately 3,000 hatchery rainbow trout during 1945-46 on Base. An additional 8,000 were planted above the Base in the CNF from 1954-83 (Table 8). In June of 1946, Marines rescued fingerling steelhead from pools drying up in the lower river. It may have been that these fish were from the 900 fingerlings CDFG stocked two months earlier approximately 3.2 km upstream. In July 1952, CDFG recommended discontinuing planting SMC on Base due to poor water conditions (CDFG 1932-1952).

Whether planted rainbow trout survived and became steelhead can only be speculated upon. A local game warden, Marty Maytorena, reported seeing the descendants of hatchery planted rainbows in Trabuco Creek just to the north of SMC at an elevation of 457 m (pers. comm. 1997). The ability of stocked rainbows to breed with the native steelhead population is possible since the origin of most hatchery rainbow stocks came from various mixtures of coastal steelhead (Behnke 1992). Steelhead in Waddell Creek have been observed spawning with resident stream trout (Shapovalov and Taft 1954).

A stream survey conducted by CDFG in October 1950, reported "steelhead abundant" for all age groups ranging from 7.6 to 35.0 cm for the area from the Base corral (located near the present day USGS gauge) upstream to Bluewater Canyon (CDFG 1932-1952). The creek was dry from the mouth up to the eastern Base boundary. Occasional bedrock pools provided summer habitat for juveniles until the coming of winter rains and continuous stream flow. Natural reproduction was apparently taking place based on observed young of the year.

In the early 1950's, CDFG warden Richard Kramer, reported "steelhead" abundant in the estuary and upstream canyon (Woelfel 1991). On his way up SMC, Mr. Kramer would stop to fish at a gravel mining pond just above Cristianitios Creek. He recalled catching at least two "steelhead" 35 cm long on spinners each time he stopped there (pers. comm. 1997). Mr. Kramer routinely walked down the Indian Potrero Trail to check fishermen and reported "always seeing at least four steelhead there". These steelhead were caught in early May (opening of trout season) and were usually adult males in their first spawning year. He described them as good eating and not wormy as had been reported in early 1900's newspaper accounts (Table 7). He also reported personally planting brown trout *Salmo trutta*, below the road crossing to the falls and at Fishermans Camp in the CNF (Table 8).

In the spring of 1960, Dave Phifer, a Marine who mapped the geology of the Base in the 1950's, reported catching rainbow trout from 25-30 cm long below Nickel Canyon and above the Clark Trail (pers. comm. 1997). Mr. Phifer also reported assisting in the stocking of 500 brown trout from CDFG in 1979 at the pools below the Indian Potrero Trail (Table 8). These 10 cm brown trout were backpacked down in plastic bags containing ice water. When Mr. Phifer returned to that location in 1983, he estimated 50 fish were still present. One brown trout he caught and ate measured 35-40 cm in length. Mr. Phifer returned again in 1987, and reported "all the browns from the original plant were gone, probably having been fished out".

In July 1968, the U.S. Forest Service (USFS) conducted a cursory survey of the upper SMC watershed and reported no fish observed. However, they did mention that steelhead and salmon had been observed migrating upstream as far as Fishermans Camp until 1959 (USFS 1970). This is the only reference to salmon being found in SMC from the literature review.

In 1979, Linda Ulmer and other CDFG personnel compiled information from previous stream surveys and interviewed biologists for a statewide stream inventory. This inventory was then incorporated into a report entitled, "Fish and Wildlife Plan for the 1980's". No actual stream surveys were conducted for this inventory (Ulmer pers. comm. 1997). The 1979 review of past surveys list rainbow trout as the most abundant fish occurring in SMC, Devil Canyon, SOC, and the San Luis Rey River (CDFG 1979). Authors such as Higgins 1991, Woelfel 1991, and Titus 1994 have cited this reference as indicating steelhead were present in 1979, when in fact the last actual survey conducted by CDFG was in 1952. No surveys were conducted on SMC by CDFG for the 42 years, 1952-1994, representing a significant data gap. After 1952, steelhead numbers begin a dramatic decline with just an occasional adult sighted in the lower river in the 1980's and 1990's.

In 1987, California State University Fullerton master's student Dave Woelfel, conducted an evaluation of the feasibility of restoring SMC for steelhead (Woelfel 1991). The objectives of Woelfel's thesis were to document the past and present conditions of SMC pertaining to the requirements of steelhead, describe the factors that have altered the creek, and develop conditions that would help restore it. Woelfel studied the physiography, climate, geology, and hydrogeology of the SMC drainage. He concluded that it would be possible to reintroduce steelhead if; (1) the banks in the lower river are stabilized, (2) groundwater pumping is halted, (3) green sunfish are removed, and (4) erosion is controlled.

Woelfel described SMC as flowing for only part of the year and going completely dry even back in the 1930's. He considered it possible for steelhead to reestablish themselves during wet years and exist in headwater tributaries like Devils Canyon (pers. comm. 1995).

Many of the interviews Woelfel conducted are cited in the literature review of this paper. During the three years, 1987-1989, that Woelfel surveyed SMC, no salmonids were observed. Yet, in August 1989, a Base game warden found a 25 cm trout at the USGS gauge station pool. This fish was described as being silvery with no parr marks when examined by a Base biologist (Boyer pers. comm. 1996).

A 1990 report to CDFG on the status of freshwater fishes in southern California listed rainbow trout as present in SMC and recommended managing for them by removing green sunfish and restoring the water table in the lower portions of the creek (Swift, Haglund and Ruiz 1990).

Steve Netti of San Diego Fly Fishers, mentioned in a phone interview two unsubstantiated reports. The first of which was of two kids having clubbed to death an adult steelhead on leased farmland just above the I-5 bridge in 1991, and in 1993; of steelhead spotted milling around in the SMC estuary at the railroad trestle. These were not included in Table 7. In addition, Mr. Netti mentioned that fishermen had released bass in SMC below the falls in the CNF (Netti pers. comm. 1995).

CDFG biologist, Steve Parmenter, surveyed SMC from the mouth to the eastern Base boundary on July 27, 1994, and found only mosquitofish *Gambusia affinis,* and crayfish *Procambarus* species (CDFG 1996). The stream was intermittent from 0.8 km above the mouth to the upper end of the watershed, with less then 1 cfs of flow estimated. He also surveyed an area 1.6 km upstream of Fishermans Camp the following day using an electro-shocker and found only mosquitofish, black bullhead, bullfrog *Rana catesbeiana*, California newts *Taricha torosa,* and tree frogs *P. regilla*. The stream consisted of a series of small pools less then 46 cm deep. There was no flow between pools, and water temperatures were 21°C.

The last known stocking of SMC occurred between 1983 and 1985, by Marty Maytorena, a CDFG warden, who packed brown trout into Fishermans Camp from a Fillmore Hatchery truck that had also stocked brown trout upstream at the Tenaja Road crossing to the falls (Maytorena pers. comm. 1997). These fish were stocked as fingerlings in two mule packs (80-lbs/mule pack), which indicate that at least 40 brown trout were stocked at the lower site. All of the trout survived the planting, but no follow up monitoring occurred.

Two important lower tributaries to SMC are Cristianitios and Talega creeks. Neither creek was cited in the literature as having historically supporting steelhead runs. Only one reference mentioned Cristianitios Canyon above the Base boundary in Orange County as being not well known, but fishes never historically recorded (Swift, Haglund and Ruiz 1990).

San Onofre Creek:

SOC is completely contained within the boundaries of the Base. Although not as large as SMC to the north, this stream historically had a run of reproducing steelhead through the early 1950's (Table 9). Adult steelhead in SOC were apparently smaller than those observed in SMC and may possibly be related to the smaller size of the stream. Steelhead were listed as possibly being native to the lower 1.6 km including the lagoon and present historically until the 1940's (Swift, Haglund and Ruiz 1990).

Table 9. San Onofre Creek summary of steelhead sightings from the literature review.

Year	Month	Location	Numbers	Size	Source
1940	May	lower creek	"many"	23 cm	Jessup pers. comm. 1996
1942		lower creek upstream of mouth	"one adult"	56 cm (estimated)	Haven photo from Woelfel pers.comm. 1997
1926-46		"personally observed"	"consistent runs"	adults	Glidden, cited *in* Hubbs 1946
1940-50		surf zone at mouth	"a few adults"	adults	Ball, pers. comm. 1997
1950	June	Estuary	"most abundant fish"	juveniles	CDFG survey, 1979 *7

* Appendix B

Dr. David Jessup, Sr., who fished the San Diego County all his life, recalled catching 15-23 cm rainbows in lower SOC in the 1940's (pers.comm. 1996). A local CDFG warden, E.H. Glidden, reported to Carl Hubbs that he had personally observed consistent steelhead runs on SOC during the preceding twenty years (Hubbs 1946).

Orville Ball, who studied at Scripps under Carl Hubbs and has written a book titled: The History of Freshwater Fish and Sport Fishing in San Diego County [unpublished], recalled a group of fisherman that would routinely fish the surf at the mouth of SOC and catch a few steelhead in the 1940's and 1950's (pers. comm. 1997). Mr. Ball thought that because SOC had never been stocked with hatchery trout that it contained the most genetically pure steelhead strain in San Diego County. Paul Haven, who's father operated a farm in San Onofre Valley during the 1930's, vividly recalled catching steelhead in both SMC and SOC for food (Woelfel 1991). In 1942, Mr. Haven caught an estimated 56 cm steelhead at the mouth of SOC (Figure 7).

A survey of the SOC lagoon on June 15, 1950, found juvenile rainbow trout the most abundant fish species followed by green sunfish. The average annual low summer flow during this period was 1.0 cfs (CDFG 1979). Surveys further upstream found no fish species in the North Fork and only green sunfish in the South Fork (CDFG 1979).

Figure 7. Paul Haven in 1942, with a San Onofre Creek steelhead.

A stream survey conducted on October 25, 1950 described Fletcher Creek, a tributary to the North Fork of SOC, as intermittent, pools 0.91 to 1.8 m deep, barrier falls 3.0 to 9.1 m high, fair spawning gravel and beaver dams present. Although no fish were observed the surveyors concluded with, "...the creek was important only as a steelhead nursery stream" (CDFG 1932-1952).

On June 11, 1971, while conducting a Base-wide fishery inventory, fingerlings up to 76 mm having parr marks and white tipped fins were noted in pools above Case Springs (USMC 1973). Case Springs empties into the North Fork of SOC. The two men present could not tell if the fish were trout or sunfish. If these fish were trout they may have been hatchery rainbows that were planted in Case Springs every year (1970-73) for a put and take fishery. On June 14, 1995, Russell Freeman returned to the pools above Case Springs and observed small green sunfish and bluegill *Lepomis macrochirus* (USMC 1973).

Habitat Conditions:

The habitat typing conducted in 1995, followed a 60 year flood event that occurred during the winter of 1993. As a result, vegetation on Base streams was still in the early stages of recovery. Habitat typing is a snapshot in time and survey results represent the habitat available for southern steelhead at the time these surveys were conducted.

Santa Margarita River:

The lower SMR in May 1995, was divided into four reaches (Figure 8), first three could be described as a flowing sand bar. The habitat type for Reaches 1 to 3 was one homogeneous glide (flatwater), with no pools or riffles. Average water depths ranged from 0.2 to 0.3 m, with maximum depths ranging from 0.7 to 0.9 m. Reach 4 was more confined and heterogenous, but flatwater habitat was still the most prevalent, representing 54% by habitat type, 80% by length, and 78% by volume (Figure 9). Pools occurred in Reach 4, but the frequency was low, representing 15% by habitat type, 2% by total length, and 4% by volume. A small amount of gravel was noted and measured 2 x 10 m and 5 x 1.5 m, a total area of 27.5 m^2. However, this gravel was over 75% embedded and considered poor quality for spawning.

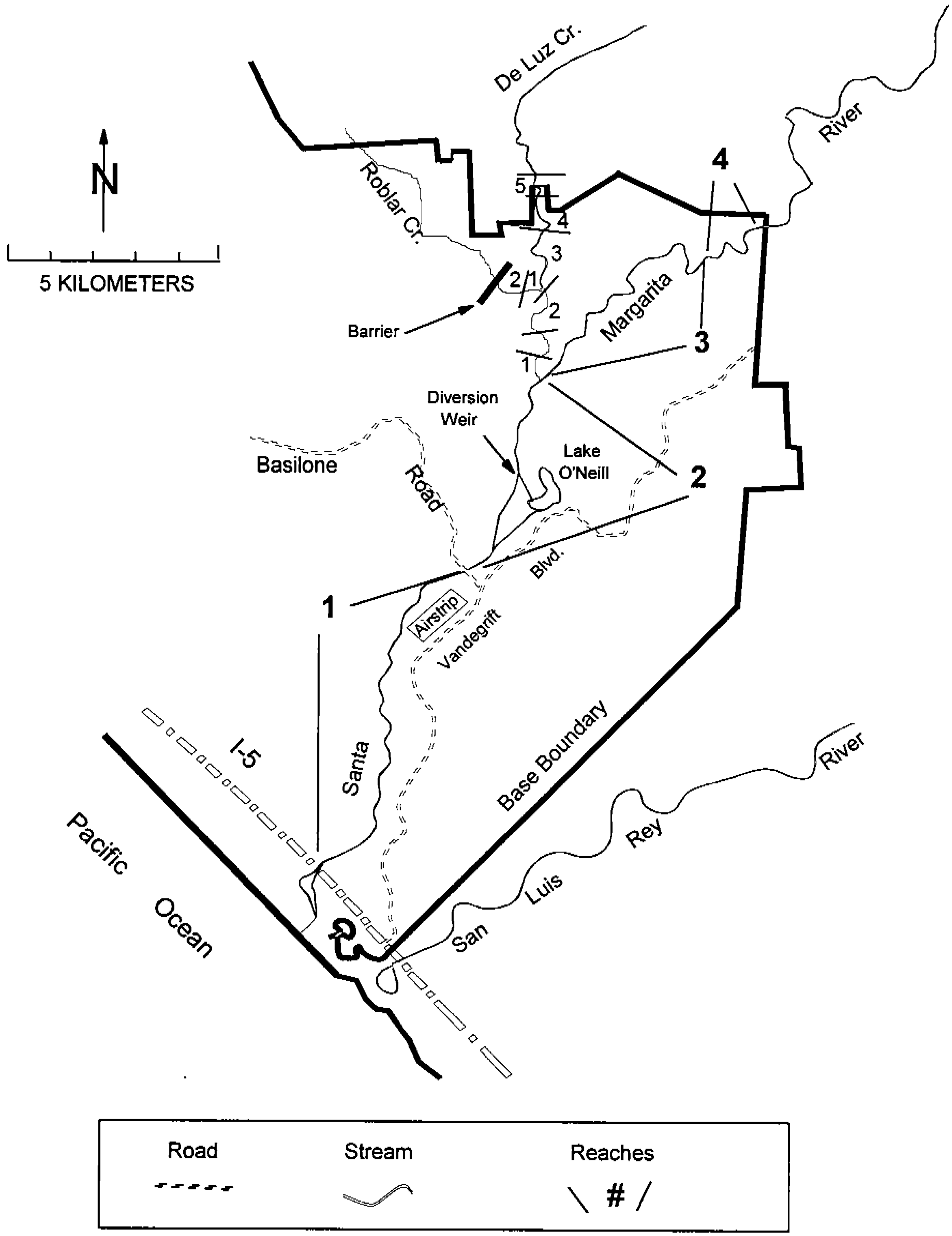


Figure 8. Santa Margarita River, De Luz and Roblar creeks depicting reaches habitat typed in May 1995.

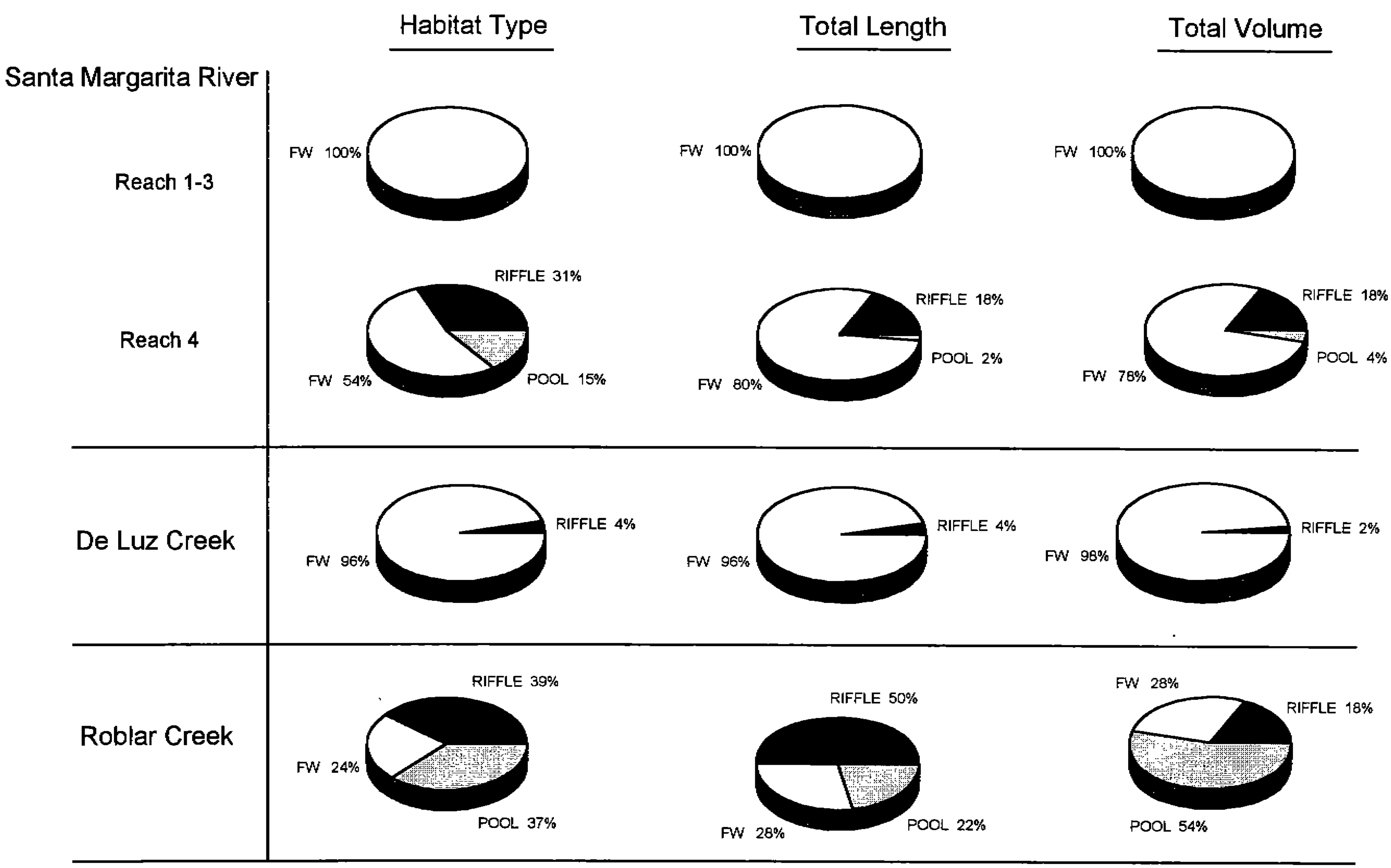


Figure 9. Flatwater, pool and riffle habitat as a percentage of type, length and volume for the Santa Margarita River, De Luz and Roblar creeks. Note: FW = FLATWATER

Stream banks were largely composed of silt and sand, with vegetation covering 58 to 76% of the banks. Giant reed *Arundo donax*, and willow were the dominant bank vegetation in Reaches 1 to 3, providing no stream canopy. Deciduous trees and grass were the dominate bank vegetation in Reach 4. Ten percent of the stream in Reach 4 had some form of canopy. Instream shelter for steelhead existed primarily around bridge abutments in the estuary. Shelter upstream of the estuary was sparse consisting of a few undercut banks, small woody debris, terrestrial vegetation and few boulders. Stream bank vegetation and composition for the four reaches is summarized in Table 10.

De Luz Creek:

De Luz Creek, flows for 8.6 km (Reaches 1 to 4) within Base boundaries. Habitat on De Luz Creek strongly resembled that of the SMR below Reach 4. Flatwater (glide) accounted for 96% of the stream habitat with the remainder considered a riffle. A 1.1 km stretch of stream was not habitat typed between Reach 1 and Reach 2 due to the homogeneousness of the stream. Survey crews hiked an additional 0.3 km (Reach 5) above the Base to the first road crossing and noticed no appreciable change in habitat. Bank composition on De Luz Creek was largely silt and sand (Table 10). Vegetative bank cover ranged from 45 to 77%. The dominant vegetation was deciduous trees (alder, live oak and sycamore) and grass. Trees provided a canopy density ranging between 6 to 20%. No pools were located in the total 7.5 km of stream surveyed. Shelter for steelhead was sparse consisting of terrestrial vegetation and small woody debris.

Roblar Creek:

Roblar Creek, a tributary to De Luz Creek, contained all three major habitat units (pools, riffles, and flatwater) as well as potential spawning gravels. The habitat types were diverse and low levels of sedimentation were noted. The lack of sedimentation may indicate that the upper basin is in good shape.

Habitat types on Roblar Creek were 39% riffle, 24% flatwater, and 37% pools (Figure 9), with the pool to riffle ratio nearly 1:1. Half of the 1.4 km stream length was considered a riffle and contained 32 pockets of gravel that could be use for spawning. The potential spawning habitat on Roblar Creek totaled 115 m^2 with the average area for a pocket of spawning gravel equal to 1.6 x 2.3 m. Pools represented 22% of the total length and 54% by volume. Pool habitat was more diverse, consisting of main channel, scour and backwater pools of various formation (Figure 10). The dominant pool formation

Table 10. Stream bank vegetation and composition, Santa Margarita River, DeLuz and Roblar creeks.

	Santa Margarita River		De Luz Creek						Roblar Creek
Stream reach	1-3	4	1	2	3	4	5	1-5	1 & 2
Reach length (km)	25.1	2.8	0.9	2.4	2.6	1.3	0.3	7.5	1.4
Mean width (m) for riffles and flatwater	18.3 - 57.6	13.4	13.1	29.8	22.0	10.0	10.0	10 - 29.8	10-12
Vegetative cover									
Right bank	58%	66%	56%	75%	81%	45%	77%	69%	17%
Left bank	73%	76%	48%	100%	72%	50%	65%	64%	15%
Dom. vegetation									
Grass	17%	36%	15%		4%			6%	17%
Brush	50%	18%	7%		58%		75%	33%	48%
Decid. trees	33%	37%	79%	100%	38%	100%	25%	61%	9%
Conif. trees									0%
No vegetation		9%							26%
Dom. bank composition									
Bedrock		5%				13%	25%	4%	31%
Boulder		22%				25%		4%	14%
Cobble/Gravel		14%	14%	25%	17%	25%	50%	20%	48%
Silt/Clay/Sand	100%	59%	86%	75%	83%	37%	25%	72%	7%
Canopy density	0%	10%	10%	20%	6%	18%	9%	6%-20%	23%
Pools by stream length	0%	1%	0%	0%	0%	0%	0%	0%	21%
Dom. shelter	Undercut Banks SWD, Terr. Veg.	Boulders	Terr. Veg	SWD	Terr. Veg	Terr. Veg	SWD	SWD, Terr. Veg	Boulders SWD, Terr. Veg.
Occurrence of LWD	0%	0%	0%	5%	2%	0%	20%	0%-10%	4%

LWD= Large woody debris, SWD=Small woody debris, Terr. veg= Terrestrial vegetation

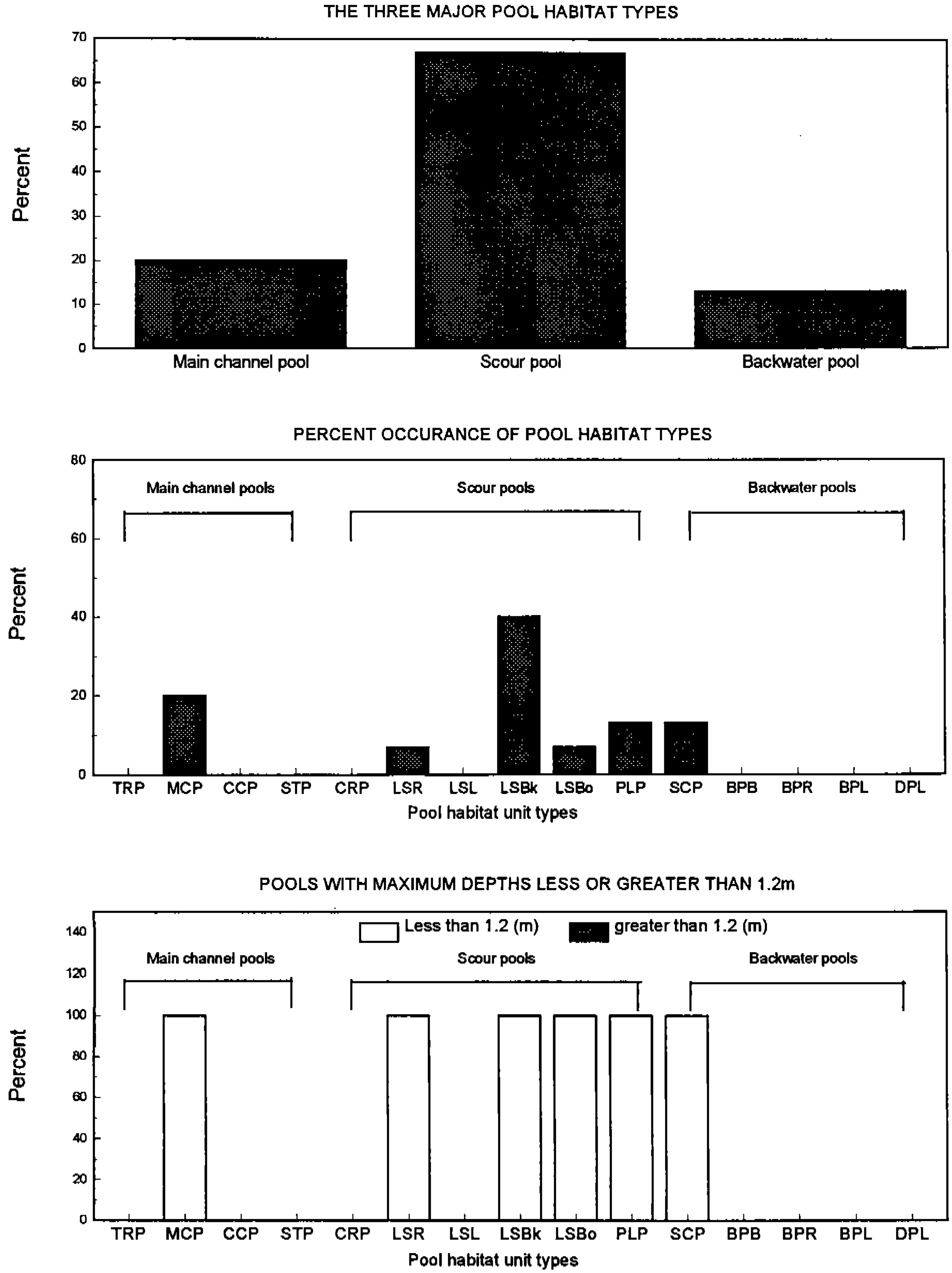


Figure 10. Roblar Creek pool habitat types with emphasis on pools available for over-summer rearing. Acronym definitions and habitat descriptions are provided in Appendix D.

was scour pool associated with bedrock (LSBk) followed by main channel pools (MCP). Roblar Creek was not mentioned in the literature review as historically having a steelhead run. A contributing factor to this may be that only the first 1.4 km are accessible to steelhead. The barrier fall (Figure 11) is the second of two falls occurring within the first 1.4 km of Roblar Creek.

Figure 11. Gayle Bustillos of the Carlsbad USFWS office at the upper falls on Roblar Creek. The falls is a barrier to steelhead.

One of the biggest factors determining whether Roblar Creek can support steelhead was the lack of pool depth. All pools were less than 1.2 m deep and vegetative bank cover was low, ranging from 15 to 17%. Twenty-six percent of the banks on Roblar Creek were devoid of any vegetation (Table 10). Where it occurred, the most common form of bank vegetation was brush and grass, 48 and 17%, respectively. Due to Roblar Creeks southwestern orientation, it is subject to long periods of direct sunlight. This, coupled with a low canopy density (23%) and lack of pool depth, could result in mean water temperatures exceeding upper lethal limits (>25°C) (Hokanson et. al. 1977; Jobling 1981; Bojornn and Reiser 1991) during July and August. The effect would be to decrease juvenile over-summer rearing potential. The lack of cover in 1995, still showed the effect of the 1993 flood. In a revisit to Roblar Creek in September 1997, we noticed that stream cover had improved, with portions of the creek completely engulfed with willow. There was perennial flow and a water temperature in the pool at the Base of the barrier was 23.5°C at 0900 hours.

Lake O'Neill Diversion Weir:

Historically on the SMR, pools were formed by constructing earthen weirs across the river channel to water livestock. Possibly the first weir was built by the Rancho Santa Margarita in 1883, to provide water for cattle. More recently, the Base constructed semi-permanent earthen berms across the stream channel to pool low stream flow and promote infiltration into the underling aquifer (USMC 1972). In reviewing old aerial photos, earthen berms were constructed on the SMR from at least 1954, to the early 1970's.

The current weir located adjacent to the Base's naval hospital is permanent. The weir was rebuilt in 1982 to replace one washed out in 1978. The height and overall strength of the new weir was increased using steel pilings and panels in conjunction with a series of large boulders placed against downstream side. Initially the new weir was approximately 3.6 m high at the center and shallower on its northern side as panels intersected the stream bank (Figure 12, top). Prior to the 1993 flood, a pool formed upstream providing a diversion of surface flow. A flood gate allowed gravitational flow from the SMR into Lake O'Neill and/or aquifer recharge basins via a tiered ditch. From 1982 to 1997, except in years with above average flow, the diversion weir would have been a barrier to steelhead. The weir would not have presented a barrier if a pool could have formed at the base of the downstream side. Steelhead require a pool depth of 1.25 times the height of a vertical obstacle to get beyond it (Bjornn and Reiser 1991), and thus a pool of at least 4 m depth would have been required. The boulders used to strengthen the downstream side of the weir prevented the formation of a pool.

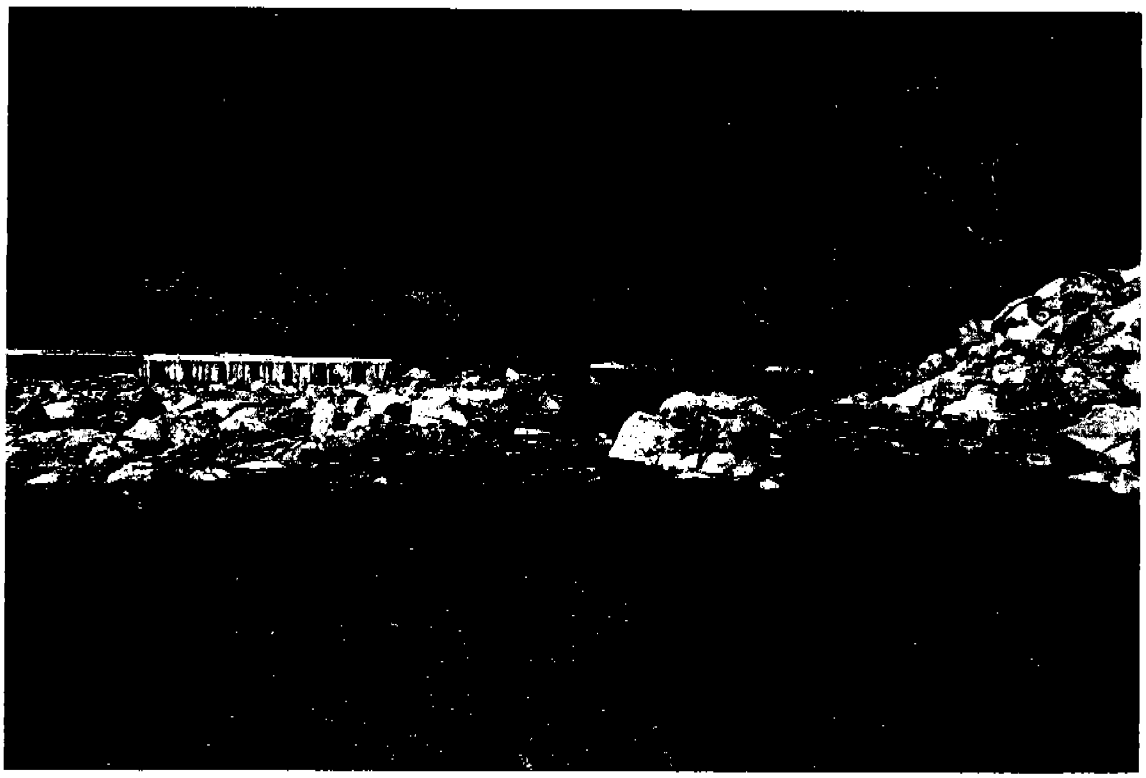


Figure 12. Diversion weir before (top) and after (bottom) 1996 modifications.

The weir withstood the 60 year flood event of 1993, but proved to be a sediment trap. Sediment from on and off Base, backfilled behind the weir. In 1996, in order to promote sediment transport the Base created two openings in the steel panels. The openings can be blocked with splashboards when diversions are necessary. In addition, large amounts of smaller rock were added to the downstream side creating more of a riffle than a falls (Figure 12, bottom). These modifications should allow for steelhead migration past the site in a greater range of flow and improve the width to depth ratio of the channel above the weir.

San Mateo Creek:

SMC habitat surveys were divided into nine reaches. Reaches 1-6 were on Base and Reaches 7-9 extended the survey upstream of the Base to the barrier falls in the CNF (Figure 13). Habitat types for all reaches surveyed were dominated by runs, low gradient riffles (LGR), mid-channel pools (MCP), and lateral scour pools associated with bedrock (LSBk). Overall, the habitat complexity was high with twenty different habitat types represented.

SMC within the Base boundary was dominated by riffle habitat, constituting 47% by habitat type, 62% by length and 67% by volume (Figure 14). Bank vegetation covered 3 to 56% of the stream margin, with the most common stream bank cover represented by brush (51%) and willow (26%)(Table 11). Stream banks were composed primarily of a cobble/gravel and silt/sand. Sand was most prevalent in the lower reaches, while boulders and cobble/gravel were more prevalent in the upper reaches.

Scour pools were the most common type of pool on Base (45%), followed by main channel (30%) and backwater pools (25%). Lateral scour pools associated with rootwad (LSR), bedrock (LsBk), and boulder (LSBo) were the most frequent formations (Figure 15). The highest number of pools on Base occurred within Reach 6. Instream shelter for steelhead was low, with the little that was available provided by terrestrial vegetation, small woody debris, and boulders. The occurrence of large woody debris (LWD) in the stream was negligible, and ranged from 1 to 3%. Canopy density averaged 20% for Reaches 1-6. Reaches 1 and 4, had areas with an above average canopy density, 25% and 36% respectively. The portion of Reach 1 adjacent to leased farmland and a State campground was confined by levees and farm roads. Reach 4 had areas with mature willow and sycamore trees, but approximately one-third was also denuded of vegetation. Areas

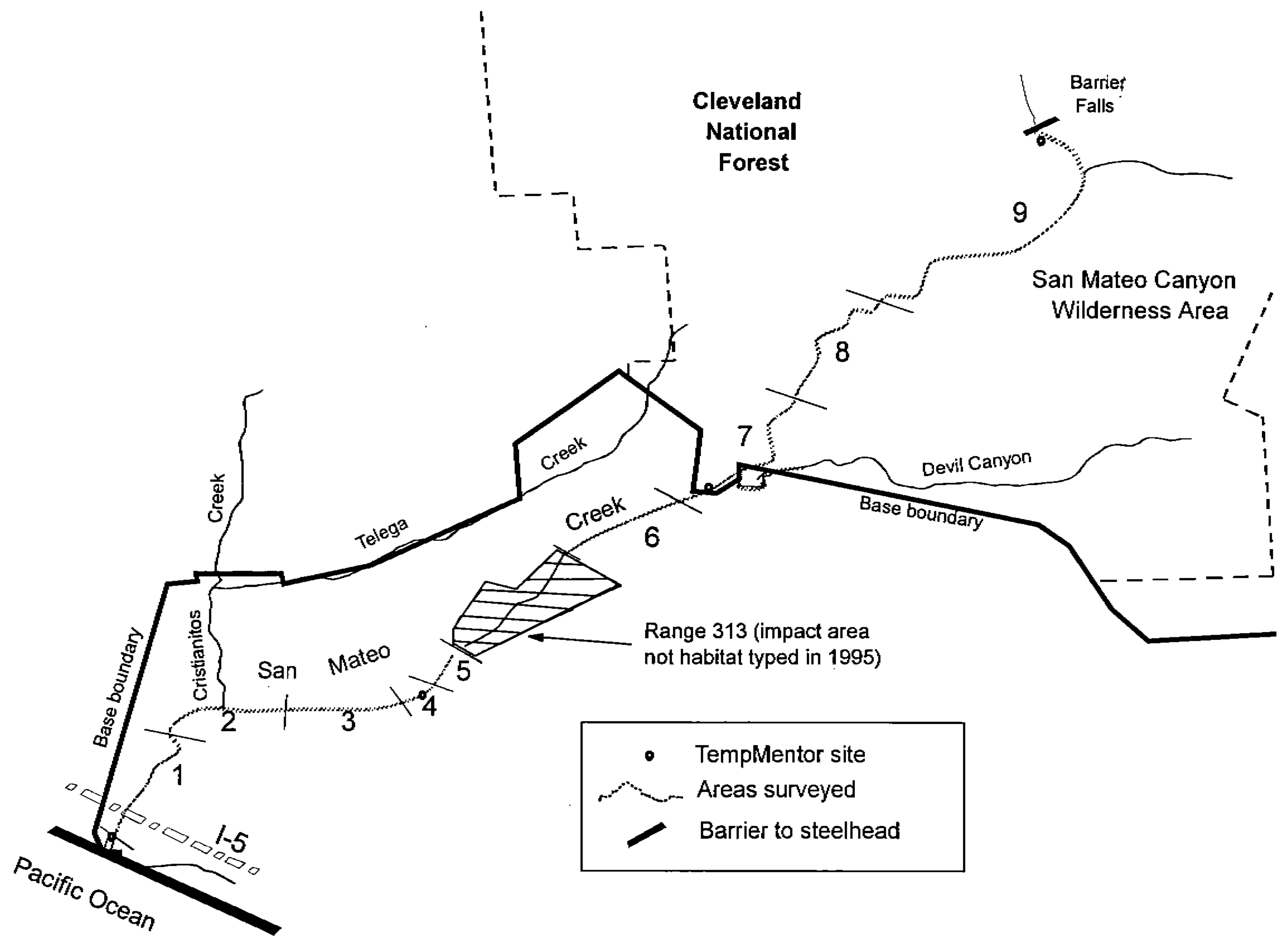


Figure 13. San Mateo Creek and tributaries; Cristianitos Creek and Devil Canyon, habitat typed in May 1995.

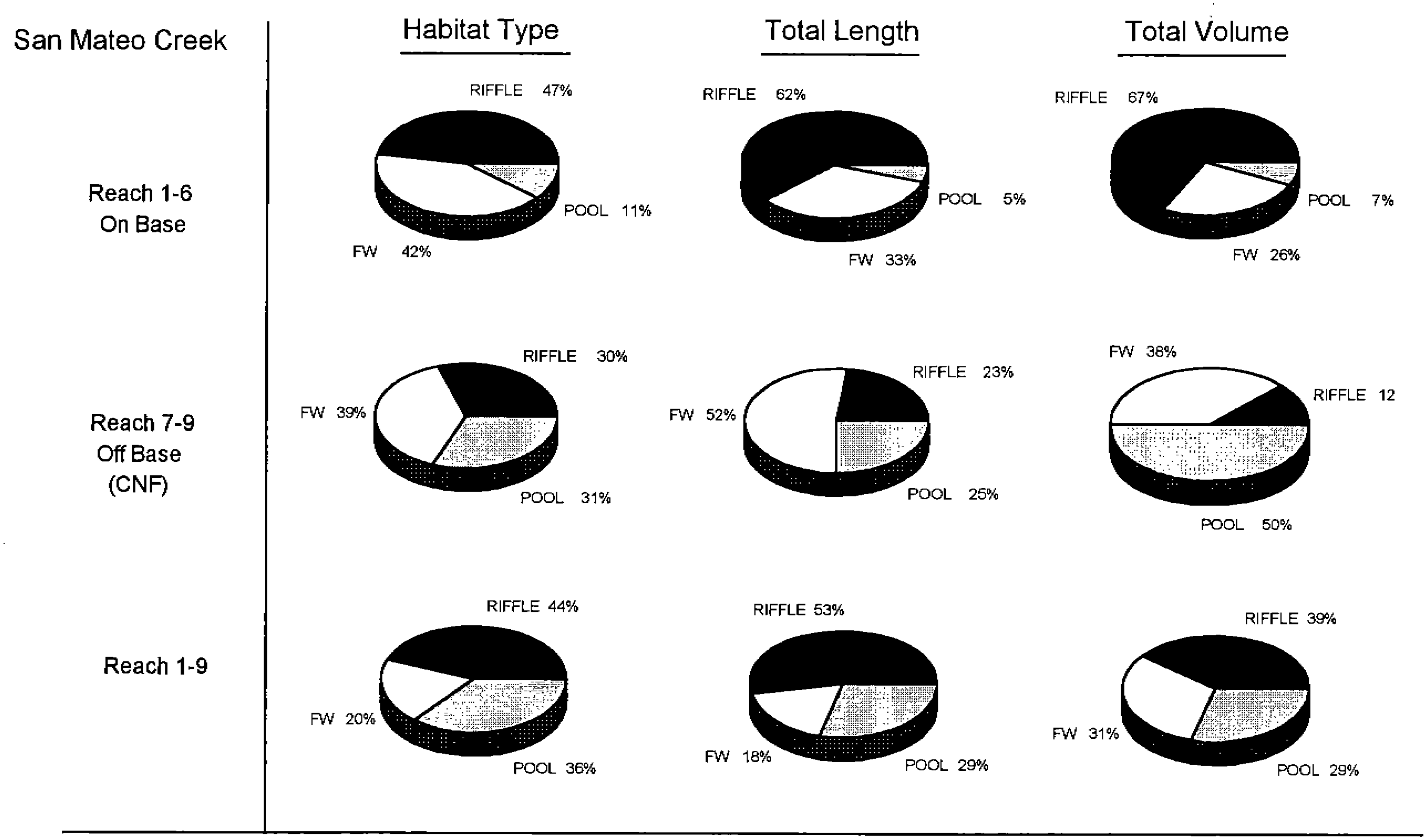


Figure 14. Flatwater (FW), pool and riffle habitat as a percentage of type, length and volume for San Mateo Creek.

Table 11. Stream bank vegetation and composition, San Mateo Creek.

	Reaches Habitat typed within Base boundaries								Reaches Habitat typed within Cleveland National Forest			
Stream reach	1	2	3	4	5	Firing range 313A	6	1-6	7	8	9	7-9
Reach length (km)	3.4	2.6	2.4	3.7	3.7	3.6	0.7	16.4	5.9	5.1	9.0	20.5
Mean width (m) for riffles and flatwater	10.0	7.0	8.5	9.0	11.0		Not mea.		9.0	7.0	5.6	6.9
Vegetative cover												
Right bank	41%	54%	45%	46%	56%		23%	48%	33%	41%	69%	52%
Left bank	42%	47%	25%	31%	49%		3%	37%	45%	59%	67%	58%
Dom. vegetation												
Grass			4%	3%	14%			6%	8%		10%	8%
Brush	45%	86%	35%	36%	66%		100%	51%	45%	21%	16%	27%
Decid. trees	33%	14%	42%	29%	13%			26%	41%	75%	74%	63%
Conif. trees	22%											0%
No vegetation			19%	32%	7%			17%	6%	4%		3%
Dom. bank composition												
Bedrock	0%	29%	4%	9%				7%	42%	28%	12%	25%
Boulder	0%	0%	4%	29%	28%		50%	18%	44%	61%	43%	46%
Cobble/Gravel	44%	42%	73%	41%	64%			52%	5%	11%	7%	7%
Silt/Clay/Sand	56%	29%	19%	21%	8%		50%	23%	9%		38%	23%
Canopy density	25%	13%	13%	36%	6%		0%	20%	15%	18%	32%	26%
Pools by stream length	0%	1%	9%	7%	4%		23%		31%	23%	22%	25%
Dom. shelter	Terr. veg	Terr. veg	SWD	Terr. veg	Boulders		Terr. veg		Boulders	Terr. veg	Boulders	
Occurrence of LWD	0%	1%	3%	2%	0%		0%		0%	0%	0%	0%

LWD= Large woody debris, SWD=Small woody debris, Terr. veg= Terrestrial vegetation

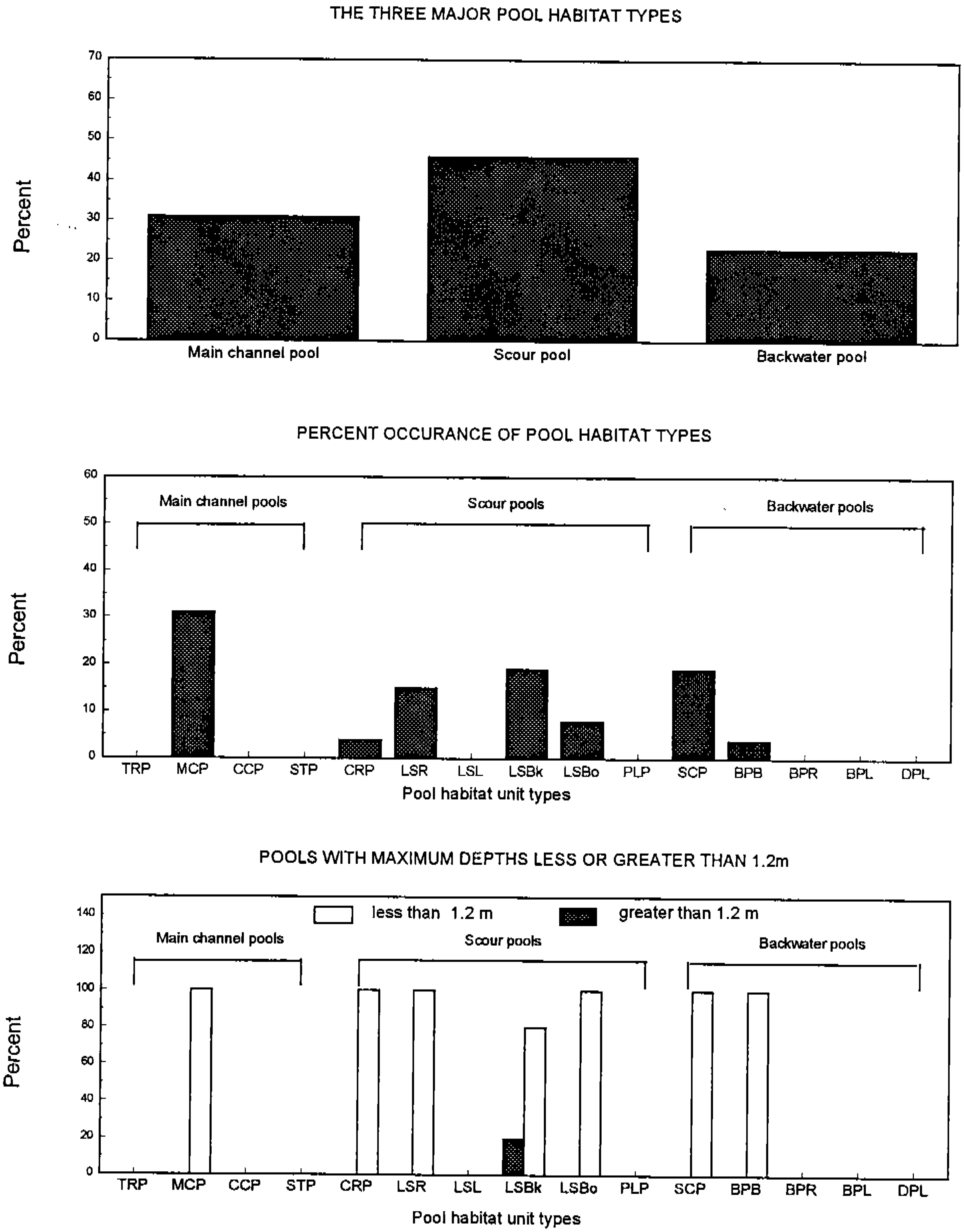


Figure 15. Pool habitat types for San Mateo Creek (Reach 1-6) on Base with emphasis on pools available for over-summer rearing. Acronym definitions and habitat descriptions are provided in Appendix D.

denuded of bank vegetation were associated with areas of bed load movement occurring during high flow events. SMC was still in the early stages of recovery from the 1993 flood.

The largest quantities of spawning gravel located on Base occurred in SMC. Areas having potential spawning gravel were first located in Reach 4 (Table 12). This spawning gravel was associated with one of the few pools located in the lower SMC. The area of largest potential spawning gravel on Base was located between Range 313A and the Telega Road crossing (Reach 6). Gravel predominately occurred in runs and low gradient riffles (LGR). Smaller amounts of potential spawning gravel were found between the Telega Road crossing and the USGS gauge station. In total, 4,017 m^2 of potential spawning gravel was located in SMC within Base boundaries. Approximately 60% of the potential spawning gravel was considered of poor quality due to siltation. The depth of embeddedness for gravel in pool tail-outs was measured as the percent of gravel surrounded or buried by fine sediments. This is often used as an indicator for the quality of substrate available to spawning steelhead. When the level of embeddedness exceeds 25%, the gravel is considered of poorer quality for spawning.

The reach encompassing Range 313A was habitat typed in March 1996, but due to the large change in flow between years and the additional year of stream side vegetation growth, a direct comparison was not possible.

The habitat types within the CNF (Reaches 7-9) were more balanced. Riffle, flatwater and pool habitat proportions were 30%, 39%, and 31%, respectively. Vegetation in these reaches covered between 33 and 69% of the stream banks (Table 11). The dominant vegetation was brush and deciduous trees (willow, sycamore, alder). Stream banks were primarily composed of bedrock and boulder. Reach 9 had a higher percentage (38%) of the stream bank composed of silt/sand.

Potential spawning gravel occurred in several locations in the CNF (Table 13). Not all potential spawning gravel located was in the CNF was measured, but the data collected indicated an increase in spawning gravel associated with pool tail-outs, some of which were classified as excellent. Gravel in pool tail-outs is a preferred spawning location of salmonids. All of the reaches on the SMC contained pools with tailouts, however, Reaches 2, 6, and 8 had the best pool tail-out gravels (50%, 33%, and 50% of pool tail-outs less then 26% embedded) (Figure 16). Conversely, Reach 7 was rated the worst at 96% embedded. Reaches 1, 3, 4, 5, and 9 contained no spawning gravel less then 26% embedded.

Table 12. Spawning gravel on San Mateo Creek within Base boundaries.

Distance upstream from RR bridge (mi)	(km)	REACH	Description	Main Channel Type		Side channel type		Potential spawning gravel Size (m)	Area (sq. m)	# of Redds possible (all areas) Max	Min	(less marginal areas) Max	Min
3.4	5.5	4	1 mi below SMC bridge	5.1	Corner pool			9 x 6	54	15	10	15	10
3.9	6.3	4	"	3.4	Step run			3 x 20	60	17	11	17	11
4.0	6.5	4	"	3.2	Glide			6 x 6	36	10	7	10	7
4.4	7.1	5	"	3.2	Glide			3 x 10	30	8	6	8	6
8.1	13.0	6	1 3/4 mi. below USGS station			3.2	Glide	7 x 6	42	12	8		
8.2	13.1	6	"	3.3	Run			10 x 10	100	28	19	28	19
8.2	13.2	6	Below Telega Rd. crossing	1.1	Low gradient riffle			30 x 10	300	83	56	83	56
8.2	13.2	6	"	3.3	Run			30 x 20	600	167	111	167	111
8.4	13.6	6	"	3.3	Run			10 x 0.5	5	1	1		
8.6	13.8	6	"	1.1	Low gradient riffle			50 x 20	1,000	278	185		
8.7	13.9	6	"	3.3	Run			40 x 15	600	167	111	167	111
8.7	14.0	6	"	1.1	Low gradient riffle			25 x 10	250	69	46		
8.8	14.2	6	"	1.1	Low gradient riffle			4 x 2	8	2	1		
8.8	14.2	6	"			6.1	Secondary channel pool	8 x 10	80	22	15		
8.9	14.3	6	"	3.3	Run			7 x 10	70	19	13		
9.1	14.6	6	"	1.1	Low gradient riffle			30 x 15	450	125	83	125	83
9.2	14.8	6	"			1.1	Low gradient riffle	5 x 6	30	8	6		
9.2	14.8	6	"	3.3	Run			3 x 5	15	4	3		
			"					5 x 5	25	7	5	7	5
9.2	14.8	6	"			6.2	Backwater pool (boulder)	5 x 5	25	7	5	7	5
9.2	14.8	6	"			1.1	Low gradient riffle	15 x 10	150	42	28	42	28
9.5	15.3	7	1/4 mi. below USGS gauging station	1.1	Low gradient riffle			6 x 10	60	17	11		
9.6	15.4	7	"	4.2	Mid-channel pool			5 x 3	15	4	3		
9.8	15.8	7	Below pool at gauge station	1.1	Low gradient riffle			1 x 6	6	2	1	2	1
9.8	15.8	7	Pool at USGS gauging station	5.4	Lateral scour pool (bedrock)			2 x 3	6	2	1	2	1
								Totals	4,017	1116	744	678	452

Table 13. Spawning gravel on San Mateo Creek within the Cleveland National Forest.

Distance upstream from RR bridge (mi)	(km)	REACH	Description	Main Channel Type		Side channel type		Potential spawning gravel Size (m)	Area (sq. m)	# of Redds possible (all areas) Max	Min	(less marginal areas) Max	Min
11.2	18.0	7		4.2	Mid-channel pool			3 1.8	6	2	1	2	1
11.2	18.0	7		4.2	Mid-channel pool			2.4 x 1.2	3	1	1	1	1
11.3	18.2	7		3.2	Glide			15 x 9.1	139	39	26	39	26
11.6	18.6	7	good gravel no measurements	3.2	Glide								
11.6	18.7	7		4.1	Trench pool			3 x 6.1	19	5	3	5	3
11.8	18.9	7		4.2	Mid-channel pool			12 x 4.6	56	15	10	15	10
11.8	19.0	7		1.1	Low gradient riffle			15 x 4.6	70	19	13	19	13
11.9	19.1	7	lots of spawning gravel	1.1	Low gradient riffle			15 x 12	186	52	34	52	34
11.9	19.1	7	all spawnable, no measurement	3.2	Glide								
12.0	19.3	7	lots of spawning gravel	4.1	Trench pool			18 x 4.6	84	23	15	23	15
12.0	19.3	7	5' bedrock falls	3.4	Step run								
12.0	19.4	7		6.2	Backwater pool (boulder)			3 x 3	9	3	2	3	2
12.1	19.5	7		5.6	Plunge pool			4.6 x 3	14	4	3	4	3
12.2	19.6	7	good spawning riffle	1.1	Low gradient riffle								
12.2	19.7	7	riparian loss, flood damage	1.1	Low gradient riffle								
12.3	19.8	7		3.3	Run			6.1 x 3	19	5	3	5	3
12.8	20.7	7	good spawning area	3.2	Glide								
12.9	20.8	7	good spawning tailout, but sandy	5.4	Lateral scour pool (bedrock)								
13.1	21.0	7	fish: bullhead	4.2	Mid-channel pool								
13.2	21.2	7	tailout gravel, heavy sand	5.4	Lateral scour pool (bedrock)								
13.2	21.3	7	tailout gravel, heavy sand	5.4	Lateral scour pool (bedrock)								
13.8	22.2	8		5.4	Lateral scour pool (bedrock)			6 x 10	60	17	11	17	11
13.9	22.4	8		5.5	Lateral scour pool (boulder)			1 x 1	1	0	0	0	0
17.5	28.1	9	Tenaja Creek enters										
18.4	29.5	9	Spawnable gravel, no measurement	3.4	Step run								
18.4	29.6	9	Spawnable gravel, no measurement	5.5	Lateral scour pool (boulder)								
18.4	29.6	9	Spawnable gravel, no measurement	1.1	Low gradient riffle								
18.8	30.3	9	Excellent spawning gravel	3.3	Run								
18.8	30.3	9	Some spawnable gravel, no measurement. Fish observed, no. ID.			6.2	Backwater pool (boulder)						
19.2	30.9	9	Spawnable gravel, no measurement	4.2	Mid-channel pool								
19.9	32.0	9	Barrier falls, no further access by steelhead.	5.6	Plunge pool								

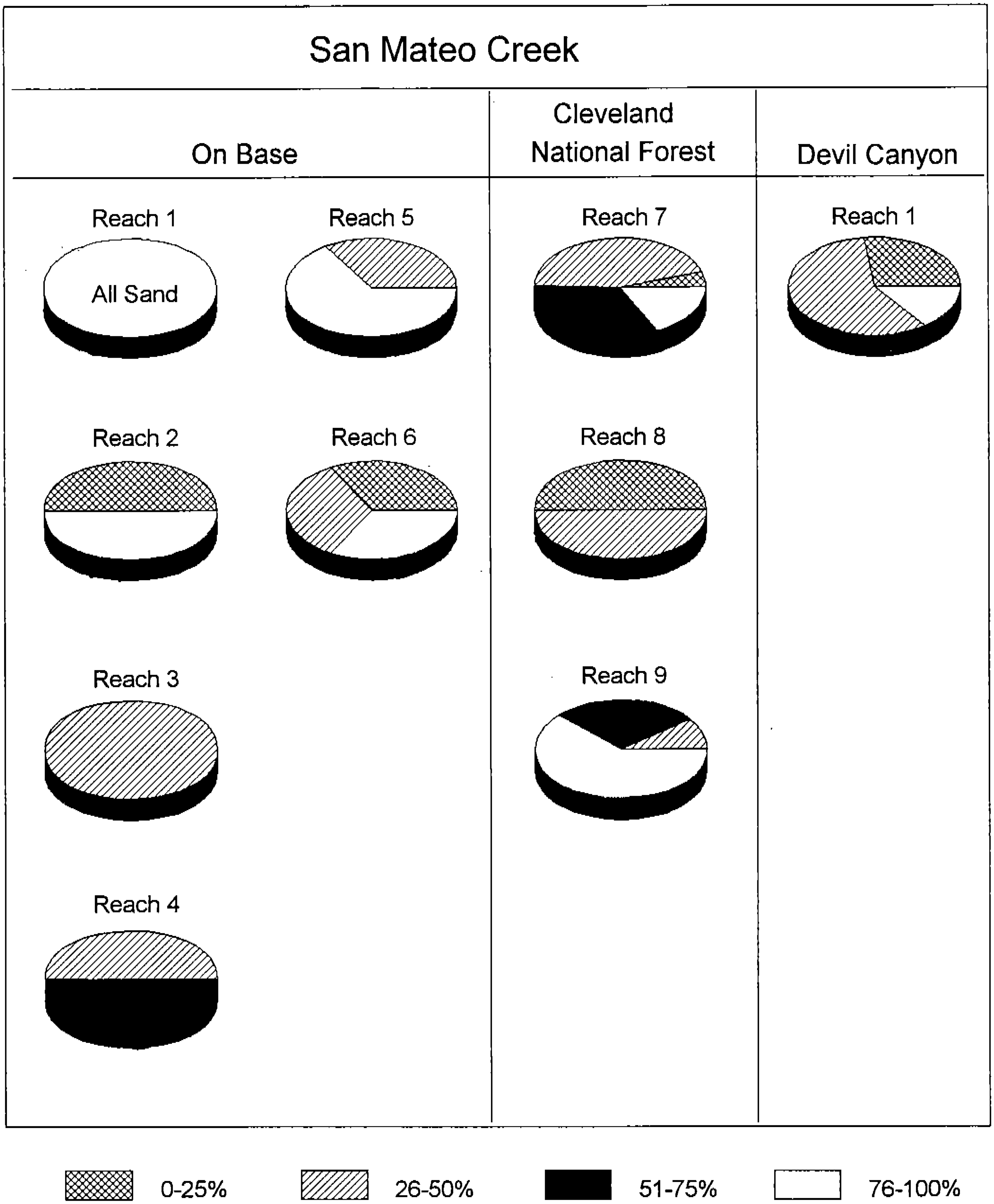


Figure 16. Percent embeddedness of spawning substrate by reach, San Mateo Creek and Devil Canyon, May 1995.

Within the CNF, pools as a percentage of reach length were relatively constant at 31%, 23% and 22% respectively, for Reaches 7, 8 and 9 (Table 11). Shelter for steelhead was in the form of pool depth, boulders, and terrestrial vegetation. Overall, pools constituted 36% by habitat type, 29% by length, and 29% by volume. Main channel pools (MCP) were the most dominant pool type (55%) within the CNF, and of these, 37% were deeper than 1.2 m (Figure 17). MCP's could contribute significantly to over-summer rearing habitat for juvenile steelhead. Lateral scour pools (LSBk) associated with bedrock also accounted for a high percentage of the pools, and approximately 60% of these were deeper than 1.2 m (Figure 17).

In September 1996, the portion of Reach 7 from the Base boundary, to the confluence with Devils Canyon, was surveyed again. The reach for the most part was dry with only three pools containing water. The average maximum depth was 1.2 m with the deepest pool measuring 1.7 m. Surface water temperature ranged from 25-29°C. The pools were thermally stratified with a four degree difference between surface and bottom. Dissolved oxygen was 7.9 mg/l at 1330-1430 hours, which was comparable to the finding of Woelfel (1991) in September 1988, for the Devil Canyon confluence pool. Woelfel also took dissolved oxygen measurements at 0620 hours in the same pool and found dissolved oxygen of 6.0 and 3.0 mg/l for the top and bottom respectively. These pools are likely permanent except during extended drought years. Carpanzano (1996) showed that juvenile trout could potentially survive these conditions by staying on the bottom where temperatures are the coolest despite stressful dissolved oxygen levels.

The dominant pool substrate in 1996 was sand with some gravel available for spawning in the tail-outs. Instream shelter for fish was poor, consisting of depth and bedrock ledges. The stream riparian vegetation was better than what was noted in 1995, with young alder trees lining, and in places completely encroaching the stream channel. Fish observed in 1996, were largemouth bass *Micropterus salmoides*, green sunfish, mosquito fish, and bullhead species. Other aquatic species observed included western pond turtles, bullfrogs, and California newts.

Devils Canyon from the confluence to the Cold Spring Canyon was also surveyed in September 1996. The stream was intermittent and eight of thirty pools were measured randomly for mean and maximum depth, with the deepest measuring 1.2 m.

Water temperatures ranged from 24°C to 31°C. The dominant pool substrate was sand with boulders. Vegetative cover consisted of a mixture of oak, sycamore, willow, and alder, with overhead canopy

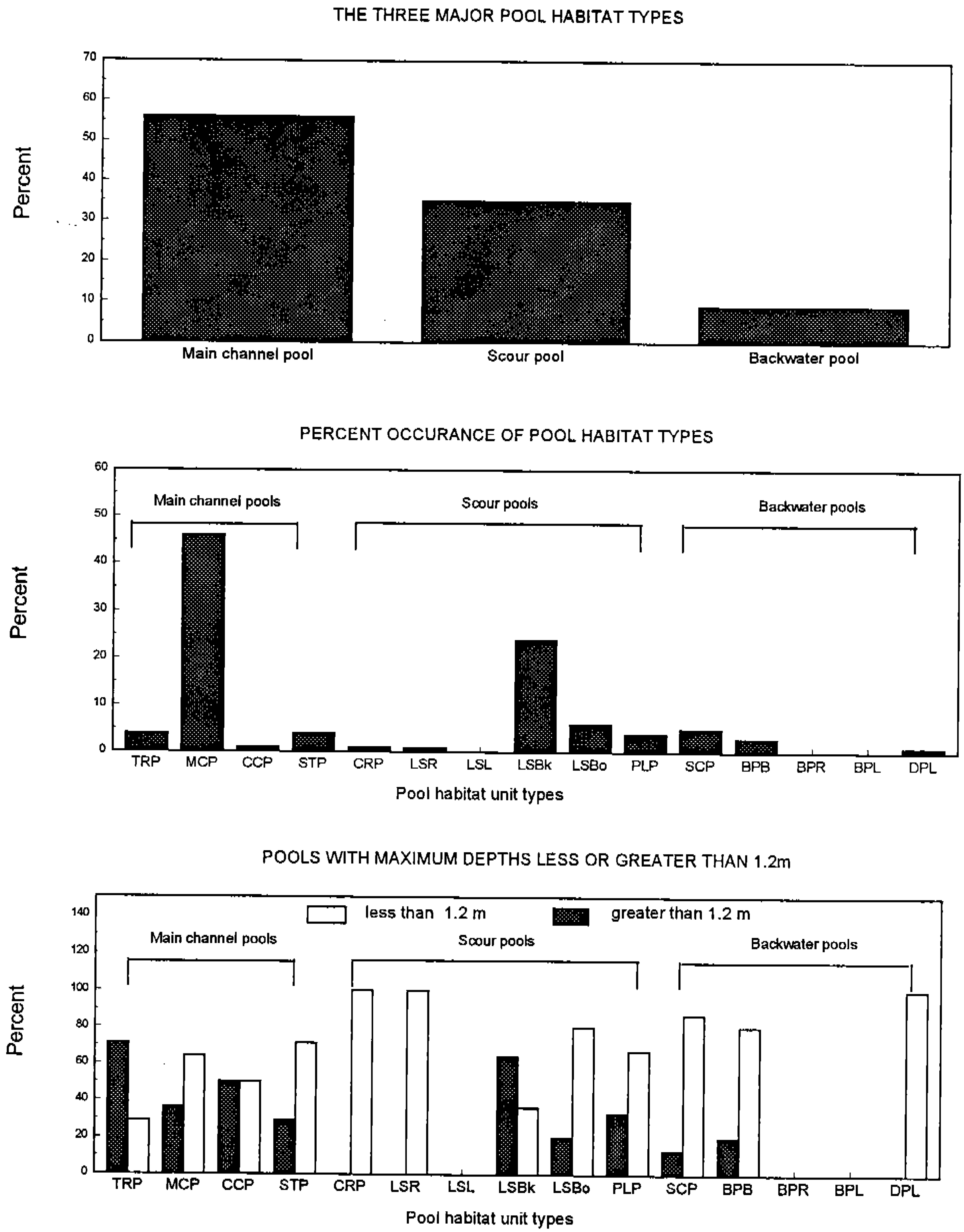


Figure 17. Pool habitat types for SMC within the Cleveland National Forest (Reach 7-9) with emphasis for over-summer rearing. Acronym definitions and habitat descriptions are provided in Appendix D.

relatively low (22%) due to little vegetation along the steep canyon wall. Instream shelter for fish was low, and represented by bedrock ledges. Spawning gravel was noted in the tail-outs of two of the eight pools. A mix of aquatic insects were observed which could provide food for trout. Aquatic vegetation consisted of bulrush found around the deeper pools. Fish, western pond turtles, bullfrogs or California newts, were not observed in Devils Canyon in September 1996.

Two major tributaries of lower SMC are Cristianitios and Talega creeks. Talega Creek merges with Cristianitios Creek within the Base boundary approximately 4.8 km upstream of SMC. With the exception of February and March, the portion of these streams on Base are dry during the remainder of the year. The lower portion of Cristianitios Creek is wide, braided, and with a predominantly sandy substrate.

Telega Creek parallels the Northeastern Base boundary, and in several places, Telega Creek is the Telega Creek road. Telega Creek does possess good substrate and stream cover along the road, but the window of opportunity when adequate flow exists may be to small to be utilized by steelhead. Both Cristianitios and Telega creek were not mentioned in the literature review as having had historical steelhead runs, and our surveys did not extend off Base in these two streams to determine whether spawning or rearing habitat existed further upstream.

Comparison with Woelfel (1991):

Dave Woelfel undertook numerous field surveys of SMC from 1987-1990 (Woelfel 1991). In his study, Woelfel divided the creek into five reaches. Reach 1, 2 and 3 encompassed the area within our Reach 1 and the first half of our Reach 2 (Figure 13). Woelfel's Reach 4 stretched from Cristianitios Creek to the upper USGS gauge station and Reach 5 continued upstream past the gauge station to the barrier falls above Fishermans Camp in the CNF (Table 14).

Woelfel's habitat observations were conducted during years of below average rainfall and below normal stream flow. In contrast, preceding our 1995 surveys, near average precipitation and stream flows had occurred during 1994 and precipitation and flows during the spring of 1995 were considered above average (Agajanian pers. comm. 1998). In 1995, the effects of the 1993 flood were still evident. Except for the larger tress, the stream banks were mostly denuded of vegetation, false banks had formed and pools where filled with silt/sand deposits. Willows, which had been removed in the

Table 14. Steelhead habitat data on San Mateo Creek condensed from Woelfel (1991).

		Corresponding USFWS Reaches		
Habitat Criteria	Estuary	1-2	3-6	7-9
Range of average depth (m)	0.3-1.0	Dry-0.1	Dry-5.0	0-1.8
Vegetative cover	Dense	0-80%	Sparse	Good
Order of substrate	Sand	Sand, cobble, sm. boulders	Boulders, cobble, gravel	Sand, gravel, bedrock
Steelhead utilization	Holding/rearing	Migration	Migration	Spawning, rearing

1993 flood, were in the early stages of recovery. Willow recovery was relatively quick. Upon resuming surveys during the spring 1996, short willows were observed lining much of the stream. By September 1996, these willows were large and portions of the stream were completely engulfed.

A comparison of Woelfel's observations and our data have many similarities. We are in agreement that habitat within the CNF contains suitable steelhead habitat, with the Base portion of the stream providing only a migratory corridor. Woelfel cited livestock grazing, groundwater removal, agriculture, traffic and fire associated with military activities, as contributing factors leading to accelerated rates of erosion. In addition, reduced stream flow and a lowered watertable has eliminated significant amounts of bank-stabilizing riparian vegetation which included alders and deep-rooted oak and sycamore trees. These trees once provided stream canopy and pool forming scour points.

San Onofre Creek:

The SOC mainstem and South Fork San Onofre Creek (SFSOC) were habitat typed in mid-April 1996. The SOC mainstem began just upstream of the estuary and ended at the confluence of the North Fork (NFSOC) and SFSOC (Figure 18). The mainstem was divided into three reaches. Reach 1 started upstream of the estuary and ended at the downstream

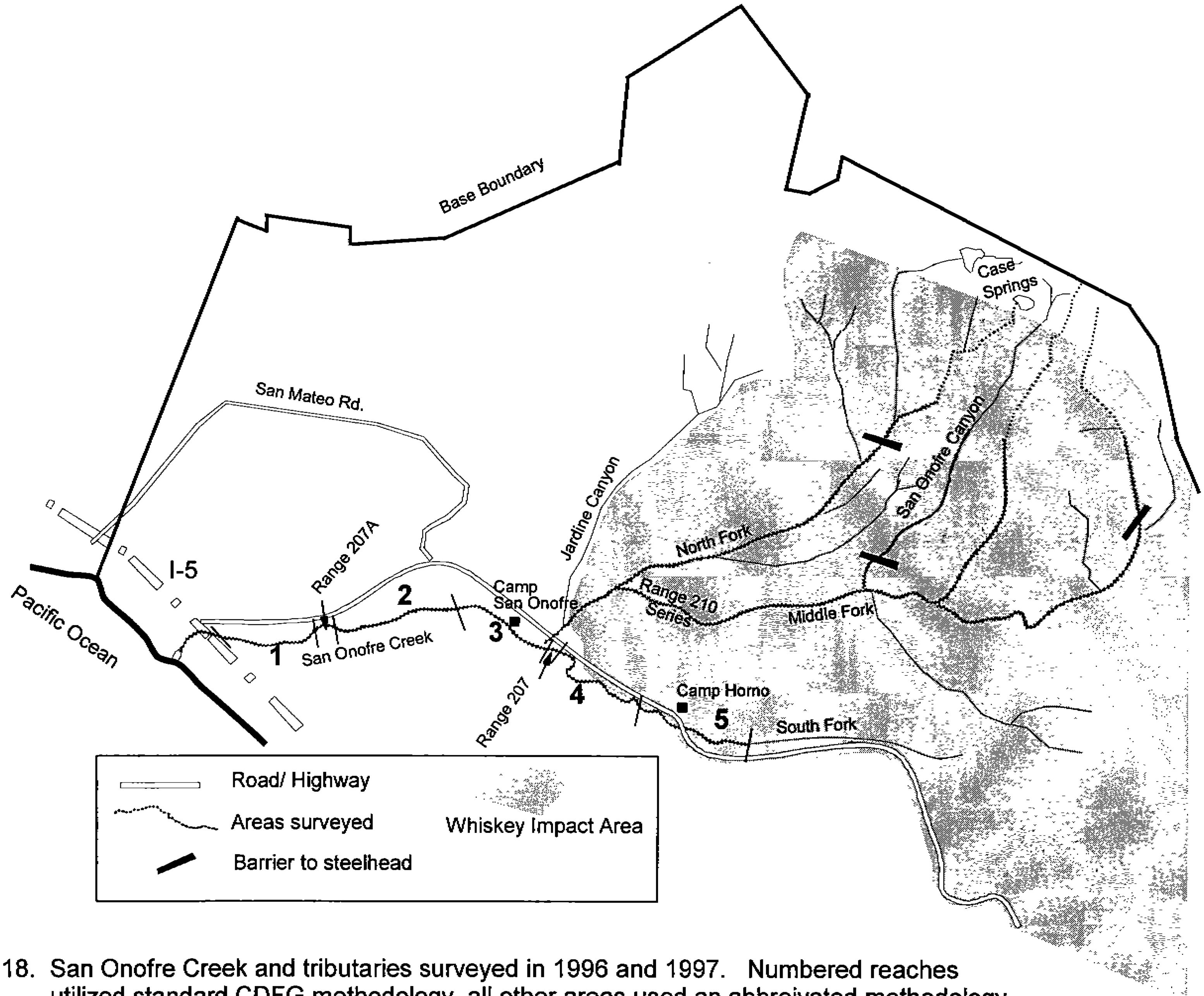


Figure 18. San Onofre Creek and tributaries surveyed in 1996 and 1997. Numbered reaches utilized standard CDFG methodology, all other areas used an abbreivated methodology.

boundary of range 207A. The first half of the reach was characterized as a wide, braided, undefined flood plain emerging from a narrows. This portion of the reach was completely dry with sandy substrate, sparsely vegetated, and used as a roadway. Stream flow was encountered approximately halfway up the reach (2.5 km) near the downstream end of the narrows. Although unknown at the time, the majority of flow encountered originated from the first of two wastewater treatment facilities treated effluent discharge.

Low gradient riffles with sandy substrate were the most common habitat within the wetted channel. The mean width of the riffle habitat was 4 meters. The dominant bank composition was cobble and gravel, with vegetative cover consisting of brush and short deciduous trees providing little overhead canopy. Pools represented 5% of the wetted stream channel. Pool depth averaged 0.2 m and primarily occurred where a jeep road crossed the stream. The water temperatures of these pools was 25°C by mid-day. Dominant instream shelter was a long stretch of aquatic vegetation providing little value to steelhead.

Reach 2 began at the upstream boundary of range 207A and ended 2.7 km upstream behind the barracks and baseball field at Camp San Onofre. Habitat consisted of flatwater (78%), riffles (13%), braided channel (8%), and pools (1%). The dominant bank composition was cobble and gravel, with brush (70%) the dominant vegetative cover (Table 15). Stream flow decreased by approximately one-half as the survey progressed upstream of the wastewater treatment outflow pipe.

Reach 3 continued upstream of the baseball field to the confluence with the NFSOC. The channel was braided with flow originating from a second sewage treatment plant located on the SFSOC. Approximately 92% of the channel had surface flow represented by flatwater habitats. The dominant substrate was sand, constituting 78% of the reach. The dominate bank composition was cobble and silt, with brush representing the dominant vegetative cover. Pool habitat composed 1% of the wetted stream channel, having a mean depth of less then 0.3 m (Table 15). Overhead canopy covered 38% of the wetted stream channel.

The NFSOC was dry at the confluence with the SFSOC. Reaches 4 and 5 continued 9 km up the SFSOC along the edge of the Whiskey Impact Area to just above Camp Horno (Figure 18). Combining the two reaches, only 55% of the channel was wet. Ten percent of the wetted channel was not surveyed due to either passing through a firing range or the stream was choked with brush. For the portion surveyed, SFSOC displayed greater habitat diversity represented by ten habitat types verses only three types on the mainstem SOC. However, there were several locations below Camp Horno and adjacent to wastewater treatment facilities which resembled a swamp. Low gradient riffle (32%) was the most common habitat, followed by flatwater (11%) and

Table 15. Stream bank vegetation and composition, mainstem and South Fork San Onofre Creek.

Stream reach	Mainstem San Onofre Creek 1		2	3	South Fork San Onofre Creek 4	5
	Dry	Wet				
Reach length (km)	2.5	2.5	2.4	1.3	3.6	5.3
Mean width (m) for riffles and flatwater		4.0	1.8	3.0	12.0	1.5
Vegetative cover	0%	98%	77%	100%	75%	59%
Right bank		61%	65%	100%	56%	60%
Left bank		61%	72%	100%	63%	58%
Dom. vegetation						
Grass			17%	33%	30%	28%
Brush	5%	56%	70%	33%	45%	22%
Decid. trees	5%	6%	3%	34%	7%	17%
Conif. trees						
No vegetation	90%	38%	10%		18%	33%
Dom. bank composition						
Bedrock					2%	44%
Boulder						
Cobble/Gravel		38%	45%	67%	25%	6%
Silt/Clay/Sand	100%	25%	45%	33%	57%	50%
Canopy density	0%	1%	38%	65%	50%	77%
Pools by stream length	0%	1%	1%	1%	3%	1%
Dom. shelter		Terr Veg	Aquatic Veg	Aquatic Veg	Terr Veg	Bedrock ledges
Occurrence of LWD	0%	0%	0%	13%	0%	0%

LWD= Large woody debris, SWD=Small woody debris, Terr. veg= Terrestrial vegetation

pools (2%). Dominant bank composition was sand/silt/clay with sand the dominate instream substrate. The dominant bank vegetation was brush with overhead canopy occurring on 60% of the units measured. Instream substrate increased from 4% to 44% bedrock between Reach 4 and 5. Instream shelter for steelhead was low, consisting mainly of aquatic and overhanging terrestrial vegetation. The occurrence of instream large woody debris, bedrock ledges, or boulders, was negligible, providing little benefit to steelhead (Table 15). The South Fork was dry above Camp Horno and the survey was discontinued.

Overall, pools were deeper on the SFSOC than the mainstem SOC, ranging from 0.6-1.2 m. Low gradient riffles/glides represented the most common habitat on the mainstem SOC and SFSOC. Spawning gravel was not located in either the mainstem SOC or the SFSOC.

SOC Within the Whiskey Impact Area:

In the spring of 1996, a CCFWO crew was allowed access to the Middle Fork San Onofre Creek (MFSOC). The survey started behind the bleachers of the Range 210 series and proceed upstream approximately 7 km. The stream was intermittent with small boulder and cobble substrate and pools formed at the base of sycamore trees adjacent to the stream. The stream channel was progressively wider with surface flow ceasing for approximately the next 3 km. Surface flow resumed near the entrance of the San Onofre Canyon, and from here on the composition of the creek changed dramatically, with multiple bedrock pools and small alder trees lining the banks of the narrow canyon. All pools were snorkeled to the confluence of San Onofre Canyon and the Middle Fork with no fish observed. A barrier to steelhead was found within the first 1 km on the San Onofre Canyon above the confluence with the Middle Fork (Figure 18). Due to time constraints, a second more thorough survey was scheduled for September 1996.

The second survey consisted of measuring a random number of pools for temperature and dissolved oxygen, and snorkeling of the uniquely deep pools. The survey started at the base of the San Onofre Canyon and proceed approximately 16.5 km to the headwaters, an elevation change of 610 m.

Of the 186 pools observed, 31 were measured. The deepest pool was 2.7 m and mean depths measured 0.3 m. Fifteen percent of the pools measured were deeper than 1.2 m and the mean maximum pool depth was 0.7 m. Pool water temperatures ranged from 21-27°C and dissolved oxygen measurements ranged from 6.0-9.0 mg/l. In several places the stream was intermittent between pools. The riparian vegetation is predominantly alder with occasional oaks and sycamore trees. A few stands of Bigcone Douglas fir *Pseudotsurga macrocarpa* were noted in several locations, but had sustained some fire damage. Overhead canopy was high in some areas and sparse in others, but the overall canopy percentage was 42%. Dominant instream shelter for fish consisted of boulders (25%) and pool depth (6%). The dominant substrate is bedrock and cobble. Relatively little spawning gravel was observed, having been noted in only 29% of the pools measured. Aquatic life consisted of California newts, frogs *Hyla* species and insects; no fish were observed.

Of notable interest, a third trip was made during September 1997, to retrieve a TempMenter left during September 1996. Although the TempMenter was not recovered, the stream was much harder to hike through than it had been in September 1996. The alders that were three to four feet high in 1996, had grown ten to fifteen feet tall and providing at least a 75% canopy cover. Although many of these trees will be scoured out in the next high flow event, many will remain to provide shade, woody debris and organics for invertebrates. The North Fork of San Onofre Creek was surveyed in March 1997, using two crews working downstream from Upper and Lower Case Springs. The first crew was halted approximately 1.7 km downstream of Case Spring by an impassable 10 m waterfall. The second crew surveyed from lower Case Springs to Jardine Road above the Range 210 series (Figure 18).

The North Fork consists of bedrock pools and waterfalls within a narrow, highly confined canyon. Maximum and average pool depth were 3 m and 1 m respectively. Dominant substrate was bedrock/boulders and sand. A series of barriers block upstream fish migration approximately 2 km above the confluence with Jardine Canyon. The lower section below the first barrier was dry spreading out into a wide alluvial flood plain. Riparian communities on the North Fork were well established and supported abundant amphibian populations as well as introduced exotic fish.

Water Temperature and Dissolved Oxygen:

Santa Margarita River:

Stream temperatures on the SMR near Fallbrook CA, show that the average monthly maximum temperatures May 1995 to September 1996, exceeded the reported lethal limit for trout (>25°C) (Hokanson et. al. 1977; Jobling 1981; Bojornn and Reiser 1991) in July, August, and September (Figure 19). In 1996, average monthly maximum temperature exceeded 25°C in July and August, and average monthly minimum temperatures occurred in early January. The 25°C reported lethal limit may be a good benchmark when steelhead are exposed for extended periods of time, it may not be as critical if fish have an

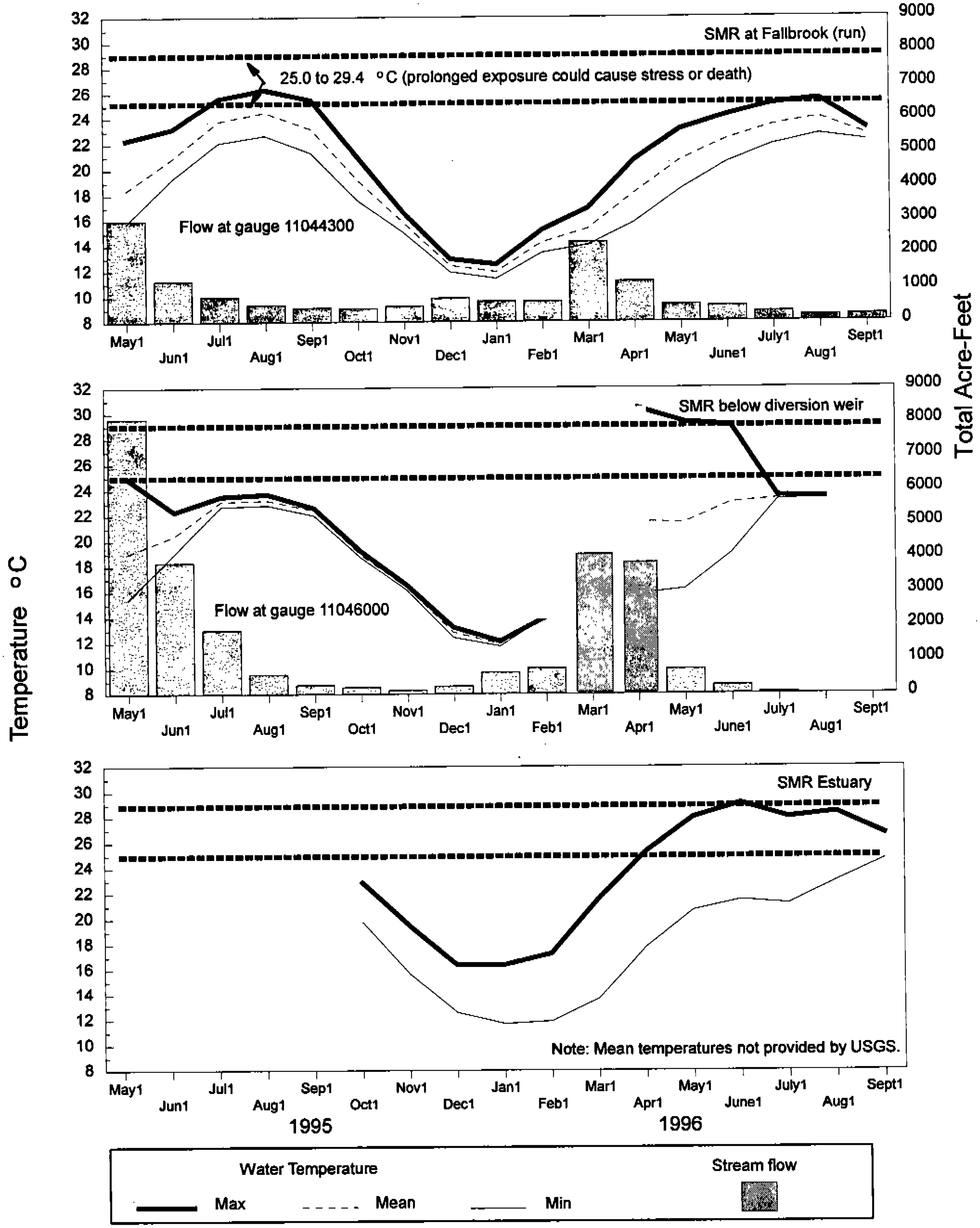


Figure 19. Water temperatures and flows for the Santa Margarita River TempMenter locations (Fallbrook near De Luz Road bridge, diversion weir, and estuary) May 1995 - September 1996.

opportunity to move in and out of areas of potentially lethal temperatures. Carpanzano (1996) found rainbow trout in streams with water temperatures as high as 28°C, and native redband trout in intermittent desert streams of eastern Oregon were found actively feeding in water 28.3°C (Behnke 1992). Steve Netti reported observing rainbow trout from San Diego streams actively feeding in water as high as 29°C (SDRWQCB 1997). Juvenile steelhead on the Eel River in northern California were found withstanding water temperatures of 29°C (Wales 1938). In addition, water temperatures of 29.4°C were found in a stream containing rainbow trout just below the Mexican border in Rio San Rafael, Baja California (Ruiz-Campos and Pister 1995).

In determining the amount of time in July and August that temperatures exceeded 25°C, an average hourly water temperature was calculated for a two week period each year. In 1995, the warmest stream temperatures occurred between July 25 and August 8, and in 1996, the warmest stream temperatures occurred between July 18 and July 31. Despite higher flow in 1995, water temperatures exceeded 25°C an average of 11.5 hours a day. The warmest temperatures occurred between 1630 and 0400 hours (Figure 20). Water temperature exceeded 25°C an average of 7 hours a day, between 1400 and 2200 hours for the two weeks in July 1996. With the exception of these warmest months, water temperatures were below the reported lethal limit for trout the remainder of the year.

A second TempMenter was located on Base below the Lake O'Neill diversion weir from May 1995 to January 1996, and again from April to August 1996. The gap in data collection resulted when the TempMenter was removed due to construction at the weir site. The greatest differences in daily maximum and minimum water temperatures occurred in the spring, prior to the flow becoming subsurface (Figure 19). During the day, temperatures exceeded 25°C in April of both years. Maximum water temperatures in April and May of 1996, exceeded 29°C during the day. At night, surface temperatures drop to 16°C, near that of early morning air temperatures.

During the spring after flows become subsurface, daily water temperatures were stabilized and significantly cooler below the diversion weir then were water temperatures near Fallbrook during the same time period. At some point upstream of the confluence with De Luz Creek flow becomes subsurface and insulated from direct solar heating, as well as heat loss during the night. The result is little variation in the daily maximum and minimum water temperature below the diversion weir, July through December.

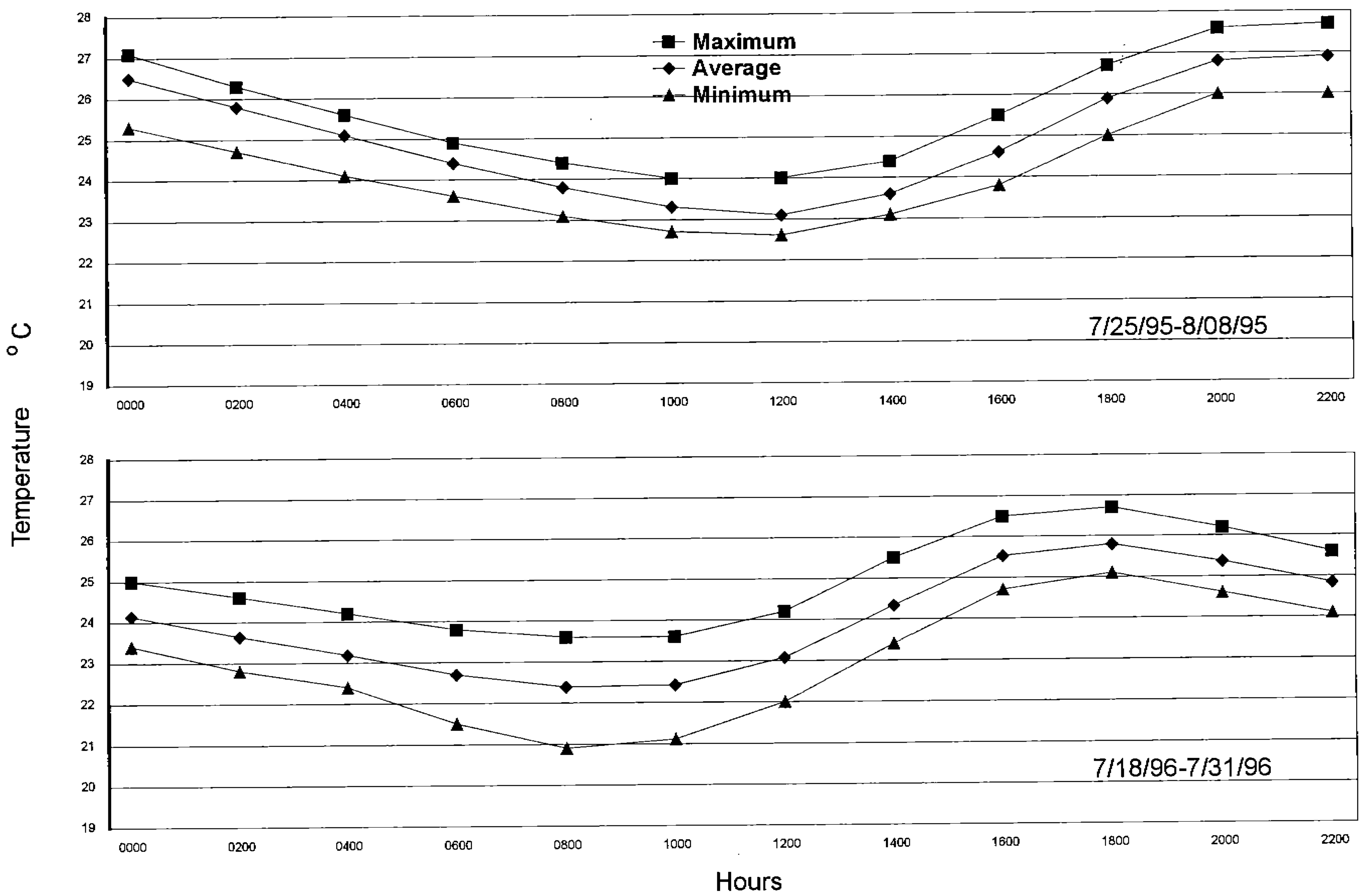


Figure 20. Average hourly water temperatures during the warmest two week period in 1995 and 1996, Santa Margarita River near Fallbrook.

Temperature and specific conductance data for the SMR estuary recorded from October 1995 to September 1996 at the USGS gauge 11046050 (SMR at the mouth near Oceanside) were evaluated. The SMR estuary/lagoon is the only Base estuary/lagoon system that does not close off to the ocean for long periods each year. Specific conductance increased beginning in mid-May and continued through mid-January. This is indicative of the mouth remaining open and probable formation of a saltwater lens. The denser water comprising the saltwater lens remains along the bottom and can act as a heat trap, resulting in an inverted water temperature profile and low levels of dissolved oxygen. Maximum water temperatures exceeded 25°C May through September, and both the maximum and minimum water temperatures exceeded 25°C in August and September. Dissolved oxygen levels were the lowest in late October to mid-November 1995 and late January 1996. Increased levels of dissolved oxygen were associated with decreased specific conductivity due to increased freshwater inflow beginning in late January. Minimum levels of dissolved oxygen again reached a lethal range when freshwater inflow decreased and salinity increased May through September 1996. Since the water quality data was recorded at only one location it is impossible to determine whether juvenile steelhead could avoid lethal fluctuations in salinity, temperature, and dissolved oxygen. Salmonids respond to increased temperatures and low dissolved oxygen concentrations in estuaries/lagoons by moving upstream into areas of freshwater inflow (Smith 1991, Zedonis 1992). In the absence of freshwater inflow or up welling, rearing salmonids are not likely to survive.

San Mateo Creek:

Water temperature data collected below the falls in the CNF show average monthly maximum temperatures did not exceed 25°C, for the period; June 1, 1995 to September 1, 1996. The highest temperatures (24.5°C) occurred in August 1995, and lowest (10.3°C) temperatures occurred in January (Figure 21A). SMC was flowing in September at the upper USGS gauge station near the eastern Base boundary (Figure 21B). Given this, it may be safe to assume that flow was continuous upstream to the falls in the CNF at least into September 1995. Conversely, flows were much lower in 1996. Cumulative monthly flow for April 1995 and 1996 at the upper USGS gauge station were 3,670 and 298 acre-ft, respectively (Figure 21B).

By late June 1996, flows at the upper USGS gauge station were already dry, and any upstream flow was likely intermittent. However, water temperatures were cooler below the falls (CNF) in 1996 than in 1995, despite less surface flow (Figure 21A). Maximum water temperatures were cooler (18.3°C) in late June than they had been in April, May or

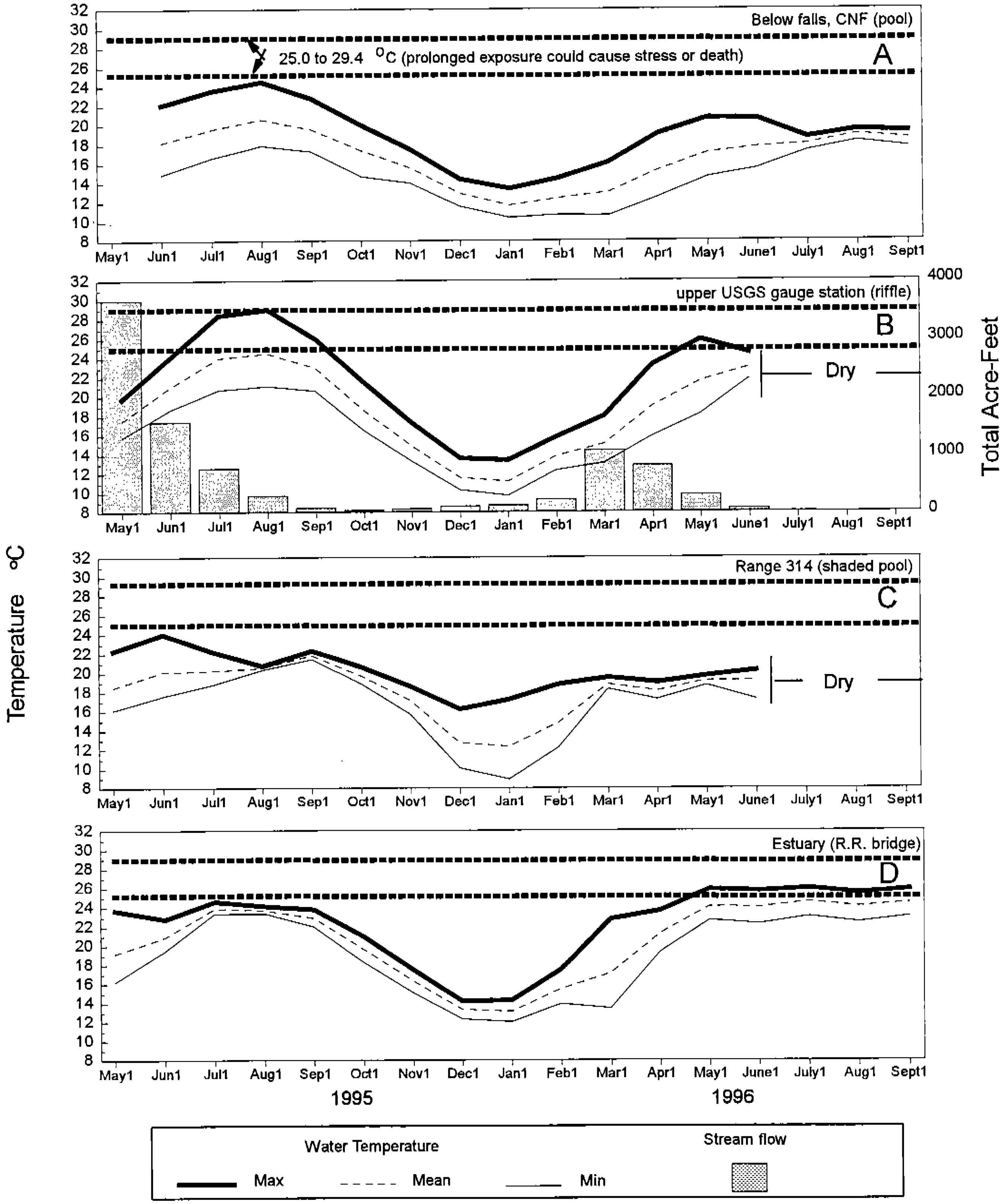


Figure 21. Water temperatures and flows for San Mateo Creek TempMenter locations (below falls CNF, upper USGS gauge, Range 314, and estuary) May 1995 - September 1996.

early June. Cooler water temperatures could be a result of several influences such as; milder summer air temperatures in 1996, increased shade due to recovering riparian habitat, greater influence of springs and coldwater seeps due to less water volume or a combination of all of the above.

In May 1995, the USFWS placed three TempMenters in SMC on Base. The first of which was located in a riffle at the upper USGS gauge station. Temperatures increased through August 1995 in proportion to the decreasing flow (Figure 21B). In 1995 the highest temperatures occurred in July and August. Hourly stream temperature data from a two week period (July 18 to July 31) showed that the temperature remained above 25°C an average of nine hours per day from 1200 to 2100 hours (Figure 22).

Temperature data in October 1995, may be more related to air temperature. SMC in October and early November 1995 may have been dry from the upper USGS gauge downstream to the estuary. In 1996, water temperatures reached maximum temperatures earlier. By early May, maximum temperatures had already reached 25°C, and the channel was dry by June (Figure 21B).

A second TempMenter was placed in one of the few pools between the estuary and the upper USGS gauge station. Located 300 m above the San Mateo Road bridge, this pool was well shaded from direct sunlight by a large mature willow tree. Water temperatures remained below 25°C throughout 1995 and 1996. Water temperature fluctuated most during the early spring and winter months. Daily fluctuations in springtime water temperatures, measured at the Middle TempMenter site (Figure 21C), resulted from the SMC flowing approximately 4.5 km from the eastern Base boundary through a relatively wide channel with large stretches of stream exposed to direct sunlight. At night, heat is lost in these same stretches due to cooler air temperatures. In 1995, SMC flow became intermittent and completely subsurface by the end of July. This happened earlier in 1996, with SMC becoming intermittent by the end of March, and mostly subsurface by May. Although surface flow has ceased, shade and subsurface flow can continue to keep water temperatures in pools relatively cool into the fall, at which time the pool may dry out. The Middle TempMenter was underwater at least into mid-September in 1995, but became dry by June 1996 (Figure 21C).

A third TempMenter was secured near the railroad bridge in the SMC estuary. In 1995, maximum water temperatures (25°C) were reached during the month of June in the estuary (Figure 21D). Water temperatures began to decrease in August and decreased at a faster rate from October through January. During February 1996, minimum

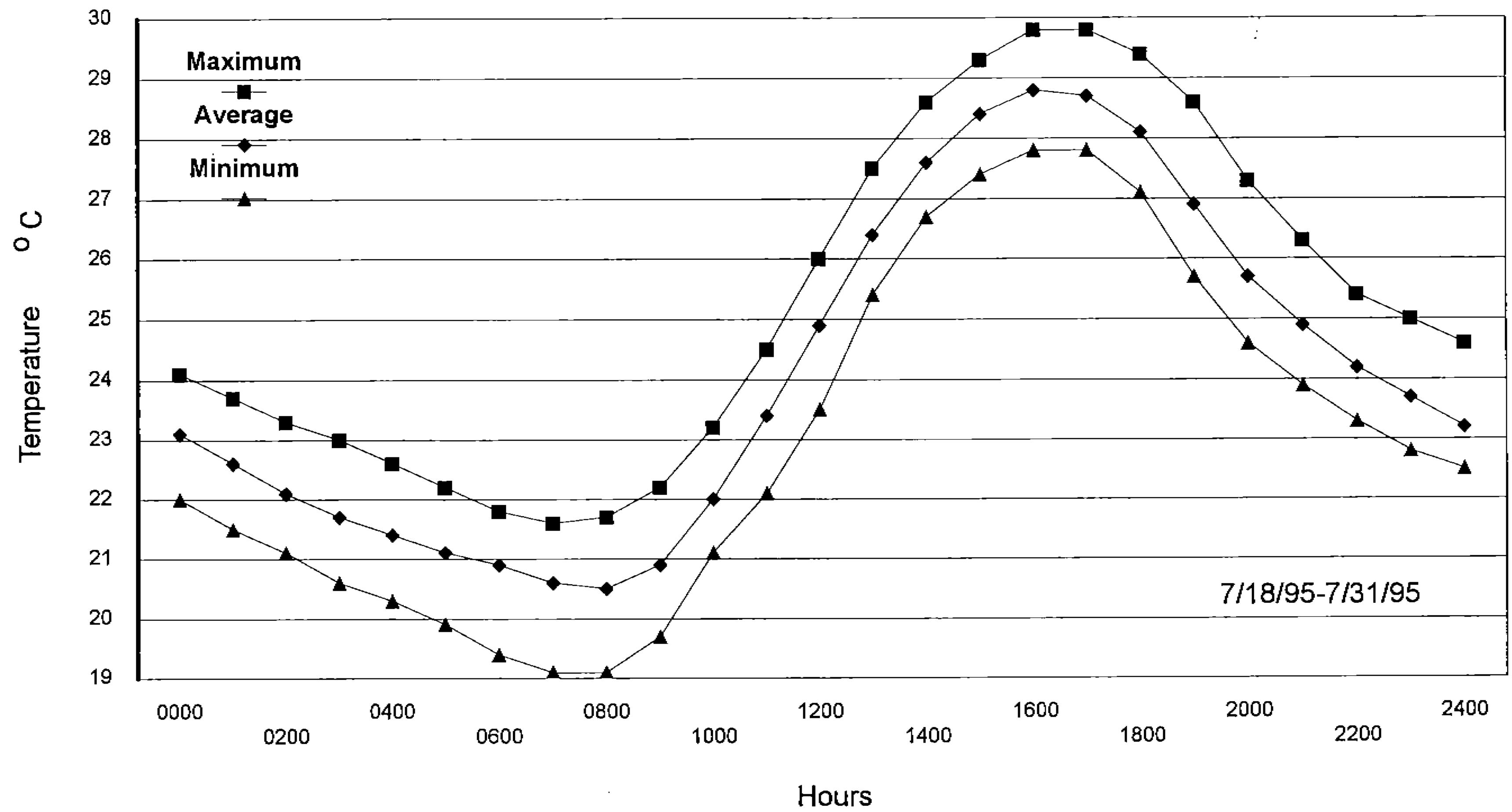


Figure 22. Average hourly water temperatures during the warmest two week period in 1995, San Mateo Creek upper USGS gauge station.

water temperatures decreased after initially starting to rise, which may coincide with diurnal tidal influence associated with a breach in the sand bar. March water temperatures steadily increased through April at which time they became relatively stable. Maximum water temperatures consistently stayed at 26°C from May through September 1996, while the average remained close to 25°C and the minimum did not drop below 23°C.

The SMC and SOC lagoons are stable and closed most of the year. Both lagoons have sandy substrate and develop extensive aquatic vegetation which provides cover. For the SMC lagoon, water temperatures at the base of bridge abutments were measured a total of 805 days, from May 4, 1995 to September 4, 1997. The number of days water temperatures exceeded 25°C varied depending on the water year type. The 1995 water year was considered above average, maximum water temperatures greater than 25°C occurred in May, June and July. Conversely, for 1996, a normal water year, water temperatures exceeded 25°C during a seven month period, March through September. There were twenty-two days when 25°C or higher was the minimum water temperature, and again water year type was a significant factor. Minimum temperatures greater than 25°C occurring during July 1995, May through July in 1996, and June and July for 1997. The 1997 water year was considered dry. Dissolved oxygen were not monitored in the SOC or SMC.

Summary of Past Santa Margarita River Water Quality:

Baseline water quality conditions of the SMR were measured by Hunsaker (1992) and the Cadmus (1992). This monitoring was instituted prior to the Eastern Municipal Water District (EMWD) and the Rancho California Water District (RCWD) discharge of reclaimed water into the SMR as a management plan to maintain compliance with 40 CFE 131.12 and State Board Resolution No. 68-16 anti-degradation policies.

Water quality data collected by Cadmus and data collected by Hunsaker were combined and examined (Cadmus 1992) as an indicator of recent conditions. Cadmus also attained a portion of past water quality monitoring data collected by the Base's Natural Resources Office as reported by Leedshill-Herkenhoff, Inc. (1988) and NBS/Lowry (1989). Based on limited information, there are some noticeable trends as cited from Cadmus (1992).

> Temporally, trends in water quality are not apparent in most cases. This may be partially attributed to spotty data, both temporally and spatially. Otherwise, the only real noticeable change in water quality over time exists at the downstream

location of Fallbrook where nitrate and phosphate concentrations increase markedly from 1982 to 1988 (some fluctuation observed). The comparison of water quality above and below the confluence of Rainbow Creek indicate the strong probability that this tributary is the source of poor water quality due to recent development in its upstream reaches.

Spatially, there are some observed trends in water quality. Storet and USMC observations indicate that, for most entities tested for (e.g. total dissolved solids, nitrate, phosphate, ect.), concentrations generally increased from the upper reaches of the SMR (just above the confluence) to the lower reaches (the vicinity of the mouth). This can largely be attributed to the general increase in human population and development in the lower watershed in contrast to the upper watershed.

The water quality concerns of live stream discharge were addressed in Cadmus (1992). A potentially significant implication cited was the affect of live stream discharge on indigenous aquatic species which are those populations well adapted to an arid environment. Also, an increase in the downstream energy associated with increased flow would alter the existing kinetic energy balance in the system, causing unknown short-term and possible long-term changes in the transport and storage of sediments, nutrients, and any toxic chemicals occurring in the system. The change in flow regime and relative proportions of nutrients within the system would also change the basis on which plant species compete for nutrients and likely cause shifts in species compositions within the affected wetlands and their associated waters. Some animal species could be harmed by these changes, but the increased productivity might also benefit other animal species with increased forage and habitat opportunities.

The question remained about the short-term and long-term effects of live stream discharges and associated increased nutrient loading rates. Would discharges cause periods of high algal growth rates, accompanied by periods of dissolved oxygen depressions or depletions resulting in subsequent fish kills in the river and/or aggravate conditions in the estuary? In a use-attainability study of the Santa Ana River (Riverside County), the SMR and its tributaries were used as a reference reach for the Santa Ana River because the SMR was considered unimpacted by the release of municipal wastewater effluents (Chadwick et al. 1992).

For dissolved oxygen with regard to steelhead, Barnhart (1986) suggested steelhead do best with dissolved oxygen concentrations of 7.75 mg/l or higher, with 5.0 mg/l sustainable for short periods and lower than 4.24 mg/l as harmful. Barnhart also noted that steelhead have difficulty extracting oxygen from water at temperatures greater than 21°C. Dissolved oxygen, however, may be less critical than temperature for trout adapted to environments having extreme water quality parameters. Rainbow trout living in permanent and intermittent flow conditions in northeastern Sierra Nevada mountains have survived near-lethal conditions (Erman 1975). Daytime dissolved oxygen concentrations and temperature in isolated pools indicated that rainbow trout fry survived near-lethal conditions frequently. Fry in pools survived temperatures of 22.4°C that were often associated with low dissolved oxygen levels. Fry in one pool had dissolved oxygen concentrations of 0.6 mg/liter a few cm below the surface, and the water temperature was 16.7°C (Erman 1975). The San Diego Water Quality Board set the dissolved oxygen level for the SMR at not less then 5.0 mg/l.

Cadmus (1992) noted that because all dissolved measurements have occurred during the day, avoiding times of expected minima, it is not known if water quality objectives for the SMR are being met. However in an early 1990's report to the EPA, Mike Marcus of the Cadmus group showed a diurnal sag in the dissolved oxygen curve did violate the stated water quality objectives. Algal mats in the SMR may suggest oxygen supersaturation could occur during peak photosynthesis and oxygen depletion at night.

During our surveys on the SMR and throughout the Base, dissolved oxygen concentrations were not found to be less than 7.3 mg/l (Table 16-17). Woelfel (1991) found dissolved oxygen concentrations in May of 3.4 mg/l in SMC just above the lagoon and 3.0-6.0 mg/l (at 0620 hours) in pools within the CNF during August. With the exception of water temperature data, the infrequent nature of our field surveys did not lend itself to the kind of consistency necessary to determine if State water quality objectives are being met. In addition, water quality tests are not very revealing because pollutants are seldom discharged continuously and therefore their presence may be missed by an infrequent sampling regime.

Macroinvertebrate sampling was conducted once during the spring of 1997, because it is indicative of present and past water quality conditions. We acknowledge one time sampling has its inherent limitations, but it does provide an initial baseline to which future investigators can compare. Nevertheless, relative abundance and presence or absence of certain indicator species can give insight into the condition of the stream and its current potential for trout.

Table 16. Dissolved oxygen data on Base for the period 4/22/96 to 4/24/96.

Location	Temp °C	D.O. (Mg/l)	Time	Altitude [1] (m)	Salinity* (0/00)
San Onofre Cr. (below Horno)					
a) vegetated pool	22.0	9.6	1345		
b) vegetated glide	22.0	9.2	1350		
c) plunge pool under bridge	21.0	9.4	1355		
d) glide above pool	21.0	8.4	1358		
Case Springs	20.0	7.8	1500	690	
Case Springs (outfall pool)	20.0	7.3	1518	645	
SMC at USGS gauge pool	26.0	9.8	1641	101	
SMC at riffle below gauge pool	25.0	9.8	1649	101	
San Onofre Estuary	26.0	11.20	1645	0	
San Mateo Cr. at Range 314	22.0	10.4	0945	69	
San Mateo Cr. (trap site)	21.5	9.2	1005	69	
San Mateo Estuary (top)	20.5	14.2	1200	0	0
"	"	13.6	"	0	10
"	"	12.8	"	0	20
"	"	12.0	"	0	30
"	"	11.4	"	0	40
San Mateo Estuary (bottom)	20.0	14.4	"	0	0
"	"	13.8	"	0	10
"	"	12.8	"	0	20
"	"	12.0	"	0	30
"	"	11.4	"	0	40
San Onofre Estuary	24.0	10.4	1222	0	0
"	"	10.1	"	0	10
"	"	9.6	"	0	20
"	"	9.0	"	0	30
"	"	8.6	"	0	40
Santa Margarita R. Estuary	17.0			0	36
Santa Margarita R. at hospital	29.0	7.7	1340	68	
Santa Margarita R. at Fallbrook	19.5	8.8	1030	88	

* Dissolved oxygen measurement at the given salinity value adjusted on the DO meter.
A salinity meter was not available at the time sampling was conducted.

Table 17. Camp Pendleton water quality data, 3/17/97 to 3/26/97.

Site	Temp. °C	Avg Depth (m)	pH	Time	D.O. mg/L	NO_3 mg/L	NH_4 mg/L	Specific Conductivity umhos/cm^{-1}	TDS mg/L	Salinity ppt
Santa Margarita River										
1	18	0.15		1700	9.50	0.03	Negligible	2.10	129	15.00
2	14	0.46	7.30	845	10.60	2.10	0.30	1.31	65	11.00
3	18	0.12	7.00	835	9.00	1.60	Negligible	1.47	74	1.00
4	27	0.24	7.60	1130	11.50	2.30	<.10	1.10	61	0.00
5	28	0.06	7.80	1400	8.20	0.08	<.01	1.35	68	4.00
6	19	0.91	7.20	1030	7.40	2.10	0.02	1.50	75	0.05
7	22	0.30	7.40	1725	8.00	1.30	0.01	1.41	71	1.00
8	22	0.61	8.30	1515	7.80	3.60	0.60	1.90	95	1.00
9	22	0.15	7.50	1150	9.60	>.01	Negligible	0.40	20	0.00
San Mateo Creek										
1	18	0.15	7.70	945	9.00	2.1	>.01	0.61	34	0.00
2	17	0.27	7.50	1450	12.00	2.2	<.1	0.57	29	<.01
3	18	0.18	6.80	1705	8.40	1.6	<.1	0.36	18	0.50
4	18	0.46	7.50	1200	9.60	2.1	Negligible	0.60	31	0.20
5	17-18	0.46	7.50	1300					26	0.00
6	17	0.91	7.00	1153	8.50	2.1	0.20	0.59	30	0.00
San Onofre Creek										
1	25	0.27	6.90	1520	8.10	3.5	0.07	0.96	48	
1	13	0.15		730	9.20					
2	21	0.06	6.80	1110	9.40	2.4	0.30	8.20	43	1.00
3	15	0.91	6.20	815	8.10	2.9	0.50	0.21	11	

Sample site locations:

Santa Margarita River

1. Estuary, 91 m below of I-5 bridge (mouth open)
2. Above Stuart Mesa road
3. Below Base Airstrip
4. Below Lake O'Neill Diversion Weir
5. Road crossing to Camp De Luz above mouth of De Luz Cr.
6. Fallbrook at De Luz road bridge
7. Willow Glen road
8. Murrieta Creek above confluence with Temecula Creek
9. Roblar Creek above confluence with De Luz Creek (on Base)

San Mateo Creek

1. Leased farmland across from State parks campground
2. Firing range 314
3. Telega road crossing (on Base)
4. Upper USGS gauge site, eastern Base boundary
5. Below Bluewater Canyon, Cleveland National Forest
6. Tenaja road crossing, Cleveland National Forest

San Onofre Creek

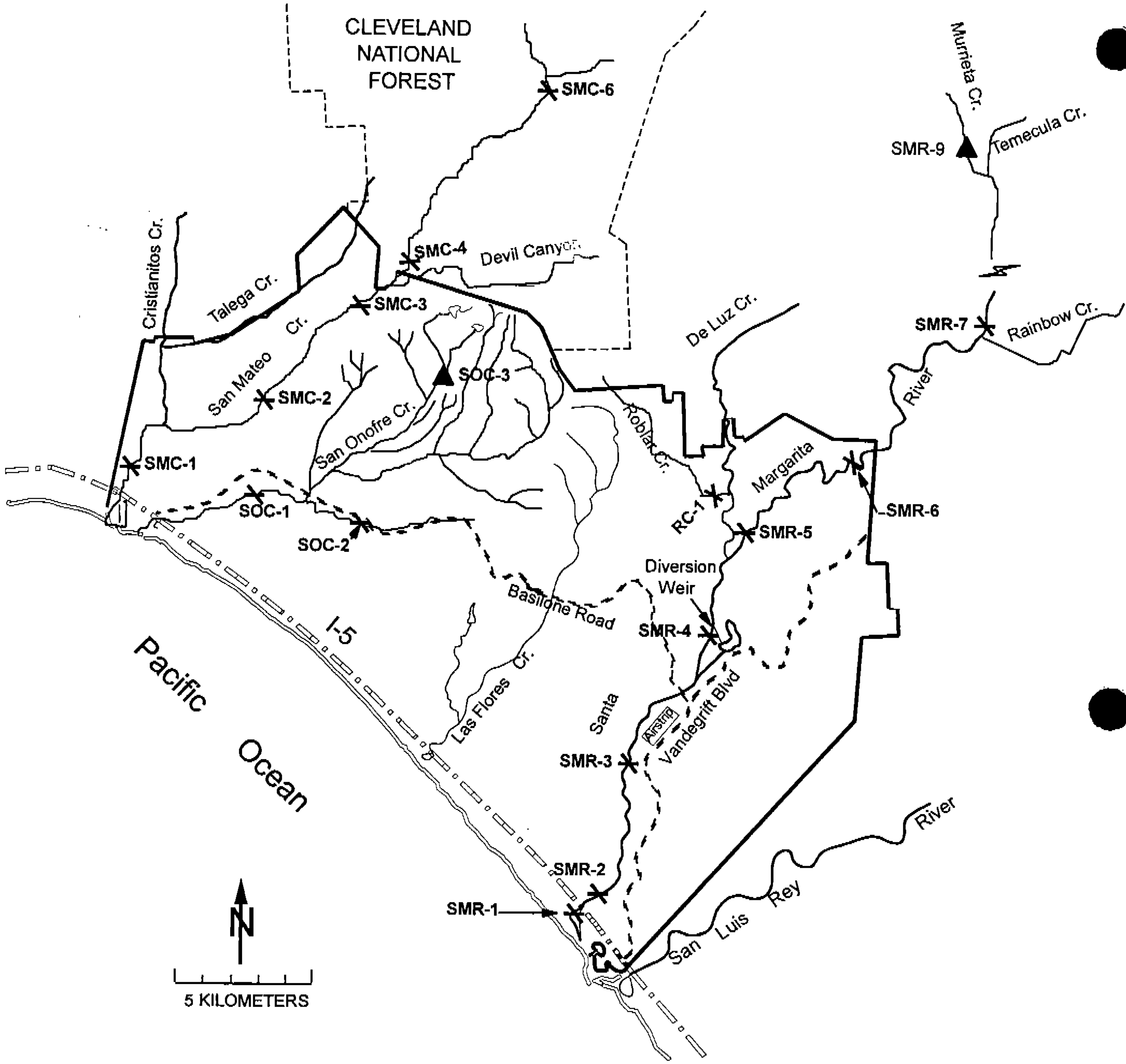
1. Below firing range 207A
2. South Fork, at Camp Horno
3. North Fork, below Upper Case Springs outfall

Macroinvertebrate Sampling:

Eleven sites were sampled on Base and three off Base (Figure 23). Sample sites were selected due to past monitoring activities (aquatic insects and/or water quality) or ease of accessability. Three of the Hunsaker (1992) sites and six of the Cadmus (1992) sites were relocated (Table 18).

In addition to water quality, Hunsaker also conducted macroinvertebrate surveys on the SMR. An invertebrate reference condition data set for San Diego County watersheds approximating pre-settlement biological, physical, and chemical conditions does not exist. Hunsaker (1992) composed reference condition metrics for the SMR by applying an aggregate data set comprised of invertebrates collected throughout San Diego County. Although this is not the preferred method in establishing reference condition values, it does accomplish the inter-basin metric comparisons necessary for population analysis. Potential bias exists in that collections taken from adjacent watersheds may reflect conditions equal to or more degraded than conditions to those in the study watershed. Furthermore, without accounting for the natural geographic variation potential among differing geographic zones, reference metrics may inadequately represent the existing habitat. For these reasons, our macroinvertebrate sampling was conducted primarily to compare the relative abundance of food items available for rearing juvenile steelhead, and secondarily to infer habitat quality trends. In general, a normal stream will be rich in species with no single group predominating, whereas a polluted stream is poor in the number or variety of species but often rich in individuals (Usinger 1956).

Collectively, sample sites were represented by 9 orders, and 45 families. Invertebrates that make up the zoobenthos include many aquatic insects such as immature mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera); groups often collectively abbreviated as EPT. The abundance of these three orders is commonly combined as an index to availability of food for stream fishes (Lenat 1988). EPT species consist of the main food items consumed by trout. Other major invertebrates consumed by trout include midges (Chironomidae:Diptera); crane fly larvae (Tipulidae:Diptera); some other dipterans; beetle larvae (Coleoptera); crustaceans including scuds (Amphipoda). The general consensus with regard to organism-substrate relationships are that coarser particles (gravel, pebbles, cobbles) are preferred by EPT whereas fine-particle substrates (sand, silt) are inhabited by chironomid larvae and burrowing forms that often are not readily available to foraging fish (Reman and Erman 1984; Minshall 1984, *in* Waters 1995).



Base boundary, Basilone Rd., Vandegrift Blvd			Insect & water quality sampling site
Stream			Water quality sampling site only
SMR= Santa Margarita R.	SMC= San Mateo Cr.	SOC= San Onofre Cr.	RC= Roblar Cr.

Figure 23. Macroinvertebrate and water quality sampling sites, March 1997. Note: Sites for SMR-8 and SMC-5 were intentionally omitted.

Table 18. Water quality and macroinvertebrate sample sites.

Past Reports			Site Locations
1992 Cadmus Water Quality	1992 Hunsaker Water Quality & Macroinvertebrates	1997 USFWS Water Quality & Macroinvertebrates	
1		SMR9 *	Murrieta Creek
2	A		Temecula Creek
3	B	SMR8 **	Santa Margarita River near Temecula
	C		San Diego State University Station
4	D	SMR7	Santa Margarita River above Rainbow Creek
5			Rainbow Creek
6			Santa Margarita River at Fallbrook PUD
7	E	SMR6	Santa Margarita River at De Luz Rd. bridge (Fallbrook)
8			De Luz Creek
		SMR5	Santa Margarita River above De Luz Camp Rd.
9	F	SMR4	Santa Margarita River at the diversion weir
		SMR3	Santa Margarita River below Base airstrip
10	G *	SMR2	Above Stuart Mesa Rd.
11	H *	SMR1*	Santa Margarita River Estuary
		RC1	Roblar Creek above De Luz Rd.
		SOC1	San Onofre Creek below range 207A
		SOC2	San Onofre Creek below wastewater Facility
		SOC3	San Onofre Creek below upper Case Springs
		SMC1	San Mateo Creek above State campground
		SMC2	San Mateo Creek below firing range 314
		SMC3	San Mateo Creek below Telega Rd. crossing
		SMC4	San Mateo Creek above USGS gauge station
		SMC5 **	San Mateo Creek between Fishermans Camp and Base
		SMC6	San Mateo Creek at Los Alomos truck trail

* water quality only
** no water quality or macroinvertebrates sampled

One Ephemoptera family (Baetidae) is less sensitive to anthropogenic impacts (Lenat, 1988). The abundance and diversity of Baetidae make them an important food source for trout. Yet due to their relative tolerance of sediment their presence is not indicative of quality trout habitat. Large numbers of Baetidae can bias an EPT score, thus, EPT minus Baetidae in conjunction with other community measures (i.e. taxa richness and percent dominant family) were used as measures of the relative habitat quality for trout. Taxa richness measures the number of different species, and percent dominant family measures community balance.

Samples from a site on Roblar Creek and from two sites on SMC, sample sites SMC-3 and SMC-4, indicated they possess the most balanced macroinvertebrate communities as represented by the largest taxa diversity and the lowest component of Baetidae species (Figure 24). The one Roblar Creek site represented the highest taxa richness value of all sites sampled. This was expressed by the low dominant family percentage and intermediate EPT metric scores and is indicative of a stable highly interactive community assemblage (Resh and Rosenberg 1994). Sample site locations SMC-3 near Range 313, and SMC-4 located in the vicinity of the boundary of the Base and the CNF, also contained heterogeneous gravel and cobble substrate. Conversely, the middle SMR 2,4,5 and SOC 1 and 2, ranked as having relatively poor macroinvertebrate communities. The middle SMR sites had relatively low numbers of taxa, and Baetidae composed between 85 and 100% of the EPT species. The four lowest sites on the SMR were represented by 168 specimens from 19 families and constituted the lowest taxa totals on Base. This was not unexpected, macroinvertebrate abundance is less in homogenous sand and silt substrates. Sample sites SMR 6 and SMR 7, showed slight improvement in the macroinvertebrate composition, and empirical habitat typing data correlated strongly with the greater habitat complexity further upstream.

SMC sample sites showed intermediate to high taxa richness values, and sites 2,3, and 4 had the highest EPT and EPT minus Baetis metric scores (Figure 24). Sample site SMC 1 showed population characteristics similar to the lower SMR sites in that it was primarily dominated by Baetidae and sediment tolerant Chironomidae species. Within the Chironomidae family, we found fewer individuals as we moved higher in the basin, which mirrored the general improvement in the quality of habitat. Members of the order Coleoptera (beetles) were found in higher numbers throughout the lower three SMC sites, indicative of lotic well mixed habitat locations.

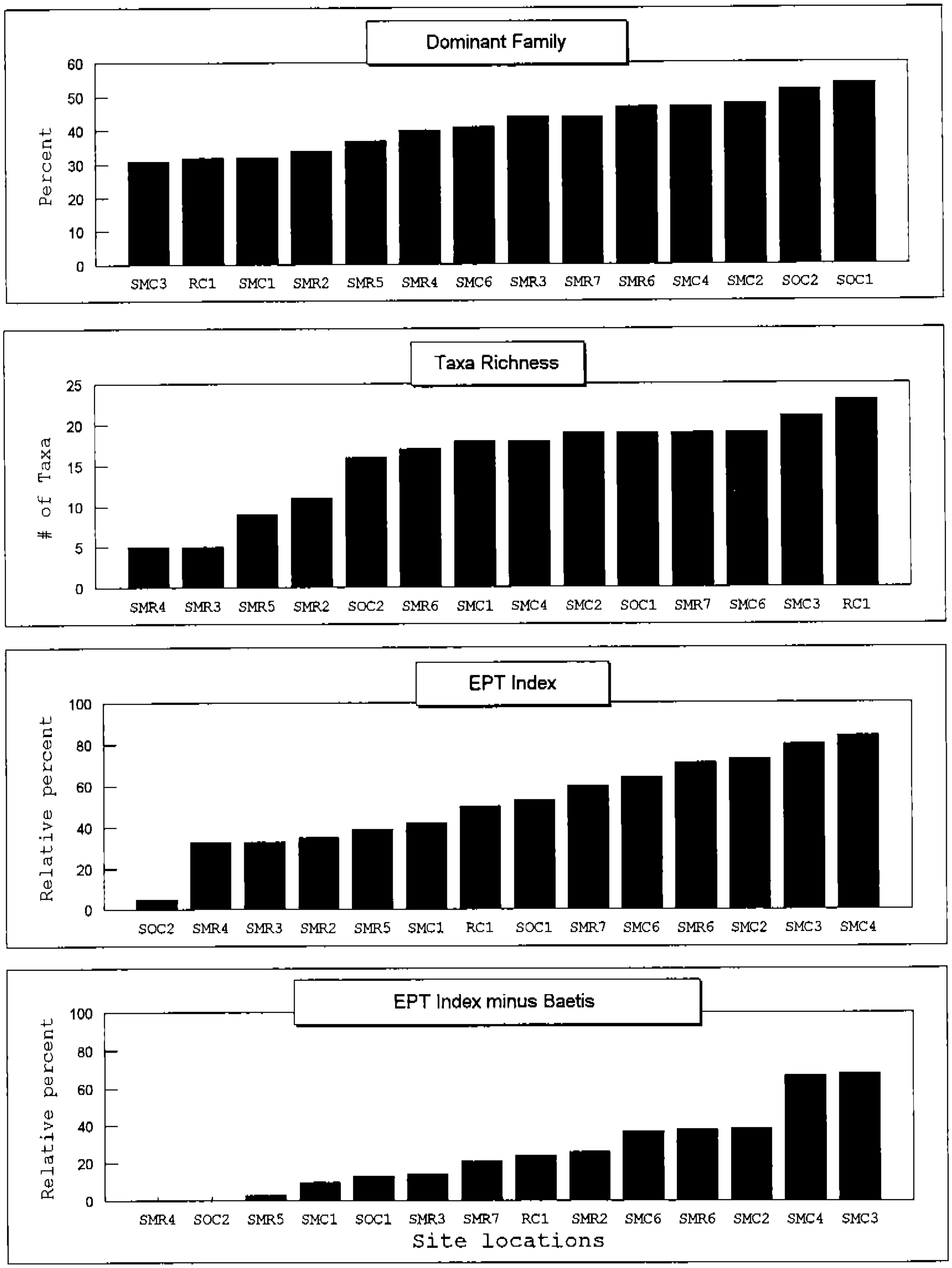


Figure 24. Inter and intra-basin macroinvertebrate metrics values from high to low, for Santa Margarita River (SMR), San Mateo Creek (SMC), San Onofre Creek (SOC) and Roblar Creek (RC).

Both SOC site scores ranked 1 and 2 respectively, for percent dominant family. Both sites consisted mainly of Baetidae and Chironomidae. Intermediate taxa richness values and low EPT scores imply degraded and altered conditions. Sample site SOC 2 had a thin layer of plant material covering the benthos attributable to its location immediately downstream of an wastewater treatment facility, a source of organic enrichment. This observation was also supported by the composition of the macroinvertebrate community. Also of interest for the two SOC sites was the fact that the stream flow is intermittent and is highly dependent on treatment facility effluent to support this community when the remainder of the creek has ceased flowing. There were 1,630 Baetidae found at sample site SOC 1, representing the highest density of all sites sampled. SOC 2 was unique in that it was the only location where leeches were found. Barbour et al. (1996) showed the presence of leeches was highly correlated with organic enrichment.

In general, the diversity and abundance of EPT species improved as habitat became more heterogenous. The transition from homogenous substrate to heterogenous substrate occurred in the upstream direction. This transition occurred just below the Fallbrook Bridge Road on the SMR, and began near Range 313 on the SMC and proceeded upstream into the CNF. The two SOC sites were relatively low in the basin, however, if sampling were to occur further upstream, the diversity scores would be expected to improve due to better quality habitat conditions.

Role of Estuaries/Lagoons:

Base streams are not dissimilar to other arid watersheds in southern California stream systems where percolation and/or extensive diversion or pumping restrict surface flows substantially in many years. Smith (1994) found upstream passage for adults in these systems was rarely completely blocked due to movement during winter storms, but smolt passage in spring was likely to be frequently restricted by low stream flow. In droughts, few smolts may emigrate, unless they migrate during peak winter flows. Smith (1994), described lagoon/estuary usage by juvenile steelhead in similar streams in central California as infrequent due to restrictive up and downstream migration opportunities and that the contribution of an estuary to smolt production probably varies from year to year. A majority of smolt production would benefit from estuary rearing during good water years but receive no benefit during periods of drought. It has been demonstrated that growth rates are greater in juveniles able to utilize the estuarine environment (Shapovalov and Taft 1954, Smith 1994), but if access is not available, rearing will occur in the river. Given the historical cyclic wet to dry weather patterns, it is plausible that steelhead reared in Base estuaries/lagoons in wet years and in the river in dry years.

Smith (1994) described growth and survival of juvenile steelhead to be good when lagoons were open to full tidal mixing. However, growth and survival were also good after lagoons had converted to unstratified (freshwater) conditions, which resulted in lower water temperatures and higher bottom dissolved oxygen levels. Survival and growth were poor when salinity was stratified, which resulted in high water temperatures and poor bottom dissolved oxygen. This occurred when the transition periods between sandbar closure and freshwater conversion occurred over a long time period.

A closed but tidally influenced estuary was beneficial to southern steelhead in the Arroyo de la Cruz. Arroyo de la Cruz flows through the Hearst Ranch in San Luis Obispo County and supports one of the larger populations of steelhead on the central coast. Watershed management practices (low cattle grazing intensity, controlled access, and little other human activity in the watershed) have maintained the vigor of the population over the years, while populations in most other central coast streams have declined or been eliminated (Jones and Stokes Associates 1982).

According to Jones and Stokes Associates (1982) the small Arroyo de la Cruz lagoon had a maximum depth of 1.0 m with depths less than 0.6 m typical in August 1981. Although the water surface elevation changed 0.3 to 0.6 m with the tide, ocean salinity was not detected in the lagoon. Conductivity ranged from 390-445 Umhos/cm which was typical for the area. Water temperatures at different locations ranged from 16 to 26°C during daylight hours. Steelhead showed a definite preference for vegetation cover. They were observed only in areas of dense overhanging willows or dense algal mats. Almost all steelhead were observed in a 61 m long area of overhanging willows. Water depth was 0.3-0.9 m, and the area extended for up to 1.8 m underneath the willows. Willow branches and roots formed a tangle in which the fish were densely packed. The estimated number of steelhead using the estuary was 7,500 to 13,000 fish. Jones and Stokes (1982), tentatively concluded that some juvenile steelhead age class 0+ and 1, migrate directly from inriver perennial habitat to the ocean when flows are high and the bar is open. Many others make the transition from upstream reaches to the ocean in two stages, especially when the bar is closed and there is surface flow in the intermittent reach. In this case, predominately age class 1 fish move from the perennial reach to the lagoon, probably between March and June, and spend the summer and autumn in the lagoon before entering the ocean. Both the perennial reach and lagoon are essential to the maintenance of the fish population. The relative importance of these reaches to the numbers of returning adults may vary from year to year, probably depending on water year type.

On Waddell Creek in Santa Cruz County, Shapovalov and Taft (1954) found a mixture of juvenile steelhead age classes (0 through 4) in the perennial stream. Such a mixture was not found in Arroyo de la Cruz (Jones and Stokes Associates 1982). The lack of variation in age classes, and segregation of age classes 0 and 1 between the perennial reach and the lagoon, may be a population adaptation to the environmental conditions of Arroyo de la Cruz (Jones and Stokes 1982). This trend may have continued further south in streams displaying similar environmental conditions.

Currently, inflow into the Base estuaries consists of natural baseflow, treated effluent discharge from a number of treatment plants, runoff from urban and agricultural areas, and groundwater seepage. When the mouths of the streams are closed estuarine habitat can be inundated with freshwater forming a lagoon. Depending on the water year type and the speed of bar formation, lagoon water quality decreases from spring months to fall months which would limit the lagoons potential carrying capacity.

All estuaries/lagoons on Base have been subject to varying degrees of degradation occurring over a long period of time. Construction of railroad and highway bridges, military training, construction of roads and dikes, water diversions, siltation etc; have led to a reduction in the historical size of the estuaries/lagoons. A time line of events reducing the SMR estuary/lagoon is documented in (USFWS 1981). Woelfel (1991) documented the same for the SMC estuary/lagoon. Similar reductions have likely occurred for the SOC lagoon due to the military beach and housing community and the San Onofre State beach.

The merits of a open SMR estuarine system have been widely discussed (SDCETF 1970, Salata 1981 and Hollis et al. 1988 cited in Cadmus 1992). Conclusions were that with periodic flushing, an estuary will have a diverse and abundant invertebrate fauna. Without flushing, dissolved oxygen decreases, nutrient concentrations increase, and temperature and salinity fluctuate drastically and often exceed the tolerance levels of aquatic invertebrates, leading to depauperate fauna. In the past, the Base artificially maintained an open estuary when levels got too high. However, from a ecological perspective the mouth of the SMR historically closed after any event which opened it (SDCETF 1970, COE 1993).

SMC and SOC lagoons are not tidally influenced. Currently, the deepest areas of the lagoons on Base are at bridge abutments ranging from 0.6-1.2 m. With the exception of the SMR, inflow into the SMC and SOC during the driest months is from groundwater seepage. While snorkeling in the SMC in September 1997, there were many cool water pockets possibly from groundwater upwelling and the majority of the surface was covered with algal mats. The estuary was completely freshwater and schools of juvenile largemouth bass were observed throughout the lagoon indicating that salinity concentrations are low throughout the summer.

Fish Surveys:

Fish species identified within Base waters were: arroyo chub, green sunfish, bluegill, largemouth bass, mosquito fish, bullhead species, tidewater goby and carp (Table 19). Arroyo chub and tidewater goby are the only native species. Exotic fish species were found in all streams surveyed except for Devil Canyon on the San Mateo and the Middle Fork of San Onofre Canyon (above the Range 210 Series), where no fish were observed. However, in the past green sunfish had been reported in perennial pools in Devil Canyon (Woelfel 1991).

The most abundant fish on the SMR was the arroyo chub. Only juvenile green sunfish were found on the SMR while both adults and juveniles were observed on SMC. In the past, adult green sunfish had been reported abundant in pools further upstream on the SMR (Hunsaker 1992). Juvenile carp were observed on the SMR only in the area above the Stuart Mesa Road.

Brown bullhead dominated the fish assemblage of SMC with both adult and juveniles observed in perennial pools. Bluegill and largemouth bass were rarely observed on SMC. Mosquito fish were abundant the entire length of SMC. In 1997, CDFG operated a downstream migrant trap in San Mateo Creek from March 6-28. Species captured included mosquito fish, crayfish, bullfrog and Pacific treefrog *Hyla regilla*.

San Onofre Creek was dominated by mosquito fish in the lower reaches below Camp Horno. The North Fork inside the Whiskey Impact Area was surveyed with an electro-shocker in March 1997, from Case Springs downstream to the confluence with Jardine Canyon. On the North Fork, green sunfish were the most abundant fish followed by largemouth bass, bluegill and bullhead species respectively. In addition to fish, bullfrog and crayfish were found in almost every pool, most likely escaping from Upper Case Springs. The Middle Fork San Onofre Canyon upstream of the Range 210 series, was surveyed several times, with no fish species observed.

Table 19. Aquatic species observed on Base, 1995-1997. A= Abundant, C=Common, UC= Uncommon, blank cells infer no observation.

			Estuarine Fish											Freshwater Fish									Amphibians						
Date	**Location**	**Gear type**	Staghorn sculpin	CA. killifish	Topsmelt	Smelt sp. (larval)	Striped mullet	Goby ssp.	Tidewater goby	Arrow goby	Longjaw mudsucker	Anchovy sp.	Juv. flatfish sp.	Bullhead spp.	Arroyo chub	Mosquito fish	Largemouth bass	Bluegill	Green sunfish	Channel catfish	Juv. carp sp.	Crayfish sp.	Bullfrog	CA. treefrog	Pacific treefrog	Arroyo toad	Toad sp.	California newt	Western pond turtle
May 1- 12, 1995	Santa Margarita River																												
"	Estuary	Seining	C	C	C		C	C																					
"	Estuary to Base boundary, Fallbrook	Direct observation													C				C										
"	De Luz Cr. (mouth to Base boundary)	Direct observation													C			C	C										
"	Roblar Cr. (to barrier falls)	Direct observation												C	C														
April 16-25, 1996	Estuary	Seining	C	A	A		C	C			UC	C	C																
"	Upstream of Stewart Mesa Rd.	Direct observation, Seining		C															C		C	A							
"	Below Lake O'Neill diversion weir	Dir. observation, Seining, Frame Net													C		C												
"	Fallbrook - De Luz Rd.	Direct observation, Seining													C														
March 17-27, 1997	Estuary	Direct observation		A			A																						
"	Mouth of De Luz Cr.	Electro-fishing													C	A	C		C			A	A						
"	Fallbrook De Luz Rd. bridge	Seining													C	A													
"	Roblar Cr.	Direct observation												C		A								A				A	
May 1- 12, 1995	San Mateo Cr.																												
"	Below Range 314	Frame Net												C				UC					C		C	C	C		
"	At San Mateo Rd. bridge	Direct observation														C													
"	At USGS gauge station	Direct observation												C					C										
"	Base Boundary to Fisherman Camp	Direct observation												C					C	C									
Sept 12, 1995	Estuary	Direct observation																											
April 16-25, 1996	Estuary	Seining							UC							C													
"	Below Range 314	Frame Net												C		N									C				
"	At San Mateo Rd. bridge	Direct observation												C															
"	within Range 314	Direct observation, Seining												C									C						
"	Above USGS gauge station	Direct observation												A			UC												
Aug 31-Sept 5, 1996	Above USGS gauge station	Direct observation												C		C							C						UC
"	Devils Canyon	Direct observation																											
March 17-27, 1997	Estuary	Snorkel & Electro-fishing			UC				UC							A													
"	Above USGS gauge station	Direct observation												A		A	C		C				C					C	C
"	Devil Canyon	Direct observation																							A				
"	Base Boundary to Fisherman Camp	Direct observation												A		A	C	C	A			A	A		C			A	C
April 16-25, 1996	San Onofre Cr.																												
	Estuary	Seining							A																				
"	mainstem to South Fork	Direct observation														A													
	South Fork to impact area	Direct observation														C													
"	San Onofre Canyon (within impact area)	Direct observation																						A		A		C	UC
Aug 31-Sept 5, 1996	San Onofre Canyon (within impact area)	Direct observation														A								A		A		UC	
March 17- 27, 1997	Mainstem below South Fork	Direct observation														A													
	N.F. below Upper Case Springs	Electro-fishing												C			C	C	A			A	A		A				
	N.F. below Lower Case Springs	Direct observation																					A	A	A			A	

Impacts of Exotic Fish:

Mosquito fish were introduced for mosquito abatement and are found in most Base waters surveyed. Mosquito fish could possibly serve as a food item for steelhead. Mosquito fish have taken over the niche of native threespine stickleback, which were important prey of salmonids (Moyle 1976).

In a southern California stream mosquito fish subsisted on a mixed diet of algae, zooplankton, fishes, terrestrial insects and miscellaneous aquatic invertebrates (Greenfield and Deckert 1973). Mosquito fish can disrupt food chains and cause large blooms of phytoplankton in small bodies of water by reducing populations of invertebrate predators and grazers (Moyle 1976).

Green sunfish are second most common fish species within Base waters after mosquitofish. In undisturbed foothill streams green sunfish occur as scattered large adults and native minnows remained abundant. In disturbed areas, green sunfish take over and native fish are rare (Moyle 1976). In Malibu Creek and the Carmel River, green sunfish were found to prey on juvenile trout (Swift 1975; Greenwood 1988 cited in Woelfel 1991). In the San Clemente Reservoir on the Carmel River, green sunfish outcompeted steelhead for benthic food (Greenwood 1988). Green sunfish dominated the SMC lagoon in the late 1980's and early 1990's (Swift 1994). Green sunfish were the only fish found in perennial pools along the upper SMC and Devil Canyon from 1987 through 1989, and may have displaced residual steelhead during drought periods (Woelfel 1991).

Bullhead species were found in large numbers in SMC, North Fork SOC, and Roblar Creek. Both young of the year (YOY) and adults were found in 1995 and 1997, with YOY dominant and difficult to distinguish between the two species. Brown bullhead were the most abundant species in SMC. YOY formed tight circling balls in perennial pools. These fish are highly tolerant of low oxygen and high carbon dioxide levels which are common to perennial pools during the summer months. Both YOY and juvenile black bullhead were found in small numbers above the SMR estuary (Swift 1994). Brown bullhead were found in Lake O'Neill in 1993 and 1994 (USFWS 1993; 1995b). They are known to swim through large schools of small forage fish and prefer feeding at night which may account for their success as predators (McGinnis 1984).

Channel catfish *Ictalurus punctatus*, are known predators of steelhead. Salmonids composed 25% of their diet on the Columbia River (USFWS 1985). A dead adult was found in the upper SMC within the CNF during our surveys. One adult channel catfish was found in the SMR upstream of the estuary (Swift 1994).

Brown trout were intentionally stocked by CDFG in tributaries of SMR and SMC. They are more aggressive and territorial then native trout and are known to prey on other juvenile salmonids (Moyle 1976). In European streams where brown trout are the native species, introduced rainbow trout have not been able to become established (Behnke 1992). In New Zealand streams, browns aggressively attacked juvenile chinook salmon and dominated their habitat (Glova 1995). The introduction of brown trout into the McCloud River in California, is assumed to be the main reason for the disappearance of the native bull trout (McGinnis 1984). On the Trinity River near Lewiston, CA., introduced brown trout occupy deep pools below the hatchery and feed primarily on juvenile steelhead and salmon releases (Jong, pers. comm. 1996).

Brown trout were last stocked on the SMC from 1983 to 1985, and have not been observed in any recent surveys on SMR, SMC, or SOC. Highly adaptable to a wide range of habitat conditions, brown trout can withstand summer water temperatures well above the preferred range of native trout (Moyle 1976). Many trout streams in the west have been successfully stocked with both brown and rainbow trout. However, to minimize direct competition, rainbow trout were restricted to the riffles and open-channel reaches while brown trout dominated the deepest pools and stream bank areas (Behnke 1992).

Redeye bass were introduced by CDFG into the SMR Temecula gorge area in 1962 for sport fishing. Redeye bass prefer small streams and upland drainage areas and occupy an ecological niche similar to that of trout and are highly insectivorous (McGinnis 1984). It is not known to what extent redeye have become established; Cooper et al. (1973), reported a few in the upper watershed in 1973, Swift (1975) called them abundant in 1975, below Temecula Creek, and Hunsaker (1992) reported catching juveniles on the SMR above the Base in 1991. The Temecula gorge has been referred to as being one of the few remaining suitable spawning areas for steelhead on the mainstem SMR (Cooper et al. 1973).

Largemouth bass were stocked into ponds and lakes all across the Base and directly into the SMR in 1968. Largemouth Bass take over the role of top predator in the habitat they occupy and can directly predate steelhead (Poe et al. 1994 cited in Stouder, Bisson and Naiman 1997). They become piscivorus at a surprisingly small size, 8-10 cm, and adults usually occupy a shoreline feeding area, where they lie under plant or root cover and wait for prey (McGinnis 1984).

Currently, largemouth bass are found in SMC, SMR, and the North Fork of SOC. Reproduction is evident in the lower SMR from 30 fingerlings that were found in an isolated slough 200 meters upstream of the blockhouse (Swift 1994). An adult caught in the SMR below the Lake O'Neill diversion weir, was a gravid female containing several arroyo chub in its stomach (Figure 25).

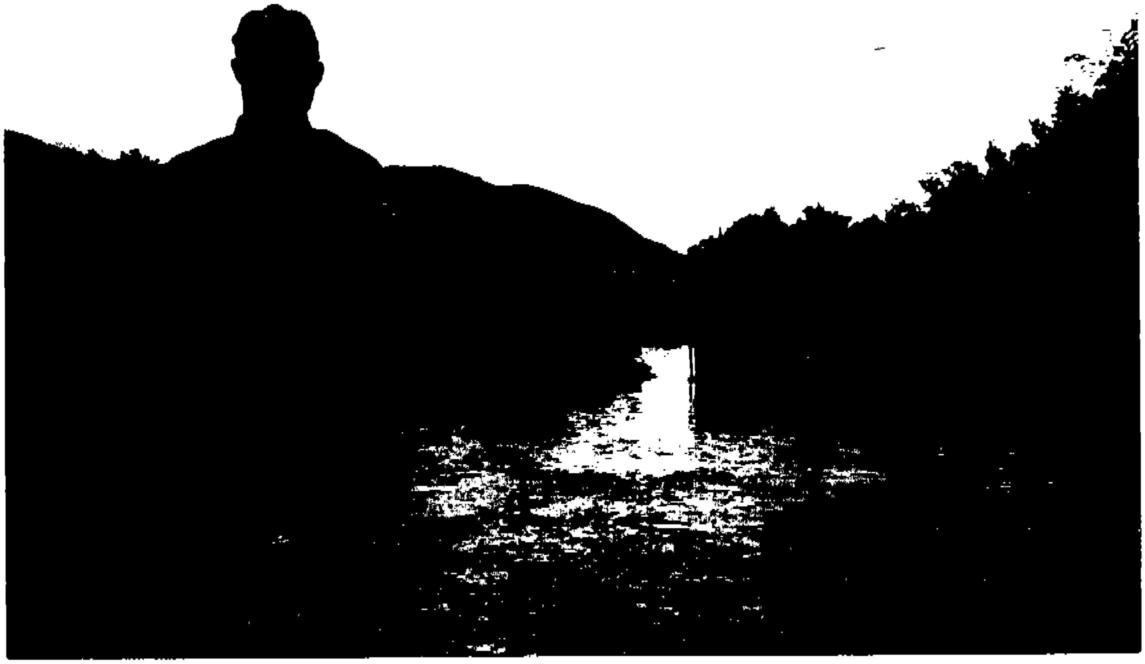


Figure 25. Mike Marshall, USFWS, with largemouth bass, below diversion weir Santa Margarita River, April 1996.

Carp prefer different habitat and food items then steelhead. However, carp can foul the water or alter the aquatic habitat in which they live by stirring up and feeding off the bottom of a stream causing poor conditions for steelhead (Moyle 1976).

Bluegill are prolific breeders and were widely stocked in Base ponds and lakes in the 1970's (USMC 1973). Bluegill eat mainly insects and crustaceans which steelhead also eat. Bluegill may have escaped into Base streams during high winter flows or from upstream locations off Base.

Black crappie *Pomoxis nigromaculatus* were not found during our surveys. However, Swift (1994) found juveniles in SMR above Stuart Mesa Road. The young are avid filter feeders on zooplankton until about 20 cm at which time they become piscivorus (McGinnis 1984). Black crappie are highly prolific breeders, and are present in large numbers in Lake O'Neill and Pulgas Lake (USFWS 1993; 1995a; 1995b). Since adult black crappie prefer minnows in their diet, given the opportunity, juvenile steelhead and arroyo chub could be prey items.

Golden shiner were not found during our surveys but in the past they have been stocked into Lake O'Neill and Case Springs as a forage fish for largemouth bass (USFWS 1993; 1995b). Golden shiner were found on the SMR in potholes above the Base hospital (USMC 1973). They have been found to reduce trout production in lake habitat by competing with juveniles for food (McGinnis 1984).

Bullfrog predation on juvenile steelhead is unknown, but suspected since they are known to eat minnows and other frogs (Behler and King 1979). Bullfrogs were abundant in SOC, SMR and SMC.

<u>Steelhead as Predators of Endangered Species</u>:

<u>Tidewater Goby</u>:

Steelhead were listed as a threat to the tidewater goby and southwestern arroyo toad *Bufo microscaphus californicus* by the USFWS in the Federal Register (USDC 1993; 1994). Under natural conditions predation would be expected to be insignificant due to the fact that southern steelhead, tidewater goby and arroyo toad coevolved. Currently steelhead coexist with tidewater goby and arroyo toad in Malibu Creek Lagoon, Santa Ynez Lagoon, Pescadero Creek, San Gregorio Creek, Piru Creek and Sespe Creek. Tidewater goby were recorded in SMC lagoon with steelhead and threespine stickleback in the late 1930's (Swift 1994).

Steelhead are a natural predator of tidewater goby and are usually found in association with them (Holland 1992). There have been documented cases of steelhead predation on tidewater goby. A 32 cm (total length) steelhead caught in Gaviota Creek Lagoon contained six to ten gobies of which some may have been tidewater goby (Swift 1989). A 20 cm (fork length) steelhead from Pico Creek Lagoon in San Luis Obispo County contained tidewater goby in its stomach (Holland pers. comm. 1996). Hence, these are reasons for listing them as a threat in the Federal Register. Other studies have shown that steelhead in lagoons usually prefer a diet of invertebrates such as amphipods and shrimp (Smith 1990). Stomach contents of adult steelhead and half-pounders caught in freshwater streams consisted mostly of aquatic stages of caddis flies, mayflies, and stone flies, other fish were rarely found (Barnhart 1990).

Camm Swift, in his draft recovery plan for the tidewater goby discussed the effects of reintroducing steelhead in southern California. The return of steelhead would presumably put more pressure on existing tidewater goby populations. Large numbers of steelhead introduced into coastal lagoons could have a disastrous short term effect, but a small number of steelhead would reflect a more natural condition. Both tidewater goby and steelhead should benefit from management efforts to recover the lagoon habitat (Swift 1995). A far greater threat to these endangered species are exotic species like largemouth bass, green sunfish, crayfish and bullfrog. Tidewater goby have disappeared in some Camp Pendleton lagoons after centrarchids were introduced (Holland 1992; Swift 1994).

Southwestern Arroyo Toad:

Arroyo toads in San Diego County are found throughout steelhead habitat. In freshwater, steelhead feed primarily on the immature aquatic stages of insects and secondarily on mature terrestrial insects (Needham 1938; Barnhart 1986). A literature review of seven diet studies conducted on rainbow trout showed no tadpole or toads among their stomach contents. Dr. Samuel Sweet, an arroyo toad expert at UCSB, stated that trout do not feed on arroyo toad and that the only phase they could possibly consume is the tadpole stage (pers. comm. 1996). Arroyo toad larvae were presented to foraging trout in Sespe Creek and although the trout sometimes approached the tadpoles they never took them (Sweet 1991). Bass, bullhead species, green sunfish and fathead minnow are known predators of arroyo toad tadpoles, as well as bullfrog and crayfish (Sweet 1991; Jennings and Hayes 1994; Holland pers. comm. 1996).

Steelhead and/or rainbow trout were not listed as predators of any toad life stage in the CDFG report "Amphibian and reptile species of special concern," (Jennings and Hayes 1994). Drought and direct human impact through trampling, illegal road maintenance, and fires, were found to have significantly decreased toad populations in the Los Padres National Forest. Arroyo toad larvae were found not to respond to the chemical cues present in water that contained fish putting them at high risk of predation (Kats et al., in Sweet 1991). Instead they depend on their cryptic coloration to hide from predators.

DISCUSSION:

The earliest historical records of steelhead occurring in Northern San Diego County were largely anecdotal, and from the neighboring San Luis Rey River. Historic population estimates for Base streams were not found in the reviewed literature, but steelhead runs on the San Luis Rey River were reportedly large enough to provide a major food supply for the Luiseno Tribe as late as the 1890's and 1900's (Shipek pers. comm. 1997). Kondolf and Karson (1995) described the natural conditions of the San Luis Rey River as probably perennial in most years; surface flow may have ceased in dry years, but the alluvial water table probably remained high, supporting riparian vegetation and maintaining deep pools as refugia for aquatic organisms. The natural conditions of the SMR, SMC and SOC may have also resembled those described for the San Luis Rey River prior to urban development and subsequent alluvial groundwater withdrawals.

As with the San Luis Rey, the earliest documentation of steelhead within Base streams is anecdotal, however newspaper articles and early stream surveys have corroborated the historic presence of steelhead. The stream which has the best documentation is SMC and its tributary Devils Canyon dating back to the early 1900's. SMC data documents the use of the upper SMC within the CNF as spawning and over-summer rearing habitat. There was no documentation of adult steelhead spawning on the SMC within Base boundaries. The data indicates the presence of steelhead in the SMC through the mid to late 1940's, after which any trout observed may have been due to hatchery trout plants. The few post 1980 steelhead sightings on SMC are probably the result of straying from other systems.

The documentation of SMR steelhead populations is not as strong as for SMC and almost entirely anecdotal. We found documentation of adult steelhead in the SMR only during the 1940's, and it seems their numbers were already low. Hatchery trout were planted in De Luz Creek in 1941-42, and the SMR was heavily planted with trout throughout the 1960's and to a lesser degree in the 1970's and 1980's.

The accounts of steelhead on SOC are anecdotal and indicate the presence of steelhead at least through the late 1940's, with a few adult steelhead caught by fisherman in the surf zone at the mouth. In a 1950 CDFG survey of the SOC estuary, juvenile trout were considered the most abundant fish species (CDFG 1979). The only other information pertaining to steelhead in Base streams or the San Luis Rey were found in a compilation by CDFG, the San Diego Coast Regional Commission, and Charles Swartz of the University of California Sea Grant Program which stated:

> ...anadromous fish runs were observed in San Diego County as late as 1945-50. ... In San Diego County, steelhead (salmon trout) occurred in De Luz Creek in about 1950-52, and reports of steelhead in the lower San Luis Rey River as late as 1940-41. Steelhead trout were observed in pools below Lake Hodges, and commonly in San Onofre Creek and the Santa Margarita River before the 'dry cycle' began in the late 1940's. Offshore, steelhead and silver salmon appear intermittently in both partyboat and commercial fishing catches (SDCRC 1974).

In a separate document on California estuaries titled: California Coastal Plan, prepared by the California Coastal Zone Conservation Commission (CCZCC 1975), it was stated that "As late as 1958, steelhead trout were observed near the mouth of the Santa Margarita River". Both of these citations were not included in our time-line tables because we were not able to obtain the original records. Records were not found for Cristianitios, Telega, Las Flores, or Pilgrim creeks which would have indicated the occurrence of historic steelhead runs in these streams.

Stream flow and precipitation in northern San Diego County fluctuates greatly from year to year. Precipitation is highly seasonal, falling primarily in the months of December through March. A dry cycle beginning in the late 1940's and continuing through the late 1970's, coincided with increases in urban development, stream diversions and the overdrafting of underground aquifers in the lower river valleys, resulting in southern California streams becoming dry much of the year (CCZCC 1975).

There were extended periods in the mid 1950's when surface flow did not reach the SMR estuary during the historically wet months of February-April. Likewise, stream flow records show the same trend on the SMC and SOC. Steelhead populations on Base streams have been extirpated and the known southern limit of steelhead in North American freshwaters has shifted northward from the Santo Domingo River in northern Baja California (Needham and Gard 1959), to Malibu Creek in Los Angeles County. Extirpation likely resulted due to an inadequate number of opportunities for adult steelhead in the ocean to ascend Base streams to spawn in riverine habitat located above the Base and for juvenile emigrations to reach the ocean. In addition, during extended drought, a greater proportion of water is taken for human use, leaving less for fish at a time when they need it the most. The native fishes are actually adapted for surviving extended periods of drought through a combination of life history strategies and physiological tolerances (Moyle et al. 1986 cited in Moyle 1995). Native trout would have had to contend not only with less water and habitat, but also increased inriver fishing pressure, disease transfer and/or predation following introduction of hatchery trout and predatory game fish.

Based on the available literature, adults spawned upstream soon after winter/spring flows breached the sand bar and juveniles emigrated the following winter. Between emergence and emigration, juveniles would require areas of perennial flow or intermittent flow associated with pools and vegetative cover for over-summer juvenile rearing. Rainbow trout have been observed surviving water temperatures as high as 29°C, but prolonged exposure to temperatures greater than 25°C would likely be lethal. In intermittent streams, higher water temperatures were avoided despite low dissolved oxygen levels. Large or deep thermally stratified pools likely provided the best opportunity for juvenile survival and growth, however shallow pools associated with coldwater seeps or springs were also used.

Roblar Creek, a tributary to De Luz Creek on Base, possesses spawning gravel, areas of perennial flow, and a diversity of aquatic insects that could be utilized as food items for southern steelhead. However, a barrier occurs 1.4 km from the confluence with De Luz Creek limiting the potential utilization of Roblar Creek to very few trout. Due to the modification to the Lake O'Neill diversion weir, adult steelhead should now be able to get beyond the weir site, which was previously considered a barrier (Higgins 1991). Our survey of SMR above the Base was limited to the immediate area around Fallbrook from the De Luz Road. We do not know the current state of habitat on the SMR available to southern steelhead above the confluence of Rainbow Creek. Based on our surveys the SMR and its major tributary on Base, De Luz Creek contained the least quantity and quality of steelhead habitat. Ironically, De Luz Creek and its tributary Fern Creek were highly touted as trout streams in the literature we reviewed.

Beginning in the mid 1990's the Eastern Municipal Water District and the Rancho California Water District began live stream discharge into SMR providing year-around flow upstream of the Base. On Base surface flow occurs during the winter/spring before becoming intermittent and/or subsurface. Southern steelhead should benefit from live stream discharge on the SMR because the timing and amount of flow in recent years was adequate to support them. The Base benefits from the additional flow to recharge their groundwater supplies, which in turn could lead to reestablishing a riparian corridor which could eventually include a woodland community. The reestablishment of hardwoods would provide instream structure and scour points which promote the formation of pool habitat. Riparian habitat near Fallbrook scoured out by the 1993 flood improved each year during our surveys. The benefits of the improved riparian areas were evident in lower average stream temperatures and a shorter duration of higher water temperatures recorded near Fallbrook. Despite less flow, stream temperatures on average were cooler in 1996 than in 1995, which we attributed to the recovery of the riparian vegetation, primarily willow.

Based on only one continuous water quality monitoring station, the USGS gauge station 11046050, it appears the SMR estuary currently does not provide over-summer rearing conditions for southern steelhead. This may be due to the formation of a heat retaining saltwater lens which can cause anoxic conditions within its sphere of influence. There are few areas between the estuary and the diversion weir where juveniles could seek refuge from the high water temperatures and anoxic conditions from late spring through November, and within these areas steelhead would currently compete with green sunfish, and largemouth bass for resources.

With the exception of exotic fish not introduced directly into SOC, the combination of drought, groundwater pumping and fish introductions which occurred on the SMR, also occurred on SMC and SOC. These two streams currently possess the best steelhead habitat on Base. Unlike the SMR, urban and agricultural development has not occurred in the upper watersheds of these streams. The upper SMC watershed is protected within the CNF and the upper SOC is located in a remote location of the Base within the Whiskey Impact Zone.

Flow conditions post 1980 in the SMC and SOC drainage have been sufficient to support southern steelhead, although as has occurred historically, some water years have been better than others. SMC is basically a migratory corridor to habitat found off-Base, within the CNF. Within the CNF, there are areas of perennial flow and pool habitat in which juveniles could over-summer. The Base portion of the stream is intermittent and subsurface most years after May. Apart from the migratory corridor, the San Mateo estuary is the only other potential habitat available to steelhead on Base. The SMC lagoon is not tidally influenced after the formation of a sand bar. Based on our water temperature monitoring, water temperatures in the SMC lagoon are not conducive to over-summer rearing during dry years unless steelhead utilized the areas of cool groundwater upwelling. Such areas were located upstream of our TempMenter location. It was evident salinity concentrations remain low during the summer, based upon the presence of juvenile largemouth bass in September 1997. The use of estuaries by southern steelhead has been documented for central California coast streams, but not for streams further south. Steelhead would likely benefit from rearing in an estuarine environment. It has been shown that growth rates are greater for those fish able to rear in an estuary and that increased size upon ocean entry is positively correlated to ocean survival (Smith 1994). However, due to a longer inriver growing season, emigrating juveniles may obtain sufficient growth to enter directly into the ocean.

The mainstem SOC may have been a migratory corridor to habitat located on the Middle Fork SOC. Based on the size of the SOC basin and extent of perennial flow, the steelhead population on SOC was likely much smaller that of SMC or SMR. Relatively small quantities of spawning gravel were located in the Middle Fork SOC, with only one area with exceptional spawning potential noted. The Middle Fork possessed numerous shallow perennial pools and several thermally stratified deep pools. The steep canyon walls help limit the amount of time the stream is exposed to direct sunlight, and probably help keep water temperatures tolerable during the summer months. Woody riparian vegetation is abundant throughout the reach. Dominant vegetation consisted of willow, alder, sycamore, and oak. The fact that no fish were observed on the Middle Fork was actually a good indiction that exotics have not been able to establish themselves.

Conversely, the North Fork which receives flow from Case Springs and little Case Springs had multiple exotic species. The South Fork SOC had good riparian and canopy, however, flow was sustained by effluent from a wastewater treatment facility. The SOC estuary was small and shallow during the period of our surveys and probably does not afford juvenile steelhead rearing.

To help evaluate the habitat data collected on Base in the absence of steelhead, we reviewed the results of Carpanzano (1996). Carpanzano studied ten streams in Santa Barbara and Ventura Counties known to have had steelhead runs within the last hundred years. Methodologies of habitat evaluation were similar to ours. The study offers insight on rainbow trout and habitat associations during low summer flows and high water temperatures. Carpanzano found streams having no trout had similar characteristics, including deep silt deposits, seasonally variable flows, sandy stream bottoms, open canopy and warm stream temperatures. In contrast, the creek with the highest rainbow trout densities had perennial flow, low stream temperatures, dense canopy, and good spawning habitat. When water temperatures approached lethal limits, juveniles sought out areas of cooler water. These areas can be found at the intersection of tributaries, areas of perennial flow, pools deep enough to intersect cool subsurface flow and the bottom of thermally stratified pools due to springs and seeps (Woelfel 1991; Nielsen, Lisle and Ozaki 1994; Matthews and Berg 1996). Trout preferred cool water despite low dissolved oxygen concentrations (Carpanzano 1996).

In conclusion, the best trout/steelhead habitat occurring on Base is within the upper SOC drainage. The remaining streams provide a corridor for upstream adult migration and downstream juvenile migration. With the exception of perennial flow occurring in the upper SOC, immediately below the Lake O'Neill diversion weir, and isolated areas below wastewater treatment facilities, areas of perennial flow adequate to support southern steelhead were not located on Base. Spawning and juvenile rearing can take place in the upper SOC, and SMC within the CNF. This includes the portion of Devils Canyon within Base boundaries. Spawning can also occur in Roblar Creek, but rearing is possible only during wet years.

Based on the available literature, southern steelhead seem very adaptable and able to survive in relatively modest habitat. Basic requirements are adequate spawning gravel, areas of perennial flow or intermittent flow associated with pools of sufficient depth to avoid lethal temperatures. Shallower pools can be kept below lethal levels if intersected by subsurface flow or if they occur in the vicinity of cold water seeps or springs. Fish in shallower pools likely have a higher mortality due to predation by birds and snakes. Deep pools able to thermally stratify likely provide the best inriver rearing potential in the absence of predatory fish. Based on this criteria, SMC should receive the highest consideration of all Base streams if restoration efforts are undertaken. SMC has the greatest quantity of suitable habitat. The majority of spawning and rearing habitat is upstream within the boundaries of the CNF and the portion within the Base boundaries was considered primarily a migratory corridor. The SOC should also be considered a candidate for any restoration efforts. However, due to the relatively small quantity of suitable habitat, it has should be secondary to SMC.

Maintaining/Restoring Steelhead Habitat on Base:

The largest area of steelhead habitat on Base occurs within the Middle Fork SOC. Small amounts of habitat also occur on Roblar Creek, a portion of SMC near the USGS gauge station, and the portion of Devils Canyon within the Base boundary. The primary concern for SOC would be to promote adult migration and juvenile emigration through the lower river. With the exception of SOC and Roblar Creek, the remainder of Base streams provide only a corridor to habitat off Base. The effectiveness of a migratory corridor leading to habitat on and off Base could be enhanced by the conservation of existing native riparian habitat. Native riparian habitats including scrubs and woodlands, affect a rivers shape and influence sediment transport, erosion, and bank stabilization (Warner and Hendrix 1984; Faber et al. 1989). Native riparian plant species also provide the best and most widely used habitat for many native wildlife. Riparian habitat along Base streams serve as refugia areas for sensitive wildlife species including the listed least Bell's vireo.

Areas of Base streams that are disturbed by human activities, vegetated with mainly non-native plant species and areas of native vegetation that have moderate levels of non-native plants or are devoid of vegetation could be considered potential areas for restoration or enhancement. The Base has already initiated giant reed eradication. These efforts should continue for the conservation of surface and subsurface flow and promote the colonization by native willow species, mule fat, oak and sycamore trees. Existing sycamore and oak trees are beneficial to southern steelhead in that they contribute shade, large woody and organic debris and promote the formation of pools when they occur adjacent to the active channel. Additional pool habitat would benefit migrating southern steelhead, providing a place to rest and hold between storm freshets. However, enhancement of the riparian habitat would also be beneficial to exotic fish species.

If the current wet climatic cycle persists in southern California, and conservation efforts throughout the range of southern steelhead result in increased populations, the possibility that steelhead will attempt to re-colonize Base streams exists. Steelhead straying from other systems is a mechanism of expanding its range and re-colonization. If this were to come to fruition, success would be impeded if measures to control exotic species are not first addressed. Complete eradication would provide the most benefit to reestablishment efforts, but due to the numerous small lakes and ponds currently containing exotics and providing a recreational fishery, eradication seems an unrealistic goal. Containment and measures to control inriver propagation, especially in the early stages of any reestablishment effort would help promote steelhead reproductive success.

Initial methods of controlling inriver exotic fishes could include use of rotenone, explosives, electro-shocking or seining in perennial pools during summer low flow. However, efforts would need to be mindful of other species such as the arroyo toad, California newt, western pond turtle, and arroyo chub. Containment of exotics in locations of recreational fisheries by screening drainage outlets, i.e. Lake O'Neill, Case Springs and wastewater treatment facility ponds, would help curb escapees and subsequent competition with juvenile steelhead rearing in perennial stream reaches. Containment would also reduce the frequency and intensity necessary to control exotics which in turn would reduce adverse effects on arroyo toad, California newts, western pond turtles, and arroyo chub.

The Base in cooperation with upstream entities, could initiate periodic snorkel surveys and/or operate adult traps as a means of monitoring for the presence of southern steelhead. Adult monitoring would need to occur in the winter and spring months if flows permit. Snorkel surveys should occur during the summer or fall months in perennial pool habitats. Juvenile steelhead would be isolated in pool habitats during these months and survey crews could cover greater distances.

The Base has already modified the Lake O'Neill diversion weir which should help promote sediment transport and deepen the active stream channel. The diversion weir is no longer a barrier to the upstream migration of steelhead. However, in the future, if steelhead are found utilizing the SMR, installation of a fish screen at the diversion inlet is recommended.

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