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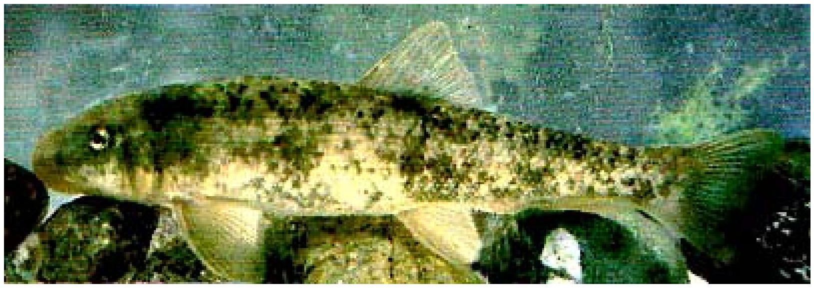

Results of the Year 2 Implementation of the Santa Ana Sucker Conservation Program For the Santa Ana River

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Prepared for the Santa Ana Sucker Conservation Team
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San Marino Environmental Associates

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Final Report

Prepared For:
Santa Ana Sucker Conservation Team
Composed of:
City of Riverside (Regional Water Quality Control Plant)
City of San Bernardino Municipal Water Department
Orange County Flood Control District
Orange County Water District
Riverside County
Riverside County Flood Control and Water Conservation District
San Bernardino County Flood Control District

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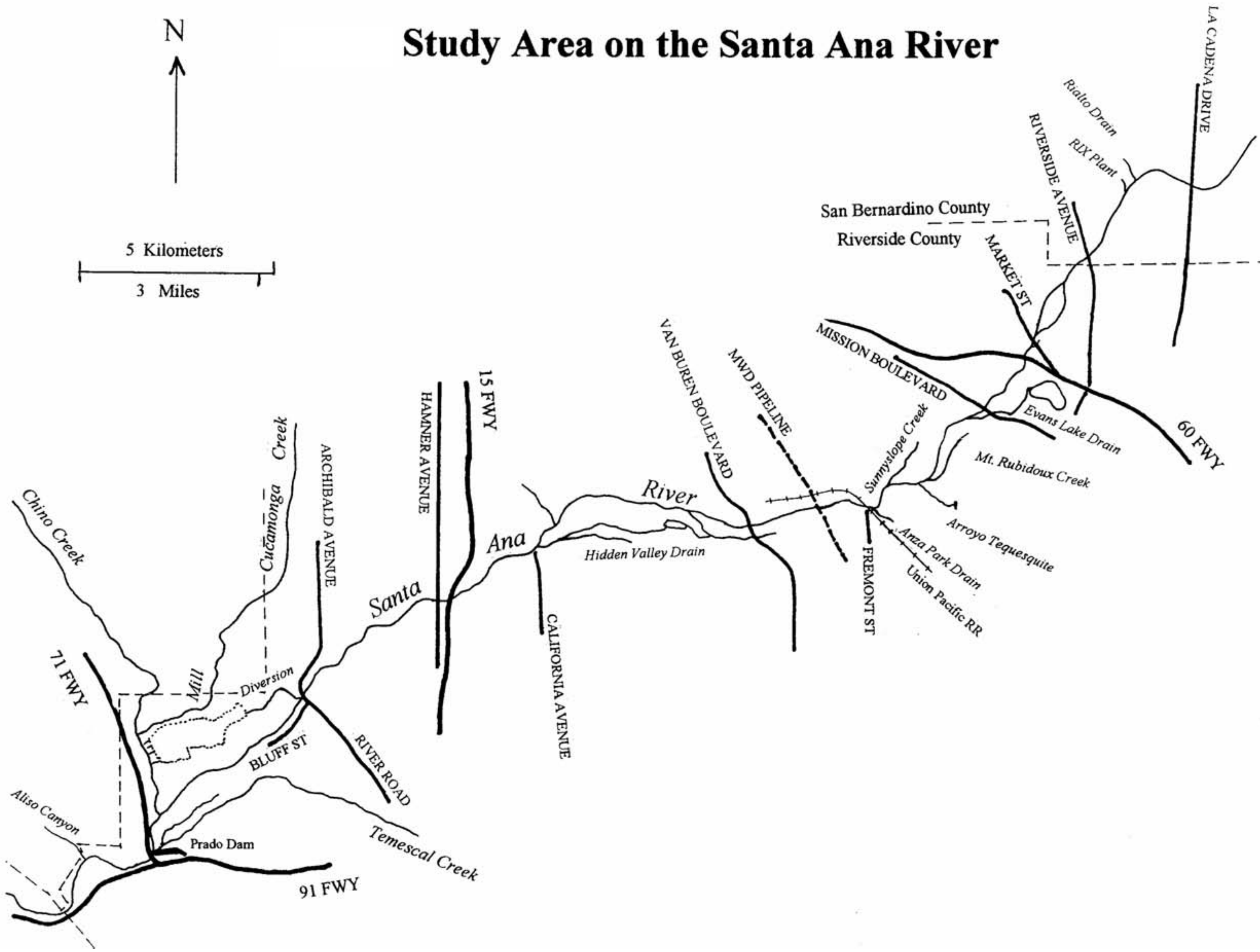
Study Area on the Santa Ana River



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I. BACKGROUND.

A. Introduction.

In the spring of 1999, an informal group of concerned local, regional, State and Federal agencies formed the Ad Hoc Santa Ana Sucker Discussion Team (now called the Santa Ana Sucker Conservation Team) to identify and implement conservation measures that would contribute to the survival and recovery of the sucker within the watershed of the Santa Ana River. Research priorities and funding sources were identified, and a three-phase, coordinated effort was initiated and completed during the year 2000. The first phase of the initial scientific studies concentrated on physiochemical variables, including organic and inorganic tissue analysis, and was performed by the U.S. Geological Survey (Saiki 2000). The second phase, which studied migration patterns, predatory fish relationships and reproduction of Santa Ana suckers in tributaries, was conducted by Larry Munsey International (Swift 2001).

1. Saiki (2000) Study.

Saiki (2000) conducted a study of Santa Ana suckers in the Santa Ana River and in the San Gabriel River. In his study he specifically examined fish condition, gut contents (diet), fish-tissue contaminant levels, water quality and environmental measures associated with fish capture.

Saiki (2000) measured length and weight of suckers captured between December 1998 and December 1999. Suckers were captured in the East Fork of the San Gabriel River and at MWD Crossing in the Santa Ana River. Attempts to capture suckers at Imperial Highway failed. The data were used to estimate relative weight, an index of fish body condition (Bagenal and Tesch 1978). These data suggested that the geometric means of relative weight were typically higher in the San Gabriel River; however, the differences were only significant in three of five cases (Saiki 2000). Furthermore, the geometric means for various size classes of Santa Ana suckers were also typically higher in the San Gabriel River than in the Santa Ana River, but again these differences were only statistically significant among intermediate-sized fish, 40-119 mm SL (Saiki 2000). Saiki concluded that these data when combined with abundance data supported the premise that the San Gabriel River supports a healthy population of Santa Ana suckers while the Santa Ana River supports a marginal population of suckers. However, Saiki collected suckers near the downstream boundary of their continuous distribution in the Santa Ana River, clearly not in the area where suckers are most abundant in the Santa Ana River. Also the data suggest only occasionally a statistically significant higher index of fish body condition. Saiki interpreted the length data to indicate that only two distinct size classes were present in the Santa Ana River while three size classes were present in the San Gabriel River. Again the importance of the pattern observed by Saiki can only be determined by studying the Santa Ana sucker where it is abundant in the Santa Ana River. It will be important to determine if Saiki (2000) is correct in suggesting that there are only two age classes representing 0+ and 1+ aged individuals. Based on the detailed study of

Santa Ana suckers in the Santa Clara River by Greenfield *et al* (1970), suckers first reproduce at 1+, which would mean that the suckers in the Santa Ana River only have one reproductive season. Data from the Santa Clara River suggest that suckers in this system typically reproduce at 1+, 2+, and some at 3+ (Greenfield *et al* 1970). The San Gabriel River may even contain individuals of age 4+ (Drake and Sasaki 1987), and even Saiki's data indicate at least 1+ and 2+. Haglund and Baskin (1997) analyzed data from the West Fork of the San Gabriel River, and based on five years of data the population contained 2+, 3+ or 4+ as the maximum age class in different years.

The contaminant studies performed by Saiki (2000) indicate that Santa Ana suckers in the Santa Ana River do not possess persistent environmental contaminants at levels which exceed the average concentrations reported for freshwater fish from throughout the United States.

Saiki also proposed that reproduction occurred earlier in the Santa Ana River than in the San Gabriel River based on the time of initial appearance of fry and observations of breeding tubercles. Saiki did not provide data which were sufficiently specific to actually determine reproduction time during 1999, but his general observations are consistent with those of Haglund and Baskin (unpubl. data from San Gabriel River).

Gut contents of suckers were analyzed from both the San Gabriel River and the Santa Ana River. In both cases the gut contents consisted almost entirely of organic detritus. Insect material was slightly more common in fish from the San Gabriel River than in fish from the Santa Ana River. These data are consistent with the results of Greenfield *et al*'s (1970) study of Santa Ana suckers and what is known about *Pantosteus* suckers in general (Smith 1966).

2. Swift (2001) Study.

Swift's (2001) study had three major goals:

1. Document possible migration or movement of suckers with reference to the potential impacts of a stream diversion below River Road, Norco.
2. Document areas and timing of spawning in the main river and its tributaries.
3. Assess the impact of exotic predators on the sucker.

As a result of these studies, Swift (2001) reached a series of conclusions with respect to the primary goals of the study.

Despite significant attempts to capture fish in the study area below River Road, Swift was only able to capture 11 sub-adult suckers. The captures were scattered throughout the year and no seasonal pattern of migration was detected (Swift 2001). A small number of young-of-the-year (YOY) suckers (17 individuals) were captured between May and August, which Swift (2001) attributed to downstream dispersal of YOY from upstream spawning areas. This work was unlikely to be able to determine the presence or absence of migration due to the rarity of adult fish in this stream reach. Furthermore, migration in other sucker species is associated with movement to and from spawning areas, and there was no suspected spawning area in this reach. Swift's (2001) capture of YOY in May through August suggests that the downstream post-spawning dispersal of YOY needs to be investigated. Again the capture of 17 YOY over a four-month period is insufficient to establish downstream movement of juveniles as a major life history phenomenon. The results of this portion of Swift's study are more likely to have a bearing on the potential significance of the diversion on the take of suckers, than to provide significant insights into the importance of movement (adult migration, YOY downstream dispersal) in the life history of Santa Ana suckers in the Santa Ana River.

Swift (2001) examined eight tributaries as potential reproductive sites: Rialto Drain, Rapid Infiltration and Extraction Plant (RIX) outlet, Evans Lake Drain, Mount Rubidoux Creek, Arroyo Tequesquite, Sunnyslope Creek, Anza Park Drain and Hidden Valley Drain. Of these potential tributary spawning sites, Swift (2001) only found larvae in Rialto Drain and Sunnyslope Creek, and concluded that reproduction was only occurring in these two tributaries. Swift also found fry in the mainstem and concluded that there was significant mainstem spawning. Swift (2001) found fry from late March until the first week of May. Based on the assumption that Santa Ana sucker's reproductive habits would mirror that of other suckers (larval emergence one to two weeks following egg-laying), Swift (2001) concluded that sucker spawning had occurred from mid-March through mid-April in 2000, a period of approximately one month. The mainstem distribution of larvae was primarily from Rialto drain downstream to about 600 meters downstream of Mission Boulevard. Larvae were rare to absent from this point downstream with the exception of the occurrence of larvae in Sunnyslope Creek (Swift 2001).

The gut contents of 121 predatory fish were examined; however, only 79 of these exotics were captured when YOY suckers were known to be present in the vicinity. The gut contents of largemouth bass, green sunfish and bullhead catfish were primarily examined. These comprised about 75% of the exotics captured. Fish were an important component of the diet of largemouth bass and green sunfish. This is consistent with what is known of the diet of these fishes in their native habitat. Largemouth bass feed primarily on fish larvae and insects by the time they reach 50-60 mm SL (Keast 1966), and by the time they exceed 100-125 mm SL they subsist primarily on fish (Lewis *et al* 1961). Black bullhead and "Tilapia" gut contents were dominated, volumetrically, by algae and non-insect invertebrates. Fish and insects were minor components (Swift 2001). Again, these finding are consistent with the literature on the diets of these fishes within their native habitats (black bullhead, Applegate and Mullan 1967; Mozambique tilapia, Bruton and Boltt 1975). Among the bullheads (*Ameiurus*) that occur in the Santa Ana River, the yellow bullhead is probably slightly more piscivorous than the black bullhead (Miller 1966). As noted by Swift (2001), the "Mozambique type" cichlid and mosquitofish are the two most common exotics where suckers are abundant. As Swift (2001) recognized, the cichlid could be a food competitor. Studies (Bruton and Boltt 1975, Man and Hodgkiss 1977) indicate that diatoms are a major dietary component to fry and juvenile cichlids, but slightly less important to adults. This ontogenetic dietary pattern is the same in Santa Ana suckers (Greenfield *et al* 1974). The mosquitofish is an omnivorous, opportunistic feeder, which will often feed on the most abundant food source, including fish larvae (Harrington and Harrington 1961, Greenfield and Deckert 1973). Despite Swift's (2001) relatively small sample size, when he combined these data with the distributional data, Swift suggested that exotic predators do not currently have a very significant impact on Santa Ana suckers (except potentially mosquitofish). Baskin and Haglund have argued that the data are not sufficiently robust to support such a conclusion. Further data is needed on the potential predation by various exotics on different life stages of the Santa Ana sucker, including the potential for mosquitofish to act as a larval predator. The potential impact of the Mozambique-type cichlids as a food competitors and other exotic interactions such as habitat modification and space competition need to be examined before a conclusion can be reached on the impact of exotics on the Sana Ana sucker population.

As a further outgrowth of the phase one and two studies discussed above, the Participants funded phase three, the development of a Conservation Plan for the Santa Ana sucker in the Santa Ana River. The Conservation Plan was developed by San Marino Environmental Associates (SMEA – Baskin and Haglund). The Conservation Program was developed based on SMEA's Conservation Plan, with an initial term of five-years. The Program will promote the conservation of the Santa Ana sucker by implementing necessary research, restoring and creating habitat, and instituting avoidance and minimization measures during "Covered Activities" by the Participants along the Santa Ana River. [Information modified from the U.S. Fish and Wildlife Service Draft Environmental Assessment, 4 October 2001]

B. Conservation Plan.

A Conservation Program for the *in situ* recovery of a population of any fish species requires that two basic life history phenomena take place: successful breeding and successful recruitment (maturing of young into the adult reproductive population). If the success of these two features of the fish's life history can be enhanced there will be an increase in the effective population size and genetic heterozygosity can be maintained. This will, in turn, reduce the chances of extirpation, which is the goal of species recovery. The establishment of multiple independent, viable populations or subpopulations of a species is an effective buffer against species extinction and is a frequently used measure of species recovery when only one or a very few populations existed prior to the initiation of recovery efforts. In the case of the Santa Ana sucker, populations exist in all of the drainages within its historic range: Los Angeles River (Big Tujunga), Santa Ana River (lower portion of the drainage) and San Gabriel River (subpopulations in each of the West, North and East forks of the upper San Gabriel River) (Swift *et al* 1993). In addition, the Santa Ana sucker occurs in the Santa Clara River. This may be an introduced population. However, the conclusion that the Santa Ana sucker is introduced into the Santa Clara River is based entirely on negative evidence. It was absent from incidental field collections in the early part of this century, but it appeared in collections later. No records of an introduction are known. Although the sucker continues to survive within each of the drainages of its historic range, its distribution in each of the drainages to which it is native has become significantly reduced. It was this reduction in the species historic distribution that has led the U.S. Fish and Wildlife Service to propose listing the Santa Ana sucker as threatened under the Endangered Species Act (*Federal Register*, Vol. 64, No. 16, 50 CFR Part 17, RIN 1018-AF34, 26 January, 1999).

The presence of the sucker within each of its historical drainages means that the typical recovery strategy of creating more independent populations will not be as important as the *in situ* enhancement, expansion, and protection of existing populations. The implementation of the Conservation Program for the Santa Ana sucker in the Santa Ana River is the first step in the overall recovery of the species.

C. Conservation Agreement.

The U.S. Fish and Wildlife Service is preparing an Environmental Assessment pursuant to the National Environmental Policy Act (NEPA) to analyze the effects of its proposal to execute (Proposed Action) a Conservation Agreement (Agreement) with various public and private sector agencies and interests (Participants). The agreement would implement the Santa Ana Conservation Program dated 1 September 2000, pursuant to NEPA and the Endangered Species Act of 1973 (ESA), as amended.

While the EA is being completed, and prior to the signing of the Conservation Agreement, the Participants have opted to fund the Conservation Program in order to initiate the Program and begin the recovery of the Santa Ana sucker in the Santa Ana River.

1. **Summary of the Results of the Year 1 Conservation Program.**

- SMEA's data support the importance of Sunnyslope Creek and Rialto Drain as reproductive sites for the Santa Ana sucker.
- Our work also supports Swift's (2001) assertion that the Santa Ana River from just downstream of Mission Boulevard upstream to Rialto Drain holds the largest, most continuously distributed deme of Santa Ana suckers.
- Suckers in the Santa Ana River breed from mid-March through late April based on the appearance of larvae (Swift 2001, Haglund *et al.* 2001).
- Santa Ana suckers can be successfully tagged with PIT tags.
- SMEA's population estimate for Santa Ana sucker from about 600 meters downstream of Mission Boulevard upstream to Rialto Drain is 6,500-6,800 fish. However, we do not have any idea of the degree of fluctuation in this number.
- Suckers spawn over medium gravel in water approximately 0.5 meters in depth with a flow of 0.20-0.24 m/sec.
- Sucker spawning habitat must contain a deeper, more protected area adjacent to the spawning area for fish to utilize when not spawning or between spawning bouts.

- Larval suckers utilize shallow (5-10 cm) water in low flow areas with a silt bottom. Emergent or aquatic vegetation does not appear to be a requirement but is commonly present.

- Larval suckers are only present for approximately 1.5 months.

- Based on Saiki's (2000) data, and SMEA's data, most suckers may not survive past 1+, meaning that they have only a single reproductive season. Due to annual variability in year class composition in Santa Ana sucker from the San Gabriel River, more data are needed.

  These results are presented in more detail in Haglund *et al.* (2001).

This document is a report on the activities carried out and the data collected during the second year (2001/2002) of the Conservation Program.

D. Santa Ana Sucker.

The biology of the Santa Ana sucker (*Catostomus* santaanae Snyder) is poorly documented. The only substantial study on the life history of this species was done on the lowland population in the Santa Clara River (Greenfield *et al* 1970). Studies are underway which will improve the understanding of this species, but much of the current knowledge is based on the anecdotal observations of a few biologists that have spent many years studying the fishes of southern California. Preliminary results from Haglund and Baskin (2002) on habitat preferences of the Santa Ana sucker in the upper San Gabriel River are presented later in this report. Implementation of this Conservation Program will significantly improve the knowledge of this fish's life history and the parameters that impact population size variation in this species.

Catostomus santaanae was originally described as *Pantosteus santa-anae* by Snyder in 1908, based on specimens collected from the Santa Ana River, Riverside, California. The hyphen was dropped from the specific name, and the species was assigned to the genus *Catostomus* by Smith in 1966. Smith considers *Pantosteus* to be a subgenus of *Catostomus*. The older literature uses the name assigned by Snyder. A complete synonymy is provided in Smith (1966).

The Catostomidae are all freshwater fish found in China, northeastern Siberia and North America. The family has thirteen genera and 68 species (Nelson 1994). North America is the center of catostomid diversity. Santa Ana suckers are small catostomids with adults commonly less than 175mm SL (standard length). Their gross morphology (Photo 1) is generally similar to that of mountain suckers (*C. platyrhynchus*) and they possess notches at the junctions of the lower and upper lips as do mountain suckers (Photo 2). Large papillae are found on the anterior of the lower lip but papillae are poorly developed on the upper lip. The jaws have cartilaginous scraping edges inside the lips. There are 21-28 gill rakers on the external row of the first arch and 27-36 on the internal row. This species has 67-86 lateral line scales; 9-11 dorsal fin rays, usually 10; and 8-10 pelvic fin rays. The axillary process at the base of the pelvic fins is represented only as a simple fold. They possess a short dorsal fin and a deep caudal peduncle. The fish are silver ventrally while the dorsal surface is darker with irregular blotching. The degree of dorsal darkening and blotching is variable. Breeding males develop breeding tubercles over most of the body, but the tubercles are most dense on the caudal and anal fins and the caudal peduncle. Reproductive females possess tubercles only on the caudal fin and peduncle (Moyle, 1976).

Photo 1. A large Santa Ana sucker.

Photo 2. Note the distinctive morphology of the lips of the Santa Ana sucker.

Santa Ana suckers are endemic to the Los Angeles basin. Their original range included only the Los Angeles, Santa Ana and San Gabriel river systems (Smith, 1966). Today small populations are still found in the Santa Ana River (Photo 4), Tujunga Wash in the Los Angeles River system, and in the upper San Gabriel River system (Figure 5) (Swift *et. al*., 1993). The Santa Ana sucker is presently listed as a Threatened Species under the federal Endangered Species Act. Large populations are found only in the San Gabriel River (Haglund and Baskin, unpubl. data). For this reason Swift *et al*. (1990) suggested that the East, West and North Forks of the San Gabriel River be considered for status as a Native Fish Management Area for this species. A potentially introduced population exists in the Santa Clara River (Photo 3); however, this population is in decline and throughout the lower portion of the drainage has hybridized with another introduced sucker, the Owens River sucker, *Catostomus fumeiventris* (Haglund, unpubl. data).

Photo 3. Sucker habitat in the Santa Clara River near the Los Angeles/Ventura County line.

Note the similarity between the sucker habitat in the Santa Clara River (Photo 3) and in the Santa Ana River (Photo 4) compared to the San Gabriel River (Photo 5).

Photo 4. Santa Ana sucker habitat in the Santa Ana River at Mission Bridge.

Photo 5. Santa Ana sucker habitat in the East Fork of the San Gabriel River.

Collection of data on the Santa Ana sucker population in the Santa Clara River could, as suggested in SMEA's Conservation Plan (Baskin and Haglund 2000), provide some insights into the Santa Ana River population. Such data might be particularly useful in understanding the carrying capacity for suckers in the Santa Ana River and their population structure.

Santa Ana suckers are typically found in small to medium-sized streams, usually less than 7 meters in width, with depths ranging from a few centimeters to over a meter (Smith 1966; Deinstadt *et al.* 1990). Flow must be present, but it can range from slight to swift. The native streams were all subject to severe periodic flooding; thus, suckers prefer clear water but can tolerate seasonal turbidity. The preferred substrates for adults are gravel and cobble but may also include sand. Although the exact habitat of the juveniles has not been systematically documented, field observations in the Santa Clara River indicate that they are commonly found over sandy substrate and in shallower water than the adults if a choice of such habitats is available (Baskin and Haglund, unpubl. data). During surveys in the San Gabriel River, sucker fry were observed in very shallow water (less than 5 cm) at the very edge of streams (Baskin and Haglund, unpubl. data). This is a microhabitat commonly exploited by very young stream fishes, where they are less vulnerable to larger piscivorous predators and, possibly, where exposure to slightly elevated water temperatures can accelerate development. Santa Ana suckers are associated with algae but not macrophytes. Although the sucker seems to be quite generalized in its habitat requirements, they appear intolerant of highly polluted or highly modified streams.

Spawning in this species occurs from April until early July but peaks in late May/early June in the Santa Clara River (Greenfield *et al.* 1970). The eggs are demersal and are spawned over gravel. Fecundity is high for such a small sucker species, ranging from 4,423 eggs in a 78mm SL (standard length) female to 16,151 in a 158mm SL female. The species is more fecund than most other catostomids. The Santa Ana sucker is relatively short-lived: few individuals survive beyond their second year and none beyond the third year in the Santa Clara River. They are reproductively mature in their first year and thus will typically spawn for two years. Growth rates in the Santa Clara River suggest first year individuals reach 61mm, second years 77-83mm and by the third year 141-153mm SL. Data from the West Fork of the San Gabriel River suggest a similar pattern of growth, but the fish in the West Fork live longer. Aging of Santa Ana suckers from the West Fork of the San Gabriel River by the California Department of Fish and Game (Drake and Sasaki 1987) led to the recognition that Santa Ana suckers could Reach 4+ years in the West Fork. The study suggested the following growth pattern for Santa Ana suckers in the West Fork of the San Gabriel River, young-of-the-year, 0-70mm; 1+, 71-130mm; 2+, 131-160mm; 3+, 161-185mm; and 4+, over 186mm (total length). Development of the eggs and larvae is described by Greenfield *et al.* (1970).

The only substantial life history study done on this species studied the, potentially, introduced Santa Clara River population (Greenfield *et al.* 1970). Greenfield *et al*. (1970) found that detritus, algae and diatoms comprised 97% of the stomach contents while aquatic insect larvae, fish scales and fish eggs accounted for the remaining 3%. Larger specimens usually had an increased amount of insect material in their stomachs. The herbivorous trophic status of the Santa Ana sucker is substantiated by it's long intestine with up to 8 coils.

E. General Distribution of the Santa Ana Sucker in the Santa Ana River.

The Santa Ana sucker is found in the Santa Ana River from about Imperial Highway bridge upstream to the Rialto Drain. However, within the river the fishes are not evenly distributed. Below Prado Dam, suckers currently are rare. Swift's (2001) surveys in 2000 failed to produce any suckers below Prado Dam, and Saiki's (2000) team never captured any suckers during their work at Imperial Highway. However, work by SMEA for the U.S. Army Corps of Engineers (ACOE)(outside the Scope of the SAWPA contract) from 21-28 September located 8 suckers, six adult fish and two fish, which may have been young-of-the-year (YOY). SMEA conducted the surveys in conjunction with ACOE's diversion of the river between Weir Canyon and Imperial Highway (Baskin and Haglund 2000). The diversion affected about 3 miles of river. Thus, not many suckers were located given the length of stream surveyed. This has been the pattern recently. Surveys find a few fish or none, and the individuals captured are adults or YOY.

Surveys sponsored by the California Department of Fish and Game in 1994 located a moderate number of YOY and a few adults in the first 3 miles of stream below Prado Dam. In the early 1990s adult suckers could regularly be taken just upstream of Imperial Highway (Haglund unpubl data), and on one occasion, in excess of 100 adult suckers were trapped by a diversion immediately downstream of Imperial Highway (R. Fisher pers comm.). Although no recent, thorough surveys exist for the river below Prado Dam, in general, Santa Ana suckers appear to have declined in recent years in the river below Prado Dam.

The river immediately below Prado Dam is different from the river reaches upstream of the dam. Much of the river is deeper, more slowly flowing with a siltier bottom (Photo 6), and the reach around Imperial Highway has been significantly impacted by construction (Photo 7).

It is not known whether there was recently or is a self-sustaining population of Santa Ana suckers downstream of Prado Dam. No reproduction has been documented below Prado, and the population may be sustained solely by immigration from the upstream population.

Photo 6. Habitat in the Santa Ana River near the mouth of Aliso Creek. Juvenile suckers have been collected from this river reach.

Photo 7. Santa Ana River at Imperial Highway.

From the MWD crossing downstream to Prado Dam, fish are widely scattered and not very abundant. Swift's (2001) work in 2000 yielded only 11 adult suckers by trapping about 4 days per month for the entire year downstream of River Road. His seining surveys yielded one adult sucker downstream of River Road in 2000. SMEA conducted a one-time, intensive survey upstream and downstream of Van Buren Street bridge (Photo 8) in June of 2001 (outside of SAWPA contract, Baskin and Haglund 2001) and failed to locate any suckers. Swift reported visual sighting of suckers at Hamner Avenue Crossing and upstream almost to California Avenue. Suckers do occur downstream of MWD crossing, but the numbers are low and the fish scattered. The only place where fish may be reliably found is in the vicinity of the Riverside Water Reclamation facility (Chadwick 1991, Susan Ellis (CA DFG) pers comm.; Chadwick 1996, Mike Giusti (CA DFG) pers comm.; Swift 2000).

Photo 8. The Santa Ana River at the Van Buren Street bridge.

Suckers regularly occur at MWD crossing. This was one of Saiki's (2000) study sites, and he found fish in both 1998 and 1999. USGS collections for the NAQUA program captured suckers at MWD crossing in July 2001 (previously in 1999 and 2000), and SMEA had collected suckers at MWD crossing earlier in the year, March 2001.

The river reach upstream of MWD crossing to Mission Boulevard consistently contains fish, but the numbers are relatively low. Swift was able to find adult suckers in the vicinity of Arroyo Tequesquite in both February and June 2000, but no suckers were captured in the Arroyo itself. This stream reach also contains Anza Park Drain and Sunnyslope Creek. Suckers are found in both of these tributaries (Chadwick 1991, Susan Ellis (CA DFG) pers comm., Chadwick 1996, Mike Giusti (CA DFG) pers comm., Swift in 2000 (2001), Haglund *et al.* this report). Sunnyslope Creek is a well-documented reproductive site for the Santa Ana sucker.

The river reach from just downstream of Mission Boulevard upstream to Rialto Drain contains the greatest number of suckers (Photo 9) (Swift 2001, Haglund *et al.* this report).

Photo 9. The Santa Ana River upstream of Market Street.

II. STUDY PLAN FOR YEAR 2 OF THE IMPLEMENTATION OF THE SANTA ANA SUCKER CONSERVATION PROGRAM.

The work plan submitted by SMEA identified the tasks listed below. These tasks continue to be based to a large extent on the original tasks for a Conservation Program which were suggested in the Conservation Plan prepared by SMEA (Baskin and Haglund 1999). Modifications are primarily due to results of the year 1 implementation of the Santa Ana sucker conservation program and to a reduced budget compared to that envisioned in the Conservation Plan. The year 2 budget has been reduced from the year 1 budget. It was known when the tasks were proposed for the 2001/2002 contract that not all the tasks could be accomplished on the reduced budget. However, it was agreed with SAWPA that the complete task list would be submitted and SMEA would do as much as the budget allowed and would emphasize those tasks which were a continuation of the 2000/2001 tasks. SMEA would also take advantage of any unique circumstances or opportunities that occurred during the field season.

TASK 1. Sucker Reproduction.

Subtask 1-1 Determine timing of sucker reproduction.
Monitor developmental readiness for reproduction at several localities.

Subtask 1-2 Determine environmental correlates of reproduction.

Utilize rainfall data, flow data, day length, lunar cycles and water temperature data. Install temperature loggers in several localities ASAP!

Subtask 1-3 Locate breeding habitat and describe it, including detailed characterization of specific egg-laying sites.
Compare characterizations of utilized habitat to non-utilized habitat.

Subtask 1-4 Establish experimental breeding sites in Sunnyslope drain based on data collected in 2000/2001 and monitor use of constructed habitat versus "natural" habitat.

Subtask 1-5 Monitor for presence of tagged individuals. Several attempts should be made to see if we can capture any of last year's tagged fish on the reproduction sites, maybe focusing on Rialto given the location of fish tagging.

TASK 2. Fry Production and Habitat Use.

Subtask 2-1 Determine habitat characteristics where fry are found and compare to areas not used by fry.

Subtask 2-2 Monitor fry growth.

Subtask 2-3 Study fry drift.
Attempt to determine the importance and timing of drift in Santa Ana suckers. Will also help determine whether there is reproduction in the mainstem or if fry are drifting out into the mainstem.

Subtask 2-4 Batch mark fry to help determine movement.

TASK 3. Population Estimates.

Subtask 3-1 Refine protocols for population estimation. Focus only on sequential recapture and eliminate mark-recapture.

Subtask 3-2 Determine population size in occupied habitat using sequential depletion as was done last year.

Subtask 3-3 Determine population structure. Using data on age-length relationships, assess the year class composition of fish captured.

Subtask 3-4 Determine numbers of adults in breeding sites. Try a couple of surveys (seining/snorkeling?) to try and estimate the number of adults on the reproductive sites.

Subtask 3-5 Compare population size from previous year.

Subtask 3-6 Begin to examine year class survival by examining year class composition from this year's sample and comparing it to the year class composition of last year's sample.

Subtask 3-7 Tag more individuals. Most tagging will occur in association with the population estimate. This task is for those unique opportunities such as with the USGS.

TASK 4. Migration.

Subtask 4-1 Determine if there is a breeding migration by examing for the presence of tagged fish in the breeding creeks early before reproduction, then checking for them again following initiation of reproduction

Subtask 4-2 Examine post-breeding movement. This can be done by tagging fish in the reproductive creeks then seeing if they are captured later in the population sampling

Subtask 4-3 Examine site fidelity in stream. See if fish tagged in the reproductive creeks stay there

TASK 5. Continue snorkeling surveys for generalized distribution data.

TASK 6. Period sampling to determine age class composition.

Subtask 6-1 Try to locate habitat used by juveniles

TASK 7. Meeting Attendance.

TASK 8. Interim reports at SAWPA meetings.

TASK 9. Data Management and Analysis.

TASK 10. Project Management.

TASK 11. Plans for 2002/2003 Conservation Plan Implementation.

TASK 12. Final Report/Annual Report Input.

Modifications to the work plan began with the elimination of creation of an experimental breeding site, due to delays in obtaining permission from U.S. Fish and Wildlife Service. However, discussions with U.S. Fish and Wildlife, U.S. Army Corps of Engineers, and California Department of Fish and Game did take place laying the foundation for completion of this task in 2002/2003. Also because a large number of fry were present in the stream during this field season, significant field effort was spent studying fry. Near the end of the field season, SMEA was asked to look at the (apparently) unusually large number of juvenile suckers present at River Road.

All work conducted as part of the second year implementation of the Santa Ana sucker Conservation Program was done under USFWS permit TE781377-3, as amended issued to SMEA (Baskin, Haglund and employees) and USFWS permit TE793644-4 issued to Camm Swift.

III. TAGGING OPTIONS.

In the Conservation Plan, Baskin and Haglund (2000) had recommended tagging suckers. The benefits of tagging to the study of the Santa Ana sucker in the Santa Ana River are extensive. In order to recover the sucker, we need to understand patterns of movement/migration, determine age class survival, document reproductive habitat use and estimate population size. Tagging should be useful in the study of all these parameters.

Prior to initiating the tagging during the year 1 implementation of the Santa Ana sucker Conservation Program, SMEA investigated alternative tagging technologies. Specifically, SMEA examined:

- Decimal Coded Wire Tag
- Soft Visible Implant Alphanumeric
- Passive Integrated Transponder (PIT) Tag
- Photonic Marking

The following table (Table 1) summarizes the advantages and limitations of the four technologies.

Table 1. Summary of the advantages and limitations of four tagging technologies.

ADVANTAGES	LIMITATIONS
Decimal Coded Wire Tag	
Can be used on small animals	Capital equipment is expensive
Minimal biological impact	Tags are not externally visible
High retention rate	Tags must be excised (lethal)
Enormous code capacity	
Inexpensive tags	
Soft Visible Implant Alphanumeric	
High retention rate	Unsuitable for small fish
Low capital costs	Requires suitable tissue
Readable in live specimens	Can become occluded
Minimal biological impact	
Passive Integrated Transponder (PIT) Tag	
Positive identification	Moderate cost
Easy field identification	Requires injection
Biologically safe	Learning curve on injection
Passive operation	
Easily injected	
Photonic Marking	
Non-invasive	For placement beneath translucent skin
Externally visible	Difficult to mark individuals
Easily injected applied	
High retention	
Ideal for batch marking	

Based on the table above, it can be easily discerned that PIT tags offered the greatest potential for studies of the Santa Ana sucker. It should also be noted that SMEA investigated the potential use of telemetry to follow fish movement, but determined that sufficiently small transmitters were not available.

The work done by SMEA in 2000-2002 has validated the use of pit tags on the Santa Ana sucker. Photos 10 and 11 show the equipment SMEA used during the sucker tagging.

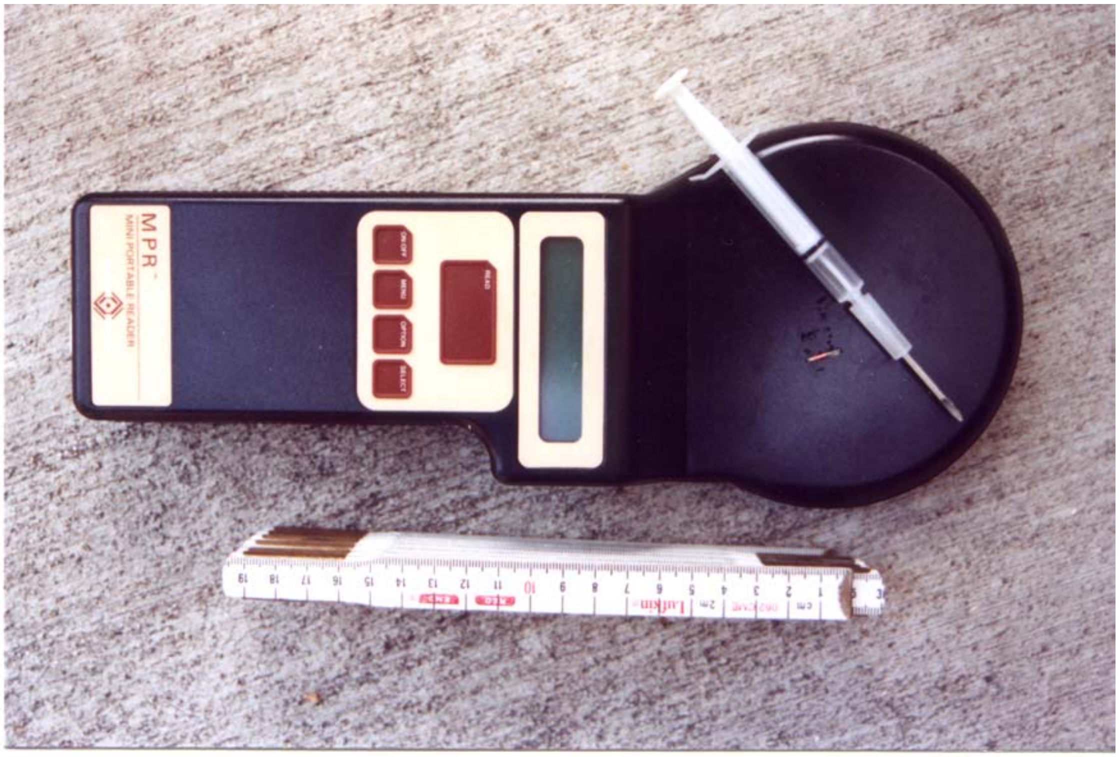


Photo 10. The PIT tagging equipment, including the reader, injector with needle and a PIT tag. A folding meter stick is provided for scale.

Photo 11. Close-up of PIT tag and injector needle. Notice the bevel on the injector needle. A folding meter stick is provided for scale.

IV. TAGGING FEASABILITY STUDY.

In 2000, once SMEA had determined the optimal tagging technology, it was decided to conduct a study to ascertain the effect of the tagging on Santa Ana suckers, since no such data existed. Specifically, SMEA wanted to determine if the tagging caused any significant mortality.

PIT tagging methods were described for salmonids based on work by the U.S. National Marine Fisheries Service (Prentice *et al* 1990a, 1990b). The techniques described in these papers combined with a protocol supplied by Howard Burge of the U.S. Fish and Wildlife Service were used to establish a protocol for tagging Santa Ana suckers. Burge indicated that he had found two sources of mortality in PIT tagging fish: 1) inexperienced personnel, and 2) anesthesia and handling. Therefore, a preliminary study served the additional benefit of gaining experience tagging, particularly Baskin, Swift, and Bryant. Only Haglund had previously PIT tagged suckers. SMEA also eliminated the use of MS-222 as an anesthetic, and used CO_2 from Alka Seltzer tablets instead.

SMEA used the following techniques during the experimental fish tagging. Because of the success of the experiment, the same techniques were used during the tagging of fish on the Santa Ana River.

As suckers were captured, they were placed in buckets containing fresh river water. After several fish were captured they were transferred to coolers containing clean river water and polyaqua (slime stimulant). Coolers were maintained in the shade, and the water was refreshed as necessary. Fish were removed from the holding coolers about 4-6 fish at a time and transferred to an anesthetizing bucket to which Alka Seltzer had been added. No attempt was made to inject fish until they had slowed down. Prior to use and following each use, needles and injectors were soaked in 70% ethanol. Tags were stored in ethanol prior to their injection. A recorder noted the number of each tag and passed the tag to the individual doing the injection. The individual doing the injection measured (standard length) and weighed the fish prior to injection. The fish were injected to the left of the ventral midline, just posterior of the pectoral girdle. The needle was inserted at a low angle to the body. When the needle opening was just occluded by the fish's tissue, the plunger was pushed. As the plunger was depressed, the needle was withdrawn so that the tag would just slide into the abdomen. The position and low angle insertion were designed to prevent damage to the fishes' visceral organs. Following tagging, the fish were placed into a recovery cooler with fresh river water and polyaqua. The water was refreshed as necessary. Once fish were recovered, they were returned to the stream (At the Santa Ana River fish are returned to the stream when collection is complete). Fish were returned to the entire stream reach from which they had been captured. Temperature was constantly monitored, and all coolers were oxygenated using bubblers.

The Santa Ana suckers from the Santa Clara River provided the perfect surrogates for the Santa Ana River suckers. They are the same species, but as previously mentioned, are specifically excluded from the federal listing.

On 9 December 2000, 24 suckers were collected upstream of the Interstate 5 bridge over the Santa Clara River. The fish were split into two groups, a control group, and a group to be PIT tagged. All fish were relaxed with Alka Seltzer then 12 fish were tagged, and the untagged fish were handled to simulate tagging. Tag insertions were performed by Haglund, Baskin and Swift. The fish were tagged in this preliminary experiment and the subsequent experiment with BioMark PIT tags (11.5 mm) in the abdominal cavity. All 24 fish were placed in coolers containing a slime stimulant and transported to the Robinson Ranch golf course. The creek on the golf course was selected as an experimental site because it was thought to be secure. The fish were placed in artificial enclosures (boxes). The boxes had holes drilled in all sides in order to allow the water to flow relatively freely through the boxes. Cobbles were placed in the bottom and the boxes were wired to two pieces of rebar (on either side of the container) that had been driven into the substrate (Photo 12). The boxes were weighted with cobbles from the river in order to help stabilize the boxes and provide a food source for the suckers. Tops were "snap on" tops, which were further secured with bungee cords. Plant debris was used to cover the boxes to make them less obvious to a casual observer.

Photo 12. Notice the two boxes in the center of this photograph; these are the sucker enclosures. This photo was taken at the Robinson Ranch golf course creek.

The fish were first checked on 12 December and it was discovered that the boxes had been tampered with, and 15 of the fish were missing. Nine fish remained in the boxes, 3 PIT tagged fish and 6 untagged fish. These fish were maintained in the golf course creek until 24 December when they were transported to the Santa Clara River and placed in the river just upstream of the Interstate 5 bridge. These fish suffered no mortality following the disturbance of the boxes. On 11 January a large flow in the Santa Clara River washed the box away terminating the experiment. Therefore, the known results are shown in the following table. This experiment lasted 27 days.

Table 2.

	Initial Number	Mortality	Surviving Number
PIT Tagged Fish	3	0	3
Fish Not PIT Tagged	6	0	6

The success of this experiment with respect to the apparent survival of the PIT tagged fish encouraged SMEA to expand the experiment.

On 29 December 2000, Haglund, Baskin and Bryant of SMEA began a second phase of the tagging trial. The purpose of the second phase was to repeat the tagging experiment with a larger sample size.

93 suckers were collected upstream of the Interstate 5 bridge during 27 minutes of shocking. Sixty fish ranging in size from 59 mm SL to 113 mm SL were used in the experiment. The

other 33 suckers were released. Twenty-three suckers were released after having been held for slightly over 2 hours, and all individuals appeared "healthy" when they were released.

For the experiment, 30 fish were tagged and 30 fish were used as a control group. All fish were relaxed with Alka Seltzer then some fish were tagged, and the untagged fish were handled to simulate tagging. All 60 fish were placed in a cooler containing a slime stimulant. All tag insertions were performed by Haglund and Baskin. An attempt was made to utilize samples (tagged and untagged fish) with equal size distributions.

The fish were placed in artificial enclosures (boxes). It took approximately an hour to place the boxes in the river. The boxes were weighted with cobbles from the river in order to help stabilize the boxes and provide a food source for the suckers. Fifteen fish were placed in each of 4 boxes with tagged/untagged ratios as follows:

Box 1 - 8 tagged, 7 untagged
Box 2 – 8 tagged, 7 untagged
Box 3 – 7 tagged, 8 untagged
Box 4 – 7 tagged, 8 untagged

Box 1 was the downstream-most box and Box 4 was the furthest upstream. Box 1 was placed in the same pool as the old experimental box containing the nine fish from the first experiment.

The boxes had holes drilled in all sides in order to allow the water to flow relatively freely through the boxes. Rocks were placed in the bottom and the boxes were wired to two pieces of rebar (on either side of the container) that had been driven into the substrate. Tops were "snap on" tops, which were further secured with bungee cords. Plant debris was used to cover the boxes to make them less obvious to a casual observer.

The old experimental box was checked at time of installation of the other boxes, all nine fish were present and appeared fine. Two new cobbles, covered with algae, were placed in the box.

Once the experiment had been completely set up, the remaining 10 suckers were released. All suckers had recovered and appeared to be swimming normally. There was no apparent damage as a result of electroshocking. All fish placed in the boxes appeared to be swimming normally and no fish were in obvious distress.

The experiment was first checked following the set up on 1 January 2001. All the fish in the old experimental box were fine. There were two dead fish in the new experiment, one each in boxes 2 and 3. The dead fish were removed, and the boxes secured. The boxes were checked again on 2 and 7 January, there was no additional mortality. On 10 January flows were high when SMEA personnel went to check the boxes, and it was decided that the boxes shouldn't be opened. On 11 January there was a very high flow that washed away the boxes, terminating the experiment.

The results of the experiment after 10 days are summarized in the table below.

Table 3.

	Initial Number	Mortality	Surviving Number
PIT Tagged Fish	30	2	28
Fish Not PIT Tagged	30	0	30

The null hypothesis is that there was no association between PIT tagging and death. The null hypothesis is rejected if $P<0.05$. In a Fisher's exact test, $P = 0.25$; so the null hypothesis is accepted.

Based on the data presented above, SMEA determined that they could PIT tag Santa Ana suckers and not affect their survival.

V. PIT TAGGING

On 19 and 21 July 2002, SMEA personnel shocked three 100-meter sections of stream in order to capture and tag the Santa Ana suckers from these stream reaches. These same three stream reaches had been shocked and the captured fish tagged on 15 and 16 June 2001 (Data from the 2001 shocking collections are presented in Appendix 1). The primary goals of these collections were: (1) to provide population estimates of Santa Ana sucker from these three stream sections, (2) to begin to develop a population of tagged suckers, so that their movement/migration in the stream can be recognized and documented, and (3) to examine the population structure of the Santa Ana sucker. Discussion of the data relevant to each of the primary goals is given below.

Three 100-meter stream reaches were chosen at random upstream of Mission Boulevard. The three sites are designated as: Site 1, upstream of Mission Boulevard; Site 2, upstream of Highway 60, and Site 3, downstream of Riverside Avenue. The stream sections are shown in Photos 13-15.

Photo 13. A photograph of the tagging site just upstream of Mission Boulevard.

Photo 14. A photograph of the tagging site upstream of Highway 60.

Photo 15. A photograph of the tagging location just downstream of Riverside Avenue

The length (mm SL) and weight (g) of each of the fish captured in the 100-meter sections is shown below in Tables 4-6.

Table 4. List of the length (SL mm) and weight (g) of the fish caught (N=120) in the 100-meter stream reach upstream of Mission Boulevard (Site 1) on 19 July 2002.

LENGTH	WEIGHT	PIT TAG NUMBER
66	5.6	
142	59.4	42645C697E
119	32.8	4264791C4C
39	1.1	
39	1.1	
37	0.9	
47	1.7	
60	4.1	
36	0.8	
45	1.7	
34	0.6	
151	53.4	4266074800
148	51.7	4264636A3A
147	52.3	4264772172
125	35.0	4265070602
125	36.8	42620D5D2B
130	39.8	4261657B34

141	70.3	4263343B23
78	9.1	
66	6.1	
52	2.7	
58	3.9	
47	2.0	
132	6.2	42617F6047
146	50.1	4261605464
64	4.2	
62	4.2	
72	8.7	
62	4.9	
65	4.7	
61	4.3	
36	0.9	
77	8.2	
66	5.9	
59	4.2	
76	8.0	
76	8.4	
55	3.0	
67	4.2	
137	49.3	42616C560B
131	40.1	4265510573
30	0.5	
40	1.6	
67	5.4	
36	0.8	
46	1.7	
59	3.7	
60	4.2	
56	2.9	
49	2.3	
46	2.2	
91	14.2	42617F6A35
119	31.1	426210431E
147	39.7	4265521922
147	53.5	42655E0062
76	9.7	
31	0.5	
51	2.0	
87	12.4	426179775F
151	55.6	4261792342
147	50.4	42620D567A

155	62.6	42645F4F20
39	0.9	
49	1.8	
31	0.5	
42	1.2	
31	0.6	
30	0.6	
40	1.8	
28	0.2	
49	2.0	
55	3.2	
146	54.5	4260163132
169	79.8	4262087C13
135	41.8	4264733865
123	32.4	4265592E76
81	11.9	4262061627
117	29.7	4264733100
68	5.2	
64	5.1	
74	7.6	
68	5.6	
158	73.3	4264614436
51	2.5	
161	61.8	42615F0109
122	30.7	42620C7043
67	5.4	
49	2.0	
47	1.9	
137	40.8	425F687349
82	9.2	42655A1F5B
130	35.4	4262005A69
72	7.5	
70	5.6	
62	4.6	
62	3.8	
145	50.5	42672E2622
139	51.3	42615D3113
151	64.4	425F5B4B7A
158	65.4	4263357E77
140	48.3	4261653228
80	10.2	42647E3D13
135	41.6	426018110D
76	7.8	
61	4.4	

51	2.0	
129	30.0	42620E272E
144	54.8	4261701E03
125	33.5	426567151D
79	9.3	
67	5.7	
65	4.9	
74	7.4	
70	5.8	
55	2.8	
161	65.5	4263245D1B
73	8.3	
36	0.8	
63	4.5	
82	9.2	425F724E17
121	30.6	4264766C60
46	1.5	
40	1.3	
55	2.8	
145	44.7	4261600774
66	5.7	
82	9.7	42631F0E54
157	62.8	4261745A6C

Table 5. List of the length (SL mm) and weight (g) of the fish caught (N=151) in the 100-meter stream reach upstream of Highway 60 (Site 2) on 21 July 2002.

LENGTH	WEIGHT	PIT TAG NUMBER
128	37.1	4265025324
138	42.5	42645F325B
63	4.2	
66	5.3	
59	4.4	
69	6.0	
67	5.7	
64	5.5	
55	3.3	
59	4.2	
165	72.5	42615F4344
171	77.4	4265006F62
122	34.2	4261634916
122	29.7	4261653979
133	41.8	426475561C
143	49.6	4261594B69

141	46.5	4261641706
139	45.3	426505704F
140	51.5	42620A4F16
141	49.8	42617F3274
145	58.5	42615F4A21
69	5.6	
74	7.5	
67	6.1	
68	5.2	
59	3.9	
65	4.7	
65	4.6	
49	2.1	
69	5.9	
62	3.7	
68	5.5	
67	5.1	
141	43.9	4265025F78
155	62.0	4261767F31
146	51.2	426509071D
127	33.3	4255717B5D
65	5.4	
40	1.0	
62	4.2	
68	6.2	
54	2.9	
58	4.0	
63	4.9	
60	4.5	
63	4.7	
74	7.7	
63	4.6	
48	2.1	
68	6.2	
65	4.7	
59	3.8	
69	6.1	
55	3.1	
61	5.0	
55	3.3	
54	3.0	
52	3.1	
62	4.8	
55	3.3	

55	3.3	
63	5.0	
151	62.6	4261644B5D
124	34.3	4261717A77
128	35.5	4261612379
67	5.2	
63	4.6	
67	6.3	
65	5.1	
86	11.7	4264793D6C
140	44.7	425F630A0C
128	35.7	42633F3E3E
76	7.5	
73	7.7	
62	4.1	
56	3.3	
67	5.2	
61	4.4	
56	3.1	
45	1.6	
132	37.2	42620D3C72
63	4.8	
68	5.5	
56	3.4	
64	4.5	
71	6.1	
61	3.8	
46	1.6	
62	5.3	
58	4.0	
61	4.7	
59	3.5	
55	3.0	
66	4.8	
69	5.3	
45	1.6	
52	2.8	
34	0.8	
45	1.9	
46	2.0	
52	2.6	
55	3.5	
63	4.9	
58	3.3	

59	3.8	
45	1.7	
52	2.7	
62	4.4	
64	5.0	
84	10.2	4265026F05
58	3.8	
57	3.7	
66	5.1	
70	5.9	
72	6.2	
45	1.5	
124	35.8	42633C151F
78	8.9	
59	3.3	
50	2.6	
60	4.0	
68	5.6	
66	6.0	
68	5.1	
68	5.4	
59	3.4	
60	4.2	
62	4.6	
54	2.7	
45	1.9	
65	5.4	
63	5.0	
61	4.5	
66	4.8	
82	10.0	4261594A4A
161	66.9	42616F7A27
147	55.3	4265036440
124	33.2	4261704909
65	4.6	
75	7.2	
71	6.0	
65	4.9	
65	4.9	
79	8.7	
63	4.0	
48	1.8	
155	63.0	4264704E3C
74	6.9	

61	4.0	
67	5.1	
62	4.4	

Table 6. List of the length (SL mm) and weight (g) of the fish caught (N=45) in the 100-meter stream reach downstream of Riverside Avenue (Site 3) on 21 July 2002.

LENGTH	WEIGHT	PIT TAG NUMBER
175	89.1	4261782B10
63	4.9	
145	56.3	4264717427
160	79.0	4264671A32
142	51.0	4261704555
62	4.6	
162	76.5	4264524D5B
78	9.2	
153	66.3	426168533E
133	44.7	426156082F
136	40.6	4264706D67
66	5.3	
61	3.7	
69	5.6	
72	6.9	
70	6.0	
70	7.1	
68	6.0	
70	6.6	
71	5.2	
71	7.4	
73	7.0	
68	5.8	
77	7.0	
89	12.5	42616A5808
68	5.4	
68	5.8	
67	6.1	
71	5.7	
120	31.7	
74	7.5	
70	5.8	
67	5.3	
57	3.2	
152	58.5	4264570D3A
73	6.5	

72	6.3	
68	5.2	
72	7.3	
77	7.3	
68	5.2	
69	5.4	
68	5.1	
60	4.1	
70	6.5	

In addition to the suckers tagged as part of the population estimate in 1991, additional suckers were tagged to increase the population of tagged suckers in the river. Fish were tagged at the following locations on the specified dates:

- 16 June 2001, Pool under Riverside Avenue bridge, N=34
- 18 June 2001, Pool under Riverside Avenue bridge, N=8
- 18 June 2001, About 100-150 m downstream of Highway 60, N=14
- 18 June 2001, Site 1 upstream of Mission Boulevard, N=3
- 22 June 2001, Sunnyslope Creek, N=19
- 27 July 2001, MWD Crossing, N=5

The length (mm SL), weight (g) and pit tag number of each of the fish captured and tagged in 2001 during the above tagging sessions is presented in Appendix 1. No comparable tagging sessions were conducted in 2002.

A. Population Estimates – Sequential Depletion.

SMEA had originally hoped that it would be possible to use a mark-recapture technique to estimate the sucker population, and thus have yet another use for tagged fish as well as an alternative population estimate. However, because it is difficult to meet the assumptions of a mark-recapture in a riverine system, SMEA preferred the use of a depletion technique. However, a recapture attempt was made following the initial tagging.

In order to ascertain the feasibility of mark-recapture in this system, SMEA tagged fish from three localities on 16 June 2001. SMEA returned to these localities on 18 June to attempt to recapture the marked fish, and associated unmarked fish in order to make a population estimate. Too few fish were captured during the recapture phase of the technique to provide a reliable population estimate. As mentioned above, SMEA used a triple pass depletion to collect the fish on 16 June as a back-up to the mark-recapture procedure. It is the triple-pass depletion procedure that SMEA employed during 2002 (See Appendix 2 for a discussion of triple pass depletion procedure and calculations). The three sites used in this study were described above. The 2001 data from the triple pass depletion are presented in Tables 7 and 8. The 2002 data from the triple pass depletion are presented in Tables 9 and 10.

Table 7. The number of suckers captured in each of the three passes, at each of the three sampling sites on 15 and 16 June 2001.

Pass #	Site 1	Site 2	Site 3
1	57	123	8
2	21	25	5
3	10	16	0

These data provide the following estimates for the population of Santa Ana suckers at each of the three 100-meter study reaches:

Site 1, upstream of Mission Boulevard = 89 fish
Site 2, upstream of Highway 60 = 164 fish
Site 3, downstream of Riverside Avenue = 13 fish

The standard error can be used to calculate the 95% confidence interval (confidence interval = $\underline{+}$1.96(SE)). This means that there is only a 5% chance that the "true" population size is outside the confidence interval. The standard errors and confidence intervals for the population estimate from each of the three sites is shown in Table 8.

Table 8. Confidence intervals for the population estimates from the three sites.

Locality	Population Estimate	Standard Error	Confidence Interval
Site 1	89	2.85	83-94
Site 2	164	0	164
Site 3	13	0.60	12-14

Based on the data presented above, one would estimate that there is an average of 86-91 fish per 100 meters. It is assumed that these habitats are representative of the habitat from 600 meter below Mission Boulevard upstream to Rialto Drain. This is a distance of approximately 7.65 kilometers. Therefore, based on the above data this stream reach would be expected to hold approximately 6,579-6,962 Santa Ana suckers.

Table 9. The number of suckers captured in each of the depletion passes, at each of the three sampling sites on 19 and 21 July 2002.

Pass #	Site 1	Site 2	Site 3
1	52	62	27
2	38	47	7
3	25	42	11
4	13		

These data provide the following estimates for the population of Santa Ana suckers at each of the three 100-meter study reaches:

Site 1, upstream of Mission Boulevard = 146 fish
Site 2, upstream of Highway 60 = 170 fish
Site 3, downstream of Riverside Avenue = 47 fish

The standard error can be used to calculate the 95% confidence interval (confidence interval = $\pm$1.96(SE)). This means that there is only a 5% chance that the "true" population size is outside the confidence interval. The standard errors and confidence intervals for the population estimate from each of the three sites is shown in Table 8.

Table 10. Confidence intervals for the population estimates from the three sites.

Locality	Population Estimate	Standard Error	Confidence Interval
Site 1	146	21.56	124-168
Site 2	170	11.56	158-182
Site 3	47	3.92	43-51

Based on the data presented above, one would estimate that there is an average of 108-134 fish per 100 meters. It is assumed that these habitats are representative of the habitat from 600 meter below Mission Boulevard upstream to Rialto Drain. This is a distance of approximately 7.65 kilometers. Therefore, based on the above data this stream reach would be expected to hold approximately 8,262-10,251 Santa Ana suckers.

Table 11. Comparison of the 2001 and 2002 population estimates.

	2001	2002
Site 1 - upstream Mission bridge	89 $\pm$ 2.85	146 $\pm$ 21.56
Site 2 - upstream Hwy 60 bridge	164 $\pm$ 0.0	170 $\pm$ 11.56
Site 3 - downstream Riverside Dr bridge	13 $\pm$ 0.60	47 $\pm$ 3.92
Average per 100 meter reach	86-91	108-134
Estimated suckers in 7.65 km	6,579-6,962	8,262-10,251

Looked at simplistically, the data appear to suggest an increase in the number of fish in the river, based on sampling at these three sites. However, two cautionary notes apply:

1. No population trend can be robustly defined by two data points
2. There were significant changes in the population structure (see discussion of population structure) between 2001 and 2002, which may reflect the exceptionally dry year of 2002.

It is essential to remember that robust determinations of population trends require many years of data. Furthermore, the Santa Ana sucker which evolved in the unpredictable hydrological regime of Southern California has evolved to become highly fecund. This allows the fish to exploit optimal conditions when they occur, and to recover rapidly after population drops resulting from years with poor recruitment (*e.g.* Greenfield *et al.* 1970).

B. Population Estimates – Snorkeling Surveys.

During 1999 and 2000, snorkeling surveys were conducted to estimate sucker density/abundance in the Santa Ana River. Because this dataset had been started in 1999, SMEA determined to continue to collect these data in 2001 and 2002. Appendix 2 contains a discussion of this technique as a method of population estimation. The data from 1999 through 2002 are presented in Table 12. This technique, although not as quantitatively reproducible, does provide a broader coverage of the river than can be accomplished using sequential depletion techniques without excessive cost and personnel effort.

Table 12. Results of snorkeling surveys 1999-2002.

YEAR, Locality	Date	Length, M	Juvenile		Adult		Total	
			number	# / 100 M	number	# / 100 M	number	# / 100 M
1999								
Below Riverside	22-Dec	645					707	109.6124
2000								
Sunnyslope	20-Jun	430					156	36.2791
Arr. Tequesquite-Mission	22-Jun	2100					46	2.1905
Market to Riverside	28-Jun	2600					422	16.2308
Riverside to RIX outlet	29-Jun	2300					125	5.4348
2001								
Sunnyslope	22-Jun	430					51	11.8605
Mission to Market	14-Jun	1700					600	35.2941
Market to Riverside	3-Jul	2600	72		671		743	28.5769
Riverside to RIX outlet	3-Jul	2300	175		223		398	17.3043
Mission to RIX outlet		6600					1741	26.3788
2002								
Sunnyslope	29-Jun	430	0	0.0000	0	0	0	0.0000
Mission to Market	26-Jun	1700	1045	0.6147	833	0.49	1868	109.8824
Market-Riverside	26,28 Jun	2600	186	0.0715	274	0.1053846	460	17.6923
Riverside-RIX	28-Jun	2300	69	0.0300	49	0.0213043	118	5.1304
Rialto Drain	28-Jun	350	30	0.0857	0	0	30	8.5714
Mission to RIX outlet		6600	1300	0.1970	1156	0.1751515	2446	37.0606

What is clear from these data is that there has been a decrease in the number of fish in Sunnyslope Creek over the period of these surveys. These surveys also pick up an increase in the absolute number of fish upstream of Mission Blvd from 2001 to 2002, and these surveys suggest there are far fewer fish in the river than do the sequential depletion data.

C. Population Estimates – River Road.

During the summer, workers around River Road found what was thought to be a very large number of small suckers. Because of this SMEA was asked to make a population estimate in the area of River Road. On 15 August 2002, a site just upstream of the bridge was selected. This river reach was in the main flow channel and thus somewhat resembled the other 100-meter sections being studied by SMEA. However, two passes with an electroshocker failed to produce any suckers. The area was then snorkeled and examined with a viewing tube. No suckers were found.

It was then decided to move upstream of the berm placed in the river by the sand mining operation. A 50 meter site along the berm was selected. Because the water is so wide at this area, a rectangle 50 meters long and 4 meters wide was cordoned off with blocking nets. One edge of the sampling area was the berm. A sequential depletion of this stream reach produced 304 juvenile suckers most between 40 and 60 mm SL. The estimated population was 304 fish per 50 meters with a standard error of $\pm$0. To make the estimate comparable to the other reaches, this would be 608 fish per 100 meters. This is almost twice the number of suckers (YOY and adult combined) as were captured at all three other 100-meter sections. Young-of-the-year suckers were extraordinarily abundant at River Road in 2002. There is virtually no data from other years.

The large number of juvenile suckers that had been observed at River Road prompted SMEA to do a young-of–the-year survey on 13 July 2002. In order to obtain a gross idea of the distribution and abundance of YOY suckers, Seven (7) sites were selected and two 50-meter reaches were seined at each. The results are shown in Table 13.

Photo 16. A young-of-the-year (YOY) Santa Ana sucker.

Table 13. Summary of data collected on 13 July 2002 - Santa Ana sucker young-of-the-year survey.

Locality		**# Seine Hauls**	**Sucker**		**Other Fishes**								
			YOY	**Adult**	**Ga[2]**	**Bb[3]**	**Yb[4]**	**Fm[5]**	**Mc[6]**	**Lb[7]**	**Gf[8]**	**Ca[9]**	**Ac[10]**
Market Street	Upstream	16	1	0	X								X
	Downstream	10	0	0	X				X				X
Mission Boulevard	Upstream	10.5	4[11]	8	X				X				X
	Downstream	11	3	3	X				X				X
Sunnyslope confluence	Section 1[1]	10	8	0	X			X					X
	Section 2	10	8	2	X			X					X
MWD Crossing	Upstream	11	0	0	X								
	Downstream	13	0	0	X								
Van Buren Boulevard	Upstream	11	0	0	X	X							
	Downstream	10	0	0	X								
Hamner Avenue	Upstream	13	0	0	X		X						
	Downstream	15	0	0	X								
River Road	Upstream	10.5	50	0	X			X		X	X		X
	Downstream	11	5	0	X			X		X		X	

1. Both 50 meter sections were upstream of the confluence of Sunnyslope Creek.
2. Mosquitofish
3. Black bullhead
4. Yellow bullhead
5. Fathead minnow
6. Mozambique cichlid
7. Largemouth bass
8. Goldfish
9. Carp
10. Arroyo chub
11. At this site several large schools were observed, in excess of 100 individuals total, captured 2 to verify that they were suckers.

The YOY survey demonstrated the presence of YOY suckers in the upstream areas and at River Road. However, none were found at intermediate sites. This raises the question of whether the large number of YOY suckers had been produced at River Road or whether they were the result of downstream drift of larval/YOY fish from the upstream reaches The currently available data do not provide an answer to this question.

D. Migration/Movement.

Four fish were recaptured during 2001 during the attempted mark-recapture procedure. All four fish had been tagged at Site 2 upstream of Highway 60. One was captured where tagged, one was captured at Site 1, and two were captured 100-150 meters downstream of Highway 60. This information is summarized in Table 14.

Table 14. Data on locations of recaptured fish.

Tag Number	Tagging Location	Date of Tagging	Recapture Location	Date of Recapture
4264761B69	Site 2	16 June	Site 2	18 June
42645F1761	Site 2	16 June	Site 1	18 June
42647B200A	Site 2	16 June	Downstream of Highway 60	18 June
4261660E7A	Site 2	16 June	Downstream of Highway 60	18 June

During the 2002 sequential depletion work at the three 100-meter sites, four fish were recaptured that had been tagged in 2001. Four recaptures is a good return, remembering that recaptures of free-ranging animals typically have a very low return.

The following table provides information on the recaptured fish.

Table 15. Location of initial tagging and recapture for the four Santa Ana suckers recaptured in 2002.

Recaptured Suckers	Tagged 2001	Recaptured 2002
Pit Tag Numbers	Tagging Location	Recapture Location
42655E0062	Site 1 – Mission Blvd	Site 1 – Mission Blvd
42645F4F20	Site 1 – Mission Blvd	Site 1 – Mission Blvd
4263245D1B	Site 1 – Mission Blvd	Site 1 – Mission Blvd
4261600774	Site 1 – Mission Blvd	Site 1 – Mission Blvd

It is interesting that all four fish were tagged and recaptured at the same site. This raises two possibilities which will need to be addressed in future field work:

1. The fish are relatively sessile and show a degree of site fidelity.
2. The fish return to specific sites for reproduction or post-reproductive holding habitat.

Only future recapture data will allow these questions to be answered.

E. Growth.

The recapture data presented above also provided an opportunity to evaluate growth in the Santa Ana sucker. Table 16 below presents the length-weight data for the four recaptured suckers at the time of tagging and at their recapture one year later.

Table 16. Length/weight data from the four Santa Ana suckers recaptured in 2002. Length is standard length in millimeters and weight is in grams.

Recaptured Suckers	2001		2002		Change	
Pit Tag Number	Length	Weight	Length	Weight	Length	Weight
42655E0062	119	29.3	147	53.5	28	24.2
42645F4F20	116	27.9	155	62.6	39	34.7
4263245D1B	132	39.2	161	65.5	29	26.3
4261600774	105	23.8	145	44.7	40	20.9
(AVERAGE)					**34**	**26.5**

F. Population Structure.

In order to evaluate the population structure of the Santa Ana sucker in the Santa Ana River it is necessary to know the sizes of the various year classes. These data are particularly important, because Saiki (2000) interpreted his data to suggest that in the Santa Ana River, the Santa Ana sucker lives only two years and therefore has only one reproductive year. This is important because in the San Gabriel River and the Santa Clara River the sucker appears to be longer lived.

Greenfield *et al.* (1970) and Sasaki and Drake (1987) provided date on the approximate size ranges of the various year classes in the Santa Clara River and the San Gabriel River respectively. Saiki's (2000) data can also be used to estimate size classes of suckers in the Santa Ana River. These data are presented in Table 17.

Table 17. Estimated lengths (SL mm) of the various age classes in the Santa Clara River, San Gabriel River and Santa Ana River.

Age Class	Santa Clara River	San Gabriel River	Santa Ana River
0+	0-51	0-70	0-80
1+	52-77	71-130	81-120
2+	77-140	131-160	121+
3+	140+	161-185	
4+		186+	

SMEA examined five years of length data from the West Fork of the San Gabriel River. Based on these data the oldest year class ranged from 2+ to 4+ depending on the year, and the strength of the year classes varied considerably.

SMEA collected two large samples of suckers during 2001. These were collected on 16 June as part of the tagging activities. The size-frequency histograms for these two samples are shown below. Examination of the Site 2 graph (Figure 2) clearly shows at least three year classes, while the Site 1 histogram (Figure 1) may show one dominant year class with a few individuals from an older year class. A size-frequency histogram for a sample of Santa Ana suckers from the San Gabriel River (Figure 3) clearly shows more year classes. Samples over a period of years will be necessary to determine if Santa Ana sucker die after only one breeding season in the Santa Ana River. If this is the case, it must strongly influence the population dynamics.

Figure 1.

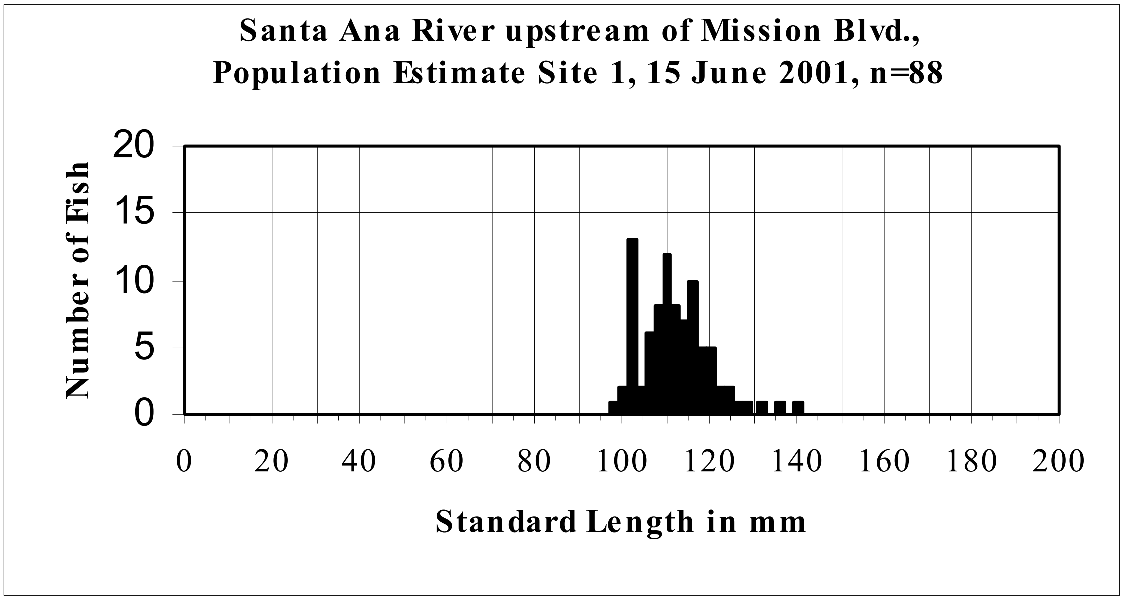


Figure 2.

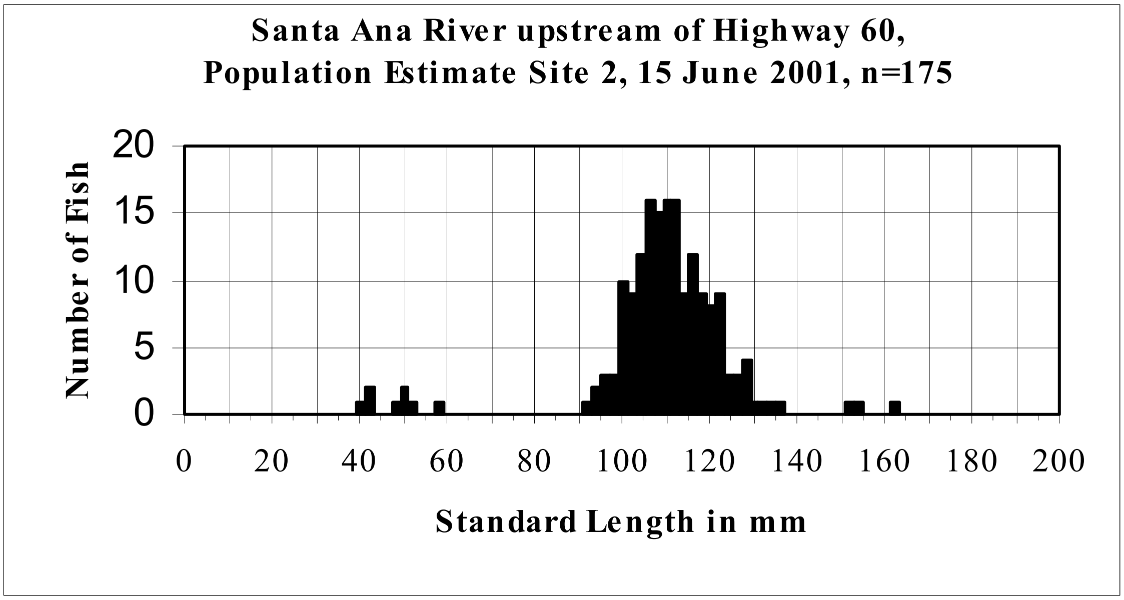
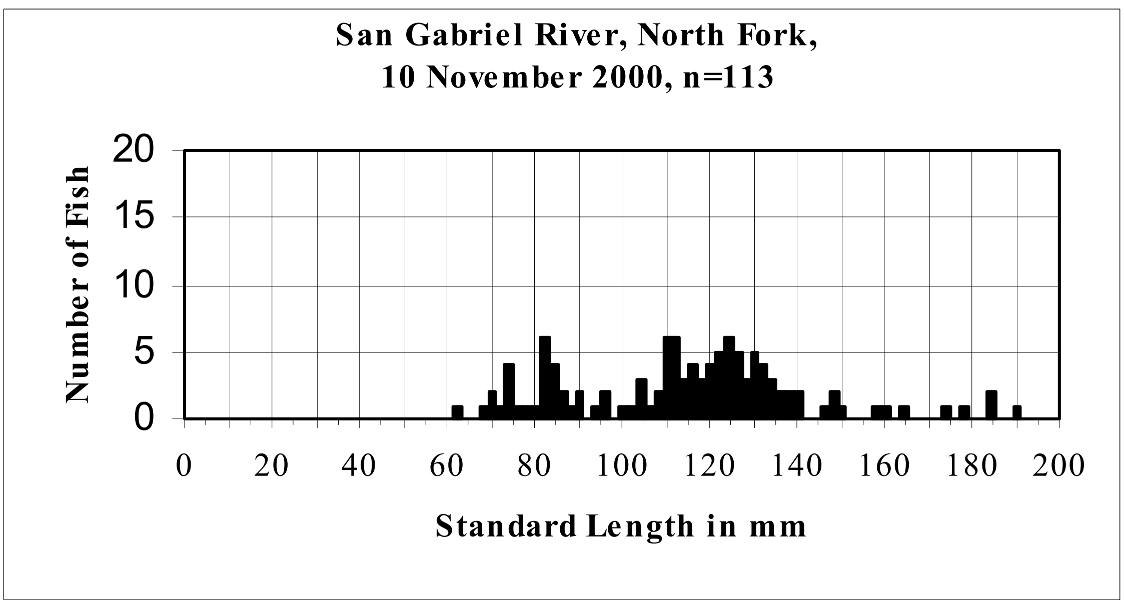


Figure 3.



An examination of the size (standard length) data presented in Tables 4-6 compared to the data presented in Appendix 1 demonstrates an obvious difference in the population structure. In 2001 the population was dominated by adults, fish greater than about 80mm SL, while in 2002 the population is dominated by younger, smaller fish less than 80 mm SL. Table 17 summarizes the differences which are displayed graphically following the table.

Table 17. Comparison of population structure data from 2001 and 2002. For simplicity, suckers less than 80 mm SL are designated as YOY and those greater than 80 mm SL are designated as adult.

SUCKERS CAPTURED IN THE THREE 100-METER SECTIONS				
Location	**2001**		**2002**	
	Adult	**YOY**	**Adult**	**YOY**
Site 1 - Mission Bridge	88	0	49	71
Site 2 – Hwy 60 Bridge	136	8	31	120
Site 3 - Riverside Dr Bridge	9	4	11	34
Totals	233	12	91	225
Year Totals	245		316	
Percent of Population	**95.10%**	**4.90%**	**28.80%**	**71.20%**

Expressed a different way, this means that the population of adult reproductive suckers in 2001 was 6,257-6,621 individuals, while the adult sucker population in 2002 was 2,379-2,952 individuals. The following four figures show the differences graphically. The differences at so extreme that no statistical analysis is required to recognize that there is a significant difference

Figure 4. Histogram showing the standard length (SL) of all suckers captured during electroshocking in 2001.

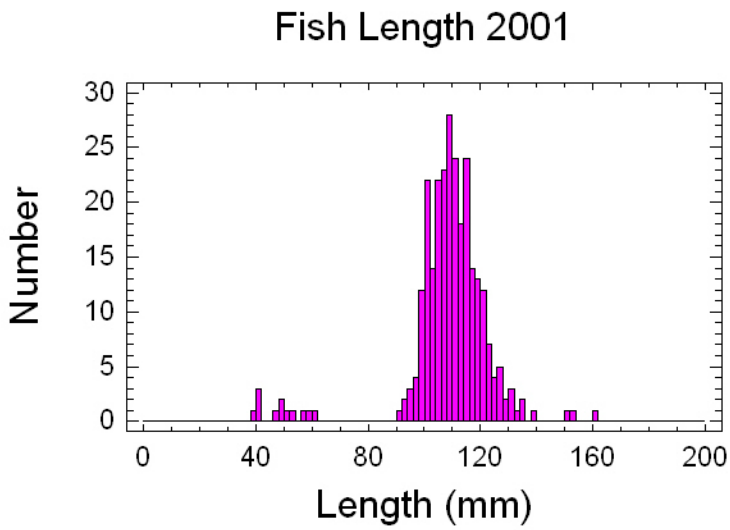


Figure 5. Histogram showing the standard length (SL) of all suckers captured during electroshocking in 2002.

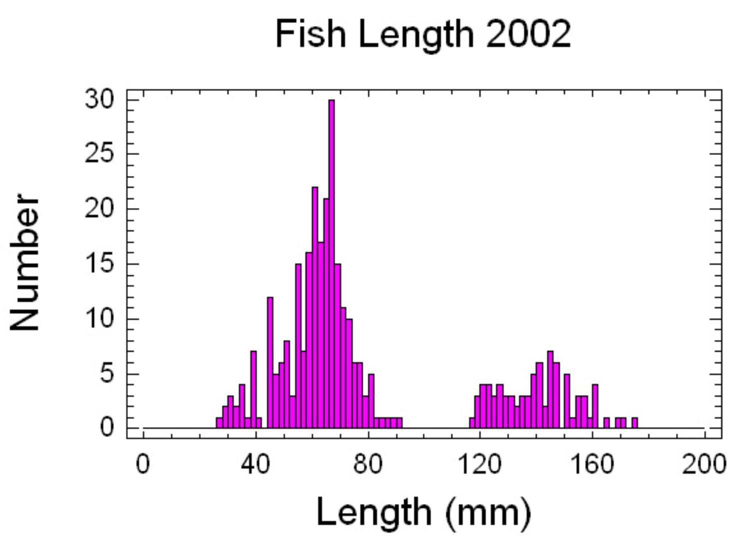


Figure 6. Box and whisker graph comparing the lengths of fish captured in 2001 and 2002.

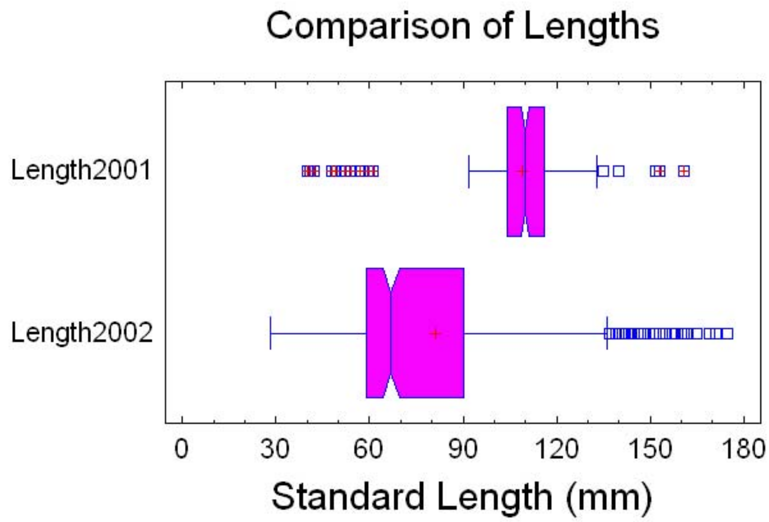


Figure 7. A comparison of the number of young-of-the-year (YOY) and adult Santa Ana suckers at each of the electroshocking sites in 2001 and 2002.

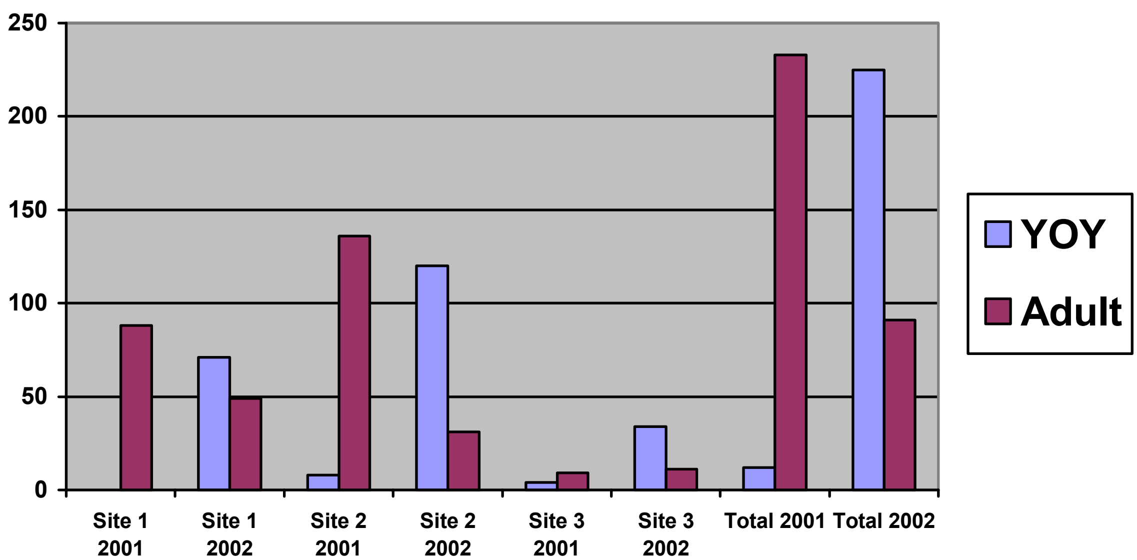


Figure 7 shows the dramatic shift in the population structure the sucker population. In 2001, the population was dominated by large fish, while in 2002 the population is dominated by small fish. While it is difficult to determine the meaning of this shift, several anecdotal observations apply. In 2001 SMEA observed relatively small numbers of fry, which is reflected in the low number of small fish captured during population sampling. In 2002 there were a large number of fry that were very widespread in the river, this observation is reflected in the strength of year class found when electroshocking. Presumeably, the small number of fry in 2001 partially accounts for the lower number of adults in 2002. If that is true and recruitment remains constant, then the large number of juveniles in 2003 should produce a large adult population in 2003. We lack sufficient data to predict how this shift in age structure will be reflected in the population in 2003. The 2003 data may give us some indication of the recruitment of these small fish into the adult reproductive population.

VI. REPRODUCTION.

A. Introduction.

Reproductive surveillance and studies took place in three tributaries: Rialto Drain, Evans Lake Drain, and Sunnyslope Creek (see Photos 16-18). Surveillance was also conducted in the mainstem, but because of the clarity of water in the tributaries, most work focused in these areas.

SMEA determined the timing of appearance of the larvae, made observations on spawning, measured characteristics of the spawning habitat, made observations on larval habitat use, and noted the disappearance of the larval stage.

Photo 17. Sunnyslope Creek.

Photo 18. Rialto Drain

Photo 19. Evans Lake Drain

B. Tuberculation Surveillance.

As a mode of tracking reproductive readiness, SMEA periodically captured a sample of Santa Ana suckers and checked the frequency of tuberculate individuals and the degree of tuberculation. Photo 19 shows the tuberculate anal fin of a sucker captured in Rialto Drain.

Photo 20. Tuberculation is visible on the anal fin of this sucker.

Tables 19-24 show the data collected during the reproductive surveillance monitoring the degree and frequency of tuberculation in Santa Ana suckers. For simplicity only four degrees of tuberculation were recognized: (1) No tuberculation, (2) Incipient tuberculation when tubercles were beginning to develop, (3) Moderately well developed tuberculation when tubercles were obvious but not fully developed, and (4) Well develope tuberculation when the tubercles were fully developed. In addition to the data presented in the following tables a sample of 24 suckers was captured at Mission Boulevard on 17 December 2000. None of these fish showed any tuberculation.

Table 19. Length, weight and tuberculation data collected just downstream of Mission Boulevard on 7 January 2001. In the following table, SL = standard length; W_T = total weight; and W_F = fish weight.

Length (mm SL)	Tare (g)	W_T (g)	W_F (g)	Tuberculation
109	31	50	19	Incipient tuberculation
117	29	57	28	None
118	29	54.5	25.5	None
108	28	46.5	18.5	None
108	27	49	22	None
102	27	46	19	Incipient tuberculation
103	27.5	45.5	18	None
83	25	34.5	9.5	None
103	23.5	42.0	18.5	None
100	23.5	41.5	18	None
100	23	41.5	18.5	None
102	24	42.5	18.5	None
106	23.5	45.5	22	None
82	24.5	35	10.5	None
102	23.5	41	17.5	None
98	23	38	15	None
91	23.5	36	12.5	None
90	23	37.5	14.5	None
101	23.5	42.5	19	None
101	23.5	42	18.5	None
97	23	37.5	14.5	None
107	23	46	23	Incipient tuberculation
100	22	40.5	18.5	None
86	22	37	15	None
99	20	38	18	None

Table 20. Length, weight and tuberculation data collected at the Interstate-5 bridge over the Santa Clara River on 15 January 2001. In the following table, SL = standard length; W_T = total weight; and W_F = fish weight.

Length (mm SL)	Tare	$Weight_T$	$Weight_F$	Tuberculation
82	42	51.5	9.5	None
71	40	46	6	None
75	40	45.5	5.5	None
57	39	42	3	None
59	38	42	4	None
69	38	43	5	None
62	37	41	4	None
59	37	40.5	3.5	None

89	36	47	11	Incipient tuberculation
82	35	43.5	8.5	None
77	34.5	43.5	11	None
75	33.5	40	6.5	None
65	33	38	5	None
65	32.5	37	4.5	None
55	31	34.5	3.5	None
62	30.5	35	4.5	None
63	30.5	34	3.5	None
63	30	34.5	4.5	None
69	29.5	35	5.5	None
52	29	32	3	None
52	28.5	31	2.5	None
72	28.5	35	6.5	None
56	28.5	31	2.5	None
58	27	30.5	3.5	None
61	24	28	4	None
47	24	25.5	1.5	None

Table 21. Length, weight and tuberculation data collected in Rialto Drain on 21 January 2001. In the following table, SL = standard length; W_T = total weight; and W_F = fish weight.

Length (mm SL)	Tare (g)	W_T (g)	W_F (g)	Tuberculation
110	60	79	19	Incipient tubercles
108	52	69	17	Moderately well developed tubercles
117	44.5	71	26.5	None
106	41.5	63.5	22	Moderately well developed tubercles
137	40	91.5	51.5	None
69	38	43.5	5.5	None
114	38	61.5	23.5	Well developed tubercles
110	36	58.5	22.5	None
92	34	45.5	11.5	None
121	33	63.5	30.5	Well developed tubercles
116	32.5	61.5	29	Well developed tubercles
95	31.5	47.5	16	None

Table 22. Length, weight and tuberculation data collected in Sunnyslope Creek on 17 February 2001. In the following table, SL = standard length and W_F = fish weight.

Length (mm SL)	W_F (g)	Tuberculation
110	23.5	None
86	11.1	None
88	12.2	Moderately well developed tubercles
104	20.6	None
105	19.6	None
90	14.5	None
117	22.4	None
87	10.6	None
98	18.5	Moderately well developed tubercles
95	15.7	Incipient tubercles
98	11.5	None
117	24.0	None

Table 23. Length, weight and tuberculation data collected at Mission Boulevard on 17 February 2001. In the following table, SL = standard length and W_F = fish weight.

Length (mm SL)	W_F (g)	Tuberculation
95	16.0	Moderately well developed tubercles
97	14.0	Incipient tubercles
100	14.7	None
108	18.4	Well developed tubercles
94	13.1	Moderately well developed tubercles
83	9.2	Moderately well developed tubercles
118	19.0	Well developed tubercles
85	9.2	None
76	6.9	None
92	12.6	Incipient tubercles
75	6.0	None
97	14.7	None
84	8.8	None
90	11.0	None
65	4.9	None
85	8.9	None
75	7.4	None
79	8.6	None

Table 24. Length, weight and tuberculation data collected at Rialto Drain on 17 February 2001. In the following table, SL = standard length and W_F = fish weight.

Length (mm SL)	W_F (g)	Tuberculation
108	18.3	Moderately well developed tubercles
116	20.5	Well developed tubercles
115	18.8	Well developed tubercles
111	22.7	Well developed tubercles
110	17.6	Moderately well developed tubercles

A definite trend of increasing tuberculation can be seen in these data, beginning in December 2000 when none of the fish captured showed any tuberculation through 17 February 2001 when tuberculation was significantly more common. This trend is summarized in Table 25 below.

Table 25. Frequency of tuberculate fish, at various localities, December 2000 – February 2001. None = No tubercles, Incip = Incipient tubercles, Moderate = Moderately well developed tubercles, Well = Well developed tubercles, and N = sample size

Date	Locality	None	Incip	Moderate	Well	N
17 Dec 00	Mission Blvd	24	0	0	0	24
7 Jan 01	Mission Blvd	22	3	0	0	25
21 Jan 01	Rialto Drain	6	1	2	3	12
17 Feb 01	Sunnyslope Cr	9	1	2	0	12
17 Feb 01	Mission Blvd	11	2	3	2	18
17 Feb 01	Rialto Drain	0	0	2	3	5

The data show a general increase in the degree of tuberculation of the suckers examined. However, between late January and mid February there is little change. Because the fish become tuberculate as they prepare for reproduction, the degree of tuberculation assisted us in tracking the general readiness for reproduction.

C. Observations of Reproduction.

Considerable field time was spent trying to observe reproduction so that the actual characteristics of reproductive sites could be measured rather than relying on a general description of a stream reach where larvae were found.

On 31 March 2001, Haglund observed spawning in Rialto Drain in the pool at the very top of the drain where the water enters the "natural" channel (see Photo 21). The fish were spawning over a gravel bar that had developed near the pool tail. A large sucker (assumed to be a female) took up a position on the gravel bar, from the deeper water adjacent to the bar 1-3 smaller suckers (assumed males) would swim up to the female. All fish were facing upstream. The smaller fish would brush against the female (quiver), then all fish would swim away, however the larger individual returned almost immediately and resumed its (her) position on the gravel bar. This process was repeated three times while Haglund watched. The observations were made using a viewing tube and the water was clear over the gravel bar but there was no visibility into the adjacent deeper water.

Water over the gravel bar was 49-53 cm deep, and the deep adjacent water was in excess of one meter (no accurate measurement could be obtained). Substrate was a medium gravel. Flow over the spawning area was about 0.20 m/sec. Fry first appeared in Rialto Drain on 7 April.

Baskin and an SMEA field technician also observed spawning in Sunnyslope Creek (see Photo 20). The observations were made on 15 April 2001. The creek was 2.2 meters wide at the spawning site. The substrate was mixed fine/medium gravel with coarse sand. Spawning took place over the gravel at a depth of 51-60 cm. Flow over the gravel was 0.77 ft/sec (0.24 m/sec). One edge of the stream was deeper and had an undercut bank with exposed willow roots. The fish moved from the deeper area up onto the gravel then returned to the deeper water.

Photo 21. Sunnyslope Creek, where spawning was observed on 15 April 2001.

Photo 22 . Rialto Drain, where spawning was observed on 31 March 2001.

Based on these two observations it appears that the suckers prefer deeper water adjacent to spawning gravel. The spawning gravel in both cases was approximately 0.5 meter deep and the flows were similar (0.20 and 0.24 m/sec). The substrate in both cases was dominated by medium gravel, modal size 0.5 to 1.6 cm.

Typical spawning of suckers is illustrated by the longnose sucker, *Catostomus catostomus*, a widespread species found east of the Rocky Mountains. Stream spawning by longnose suckers was reported at depths of 15-30 cm. in a current of 30-45 cm/sec. over gravel substrate of 0.5 to 10 cm. diameter (Geen *et al.* 1966). Our observations of spawning of *C. santaanae* in the Santa Ana river study area are consistent with this data.

D. Analysis of Spawning Gravels

A sample of gravel was collected from each of the two spawning sites and analyzed for particle size. The histograms for particle size are shown below (Figures 7 and 8) along with their cumulative percent curves (Figure 9).

The graphs clearly show the dominance of the gravel sized particles and the presence of some sand. Sand ranges from 0.0625 mm to 1.00 mm in diameter, while gravel ranges from 1.00 mm to 64 mm in diameter. No significant amount of silt was present, nor were large particles present at either site.

These data will be used when “artificial” spawning areas are established

Figure 7. Histogram showing sediment size composition at an observed spawning site in Rialto drain.

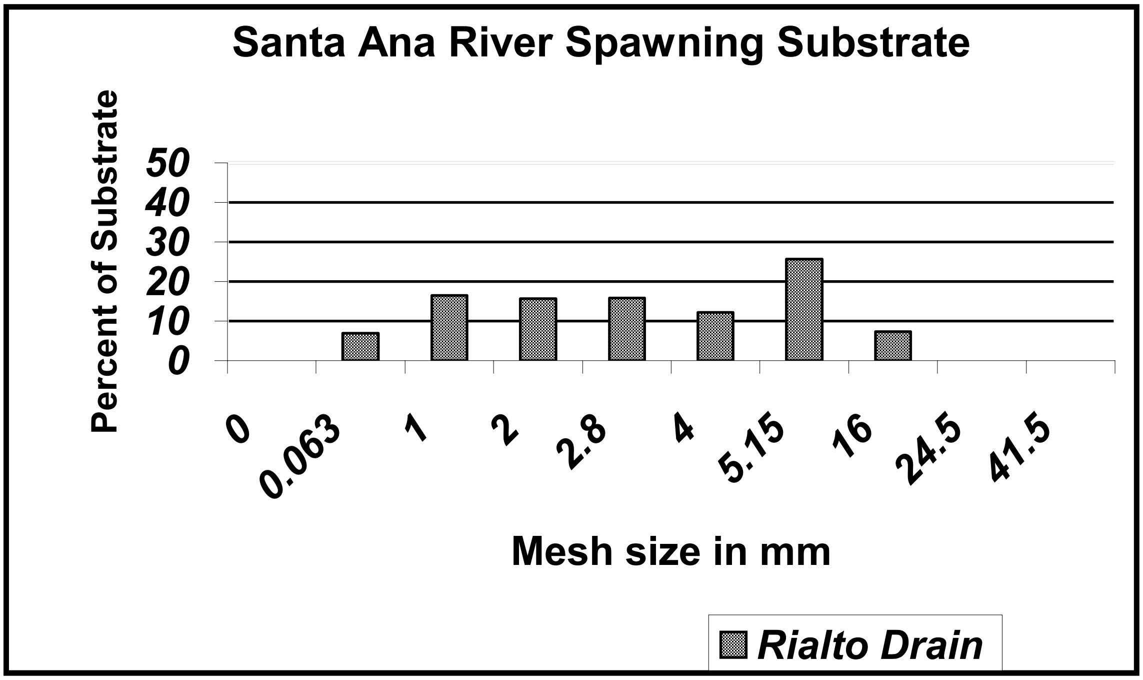


Figure 8. Histogram showing sediment size composition at an observed spawning site in Sunnyslope Creek.

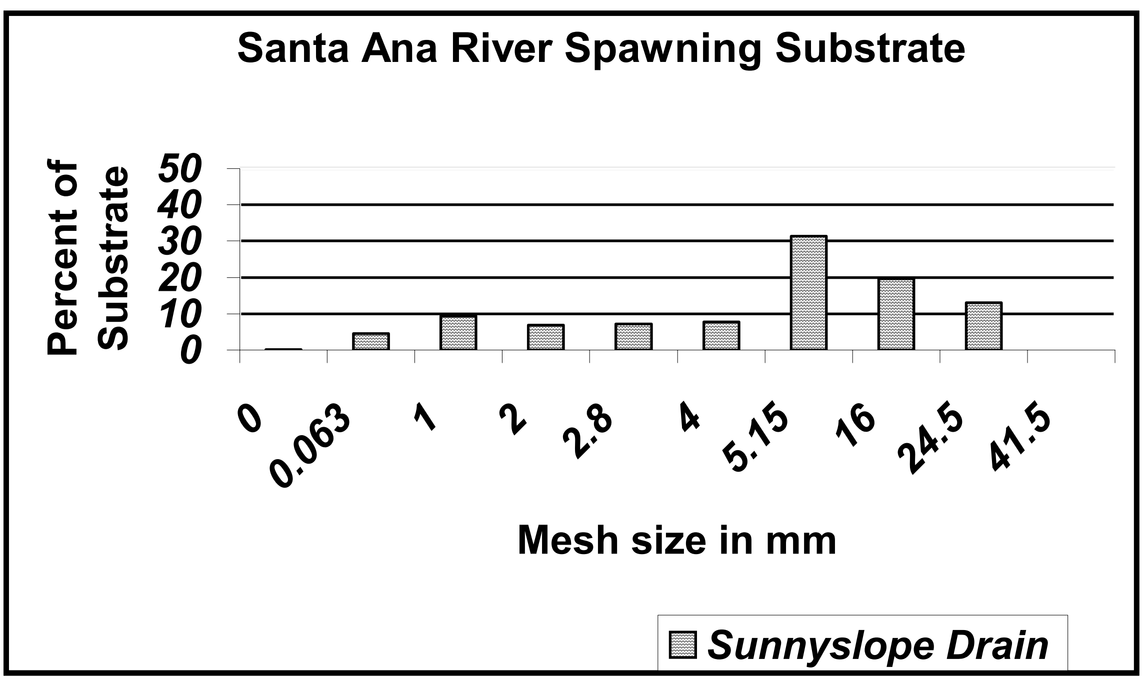
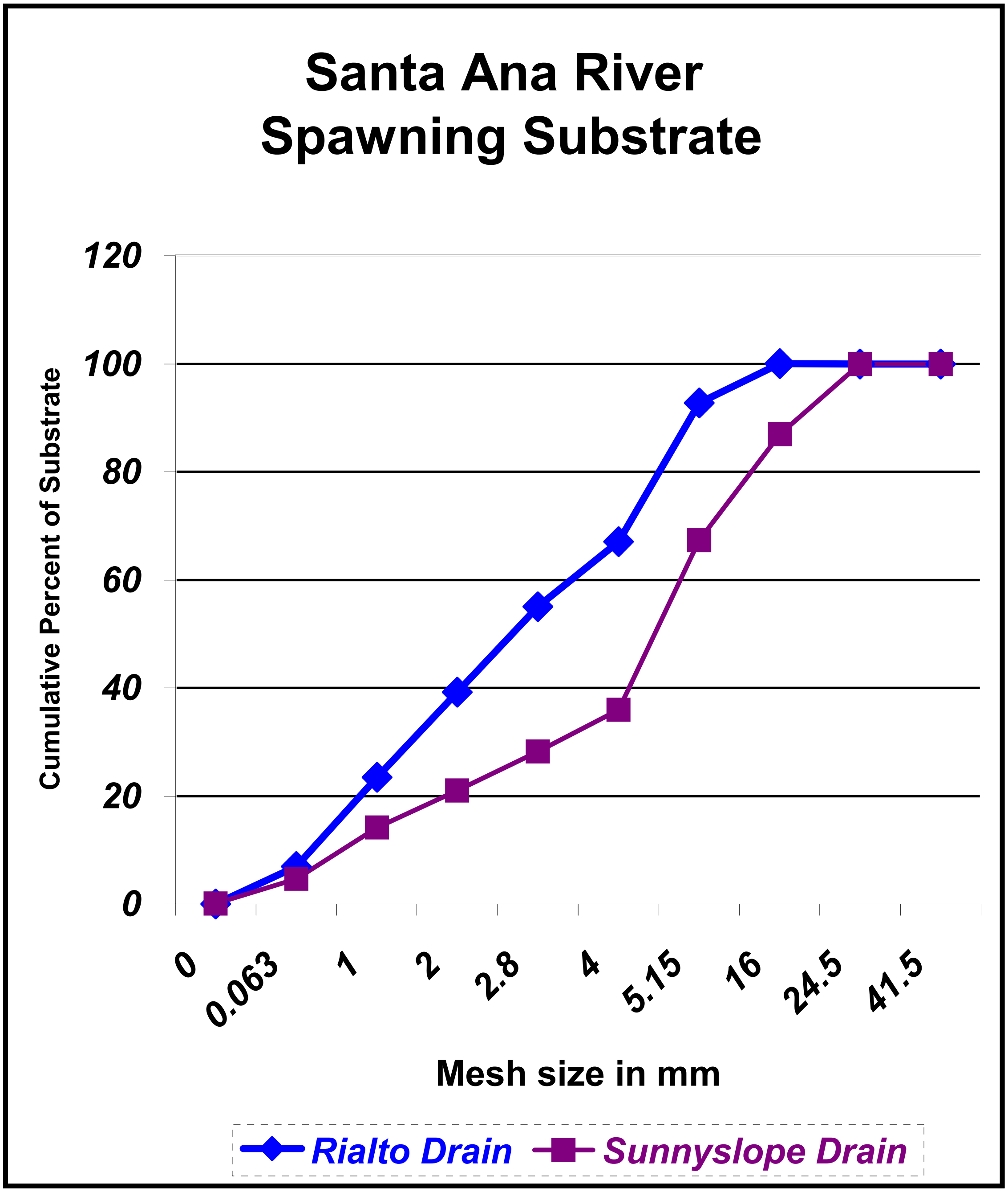


Figure 9. Cumulative percent curves for sediment composition at the two observed spawning sites.



E. Observations on Larvae.

As described above, larvae appeared in Sunnyslope Creek on 31 March, Rialto Drain on 7 April. However, larvae were not detected in the mainstem at Mission Boulevard until 29 April, which raises the possibility that the larvae found in the mainstem had drifted out of the tributaries. Larval drift is a common feature of the life history of riverine suckers (Kennedy and Vinyard 1997).

Because of the abundance of the larvae, the access, and the ease of viewing, most observations of larvae were made in Sunnyslope Creek. Observations were made from the appearance of larvae on 31 March through mid-May when the larvae disappeared.
Larvae were almost always associated with specific habitat characteristics. Flow is low and consequently the bottom substrate is usually silt. Fry are most commonly found in shallow water 5-10 cm deep. They may or may not be associated with emergent vegetation or algae. However, in Rialto Drain they were frequently associated with small pockets of shallow water associated with an algal mat. These habitat characteristics apply to Sunnyslope Creek, Rialto Drain and the mainstem (see Photo 22).

Photo 23. Larval habitat in Sunnyslope Creek.

As part of the larval investigations SMEA devised a method of reliably recognizing larval suckers based on fin position, post anal distance and distribution of melanophores. This allows capture of larvae, and their identification in a petri dish without any larval mortality. All SMEA personnel were trained in larval identification. This technique will prove beneficial for more detailed larval studies next year.

The following three photographs show the development of larval Santa Ana suckers from just post-gravel emergence (6 mm total length (TL)) until they transform and settle to the substrate (15 mm TL).

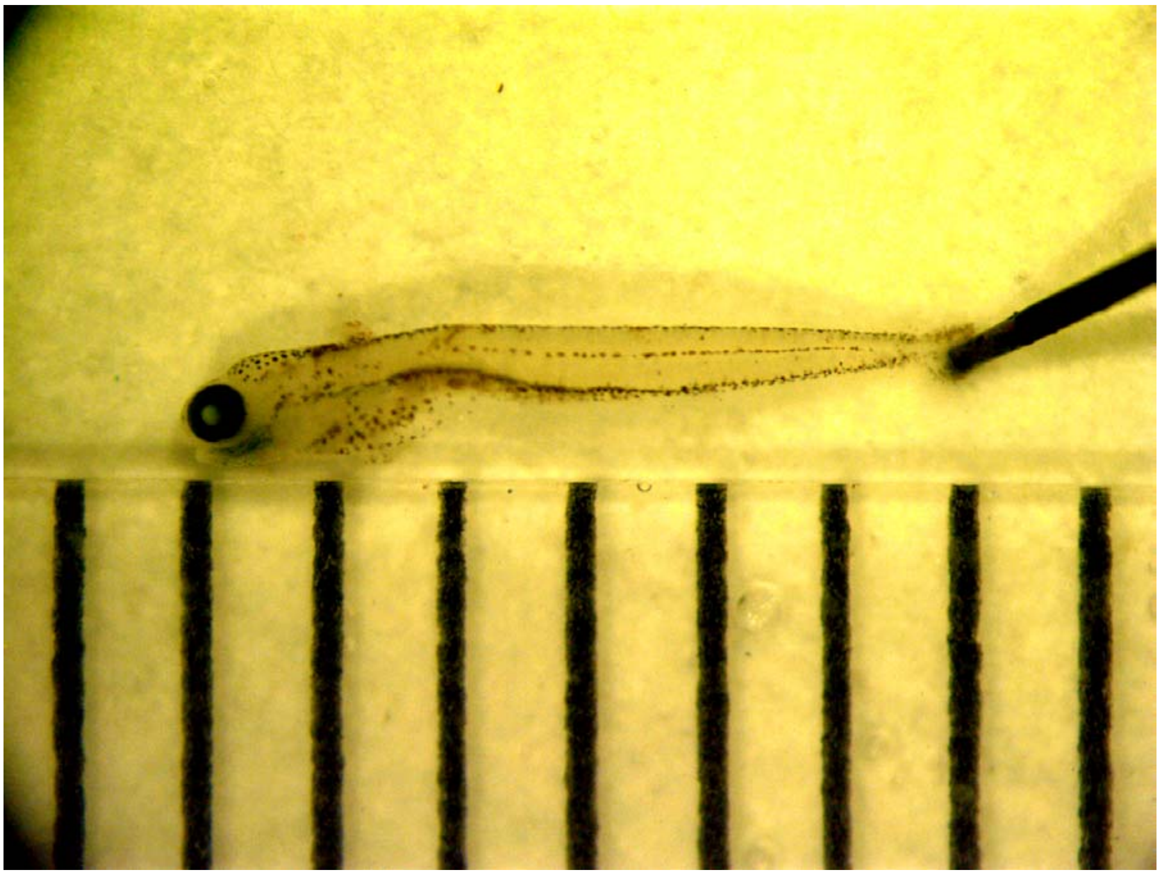


Photo 24. Santa Ana sucker fry at 6 mm TL from Rialto Drain.

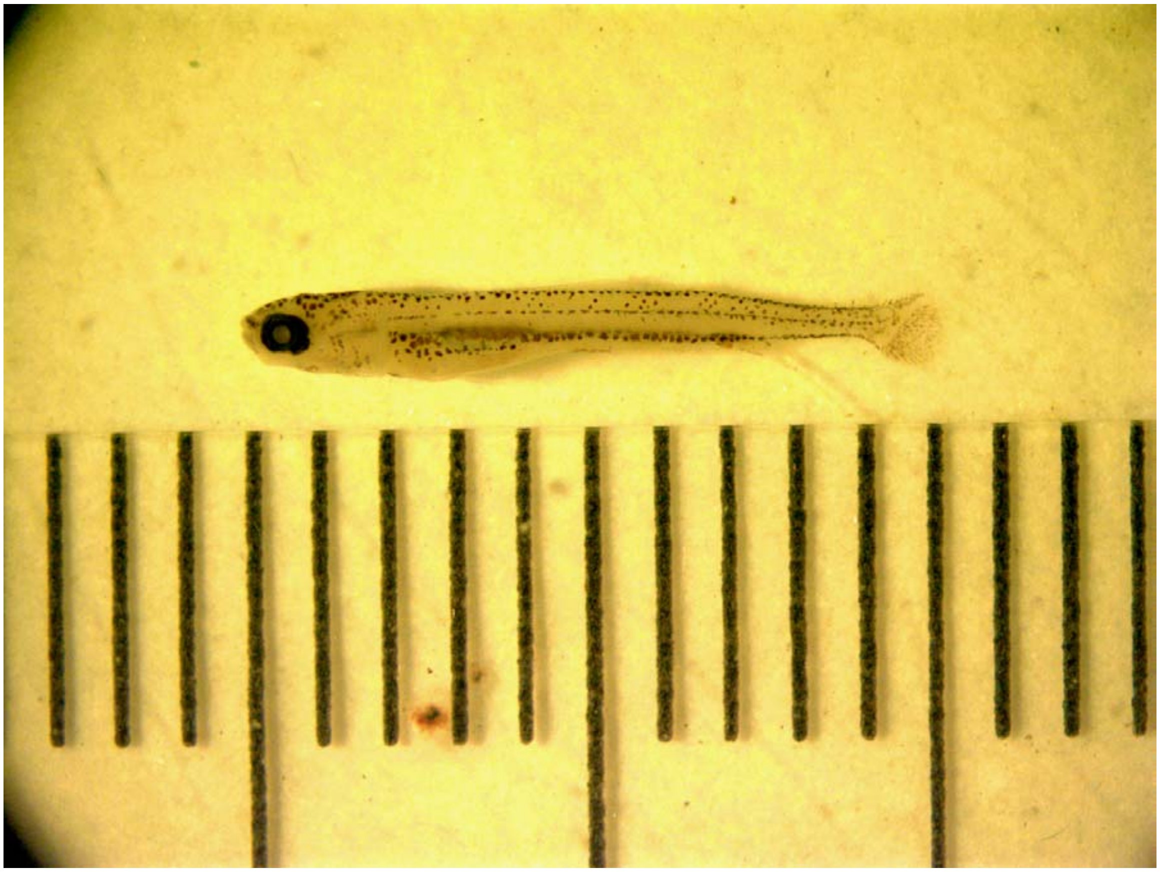


Photo 25. Santa Ana sucker fry at 10mm TL from Rialto Drain.

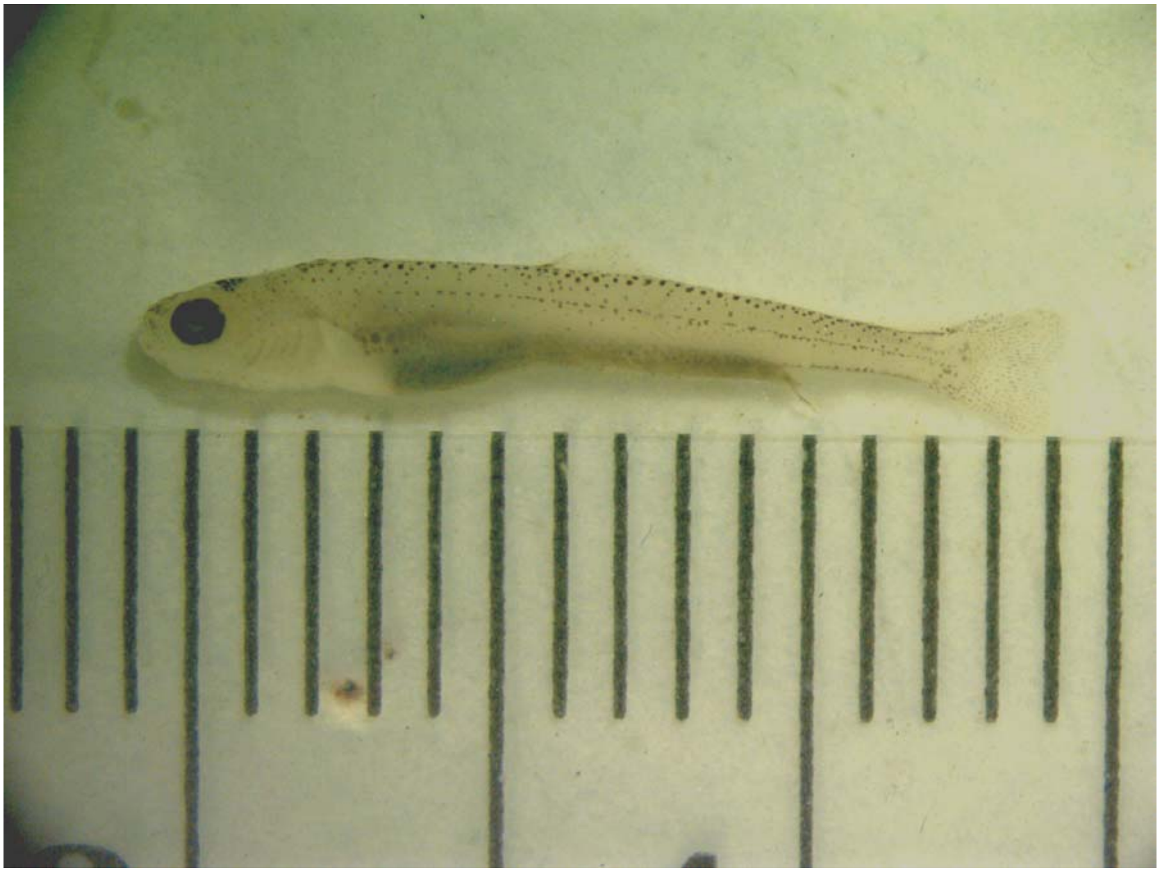


Photo 26. Santa Ana sucker fry at 15mm TL from Evans Lake Drain.

In order to study the fry it is important to be able to identify sucker fry. Three cyprinid fishes potentially reproduce at a similar time and are found sympatrically with the sucker in the Santa Ana River. The arroyo chub is native to the drainage, but the other two cyprinids, the fathead minnow and the carp, are exotics. Although other fishes such as mosquitofish, bullheads and cichlids are present; their larvae are easily distinguished from the sucker larvae. The following three composite photographs illustrate the key characteristics allowing the identification of sucker larvae.

Photo 27. (following page)

Lateral View of Fry

Santa Ana Sucker

Larvae are elongate, and later developed specimens show the presence of a sub-terminal mouth (white arrow). Larvae have a row of melanophores that extends forward from the caudal base about three quarters or more of the body along the lateral line (black arrow). Sucker larvae lack a distinct caudal spot at the caudal base but have melanophores extending to the end of the caudal rays. The dorsal fin base has a row of melanophores on each side.

Arroyo Chub

Larvae have a row of melanophores that extends forward from the caudal base about three quarters or more of the body along the lateral line (black arrow). Chubs have a large caudal spot with multiple rows of melanophores (white arrow). Larvae have a fairly dark dorsal fin base.

Carp

Carp larvae have a vertical bar (arrow) of melanophores at the base of the caudal fin bounded posteriorly by a depigmented area.

Fathead Minnow

Larvae lack the pigments and have a single lateral pigment line (arrow) on the posterior half of the body. Fathead larvae have a small caudal spot made of a few melanophores.

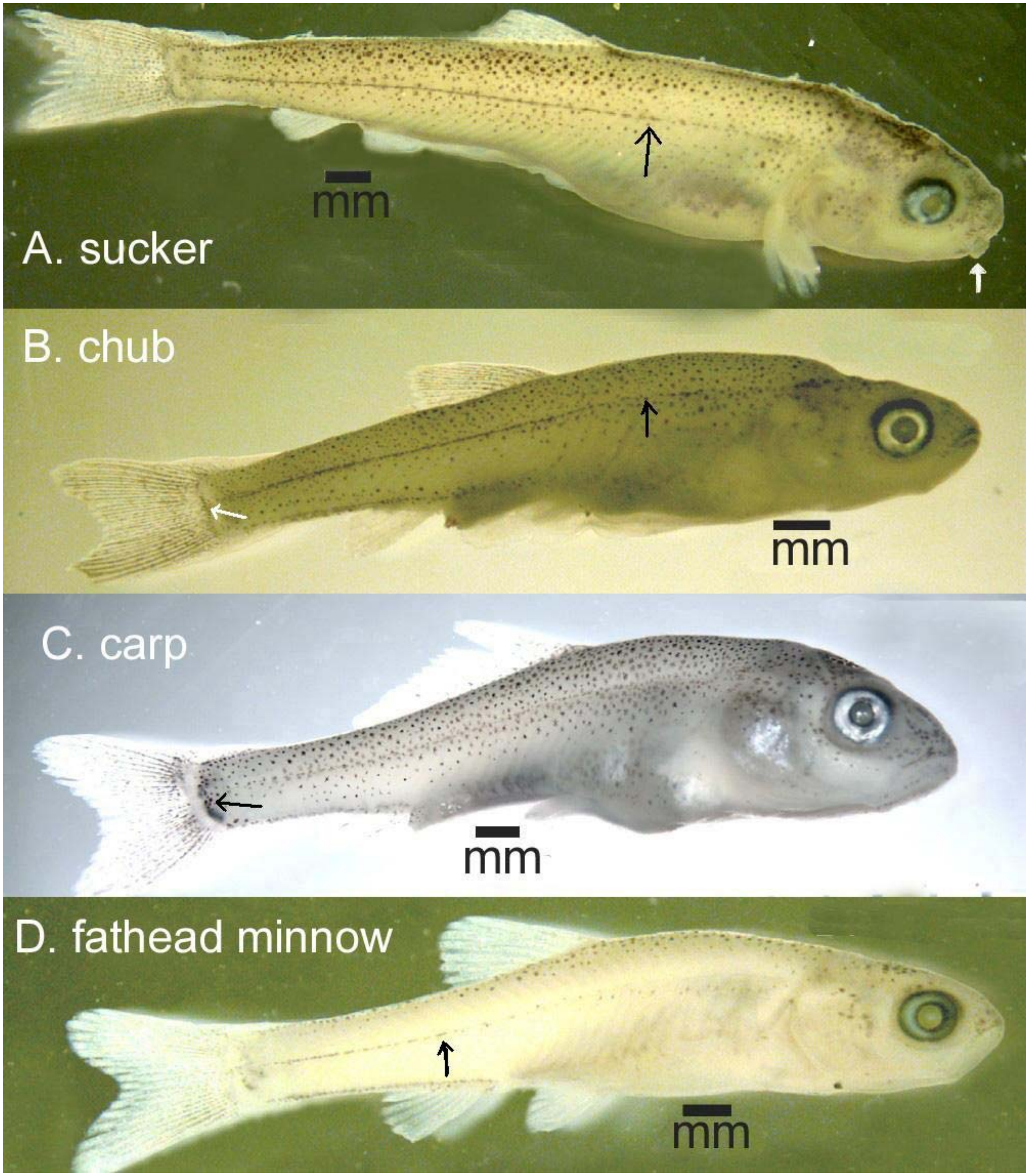

A. sucker
mm
B. chub
mm
C. carp
mm
D. fathead minnow
mm

Photo 28. (following page)

Lateral View of Fry – Anal Fin

Sucker larvae can be distinguished by the position of the anal fin, where the distance from anal fin origin to tip of snout, is 66% of the total length or greater.

A. Santa Ana Sucker
Total Length = 11 mm Anal Distance = 8.5 mm
Anal Distance/ Total Length X 100% = 77.3%
B. Arroyo Chub
Total Length = 15 mm Anal distance = 9.25 mm
Anal distance/Total length X 100% = 61.7%

C. Carp
Total Length = 15.0 mm Anal distance = 8.5 mm
Anal distance = 56.7%

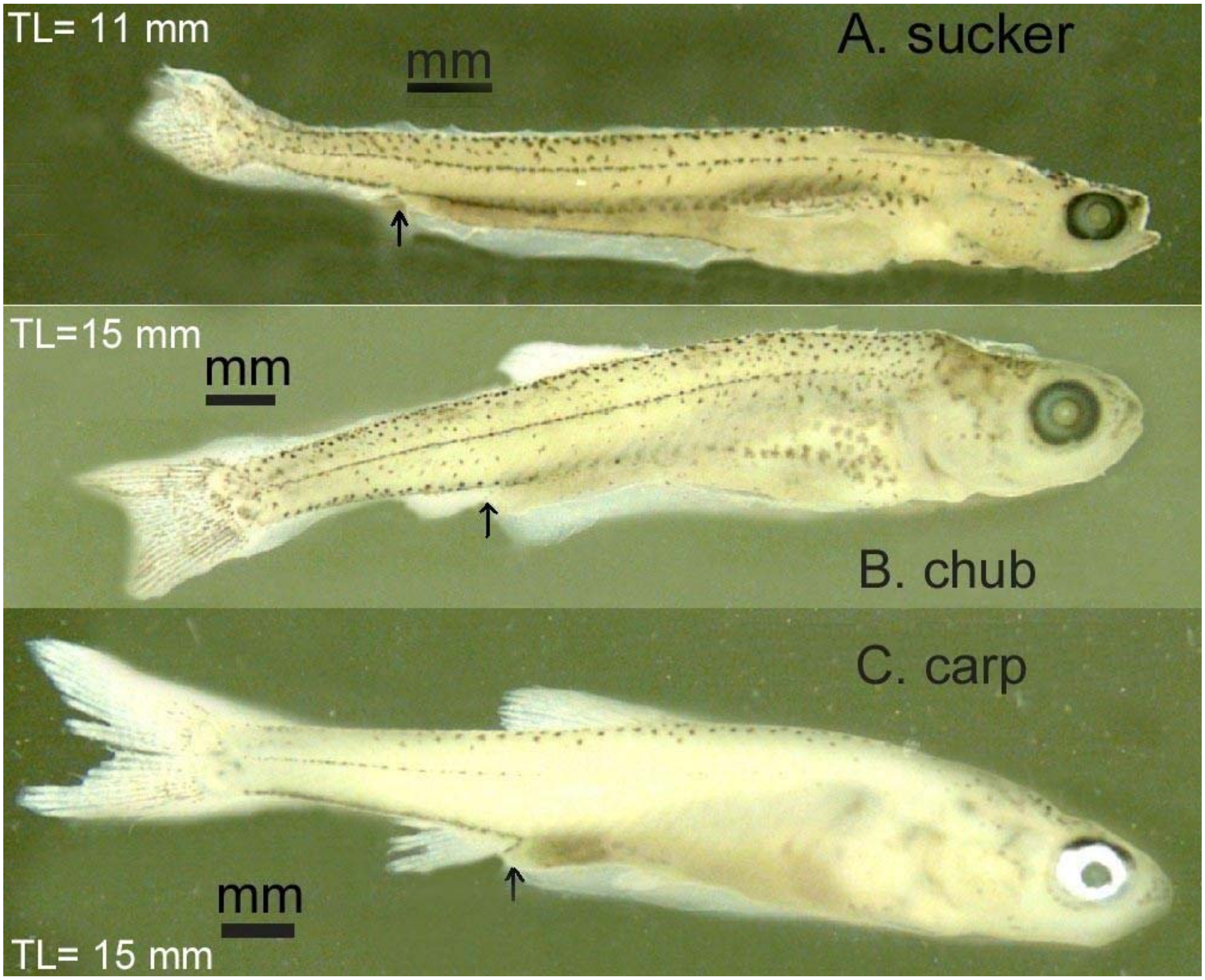

TL= 11 mm
mm
A. sucker
TL=15 mm
mm
B. chub
C. carp
mm
TL= 15 mm

Photo 29. (following page)

Dorsal View of Fry

Santa Ana Sucker

Larvae are very dark with a large number of melanophores found dorsally and laterally. Larvae, up to 15 mm SL, have two separate distinct rows (black arrows) of melanophores on either side of the mid dorsal ridge.

Arroyo Chub

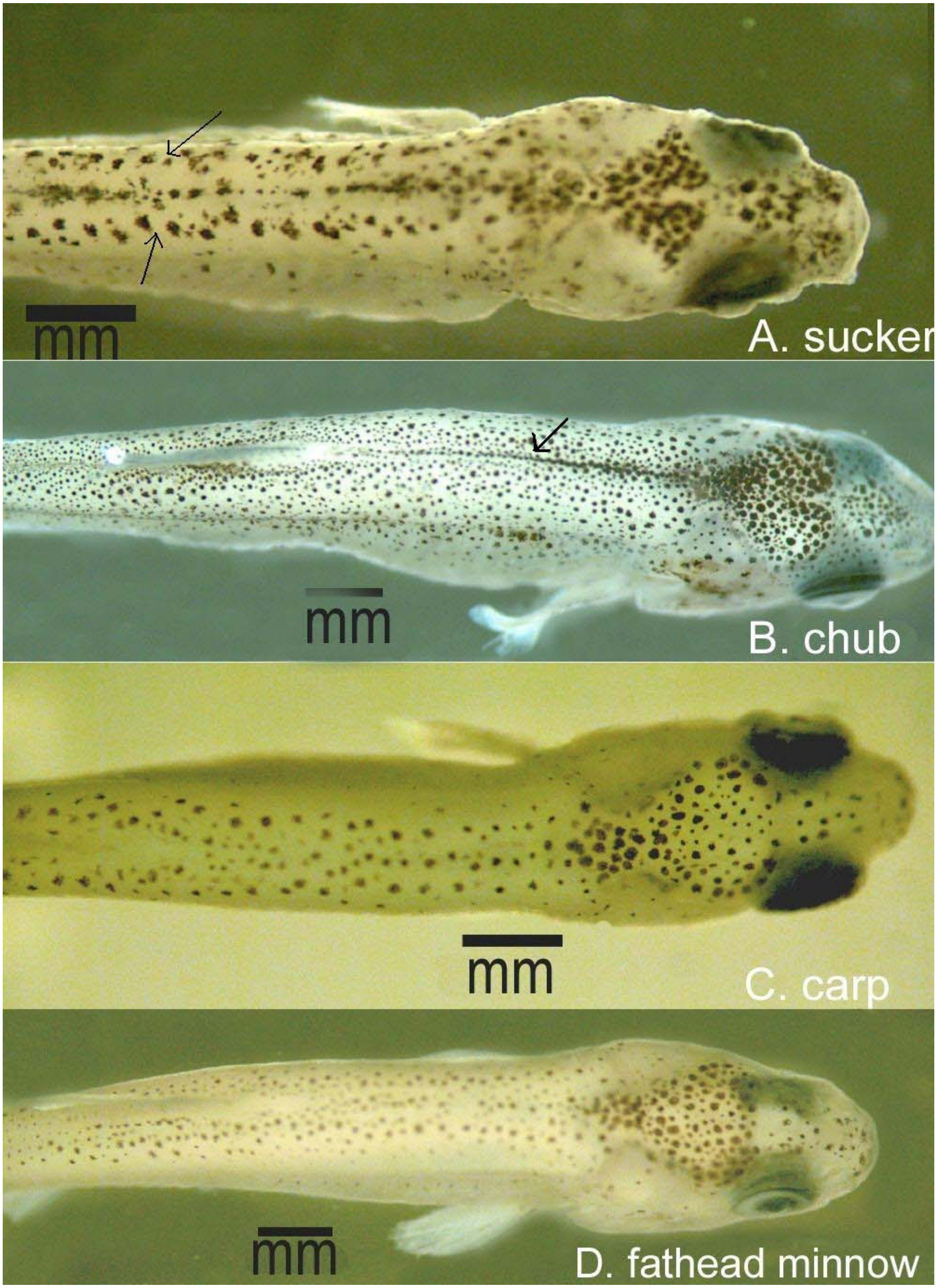
Larvae are dark with a large number of melanophores found dorsally and laterally. Larvae have a sharp dark single line of melanophores (arrow) extending from the occipital patch.

Carp

Larvae are robust with thickened bodies, paler, and have a uniform dusting of melanophores on the dorsal and lateral side.

Fathead Minnow

Larvae are slender and attenuated in body and have paler melanophores dorsally and laterally.


mm
A. sucker
mm
B. chub
mm
C. carp
mm
D. fathead minnow

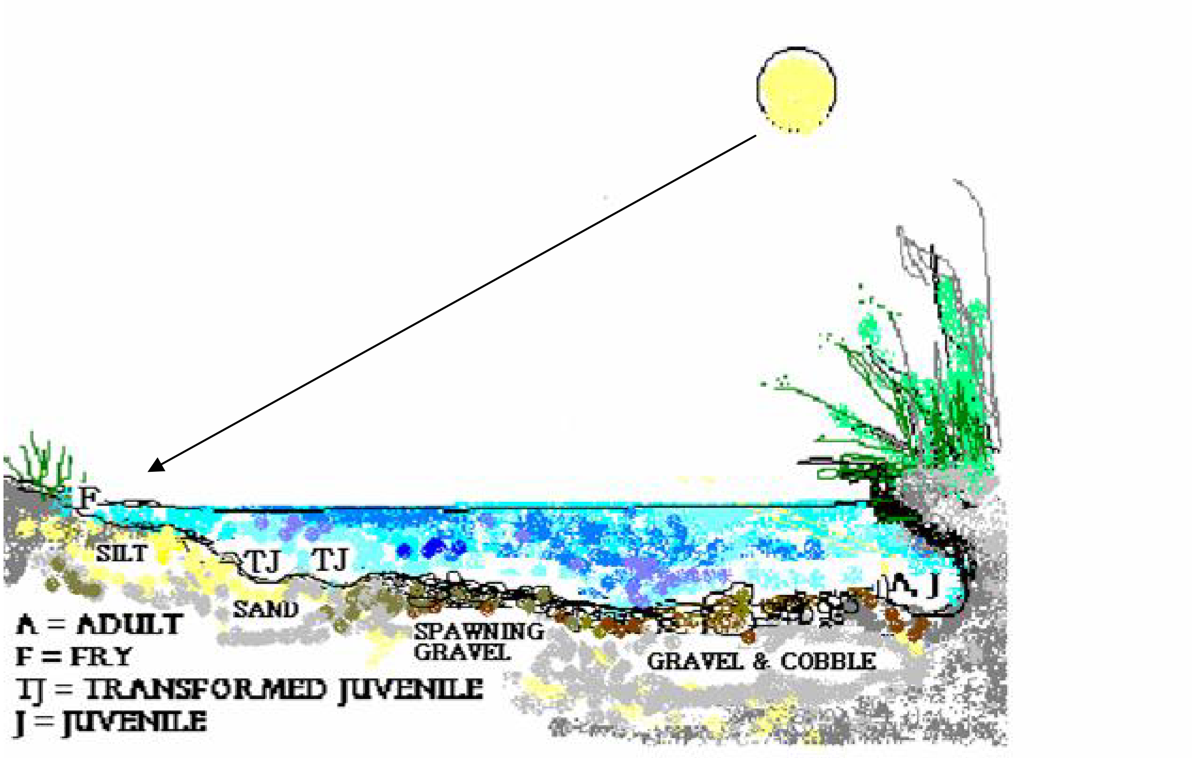


Figure 9. This is a diagrammatic representation of an idealized cross-section of the Santa Ana River showing habitat utilization by the Santa Ana sucker.

VII. Habitat Preferences of Various Sucker Life Stages.

The following figures show examples of the typical microhabitats shown in the idealized cross-sectional diagram (Figure 9)

Photo 30 shows an undercut bank with vegetation adjacent to deep flowing water in Sunnyslope Creek. Within a few meters upstream there is a shallow area of typical spawning gravel. Several ripe adults were found in this spot in February of 2001.

Photo 31 shows the fry habitat along the left edge of the stream adjacent to the vegetation. Depths here where the fry were found were about 10cm. with undetectable flow. No fry were found on the right edge of the stream at the same time. This is consistent with our hypothesis that the fry tend to be found at places with maximum sun exposure in the afternoon when water temperatures tend to be higher.

Figure 30. Adult sucker habitat, Sunnyslope creek, February 2001. Arrows indicate deep area of undercut bank.

Figure 31. Sunnyslope Creek. White arrows indicate areas where fry were found.

Photo 32 shows the precise places where sucker fry where found on May 11, 2002. This was a year without significant flushing flows and fry appeared to be much more numerous throughout the season than in 2001, when more high flow events occurred. The sticks in the water in the foreground (black arrows) and background indicate the precise location of fry. Fry were found also in the shallow water in the right foreground (white lines) where a set of measurements was taken of depth and distance from the edge at regular intervals, noting the presence or absence of fry at each spot. The depths where fry were found here range from about 3 to 10 cm. None were found at shallower depths and very few deeper (maximum fry depth here was 12cm.).The range of depths in the area measured was 0 to 25cm.

Photo 32. Fry habitat, SAR mouth of Sunnyslope Creek, May 2002.

Note also the open sun exposure at this locality. Fry tend to be found on the downstream side of flow obstructions such as vegetation (see Photo 33) and sand bars such as this one where flow is reduced. Note dark silt material on the sandy substrate. This silt material tends to settle out of the water where the water flow rate is reduced, and the darkly pigmented fry match well with this background. We have not been able to test if the fry are picking out the shallow depth, the lack of flow, the dark silt on the substrate, or a combination of these factors.

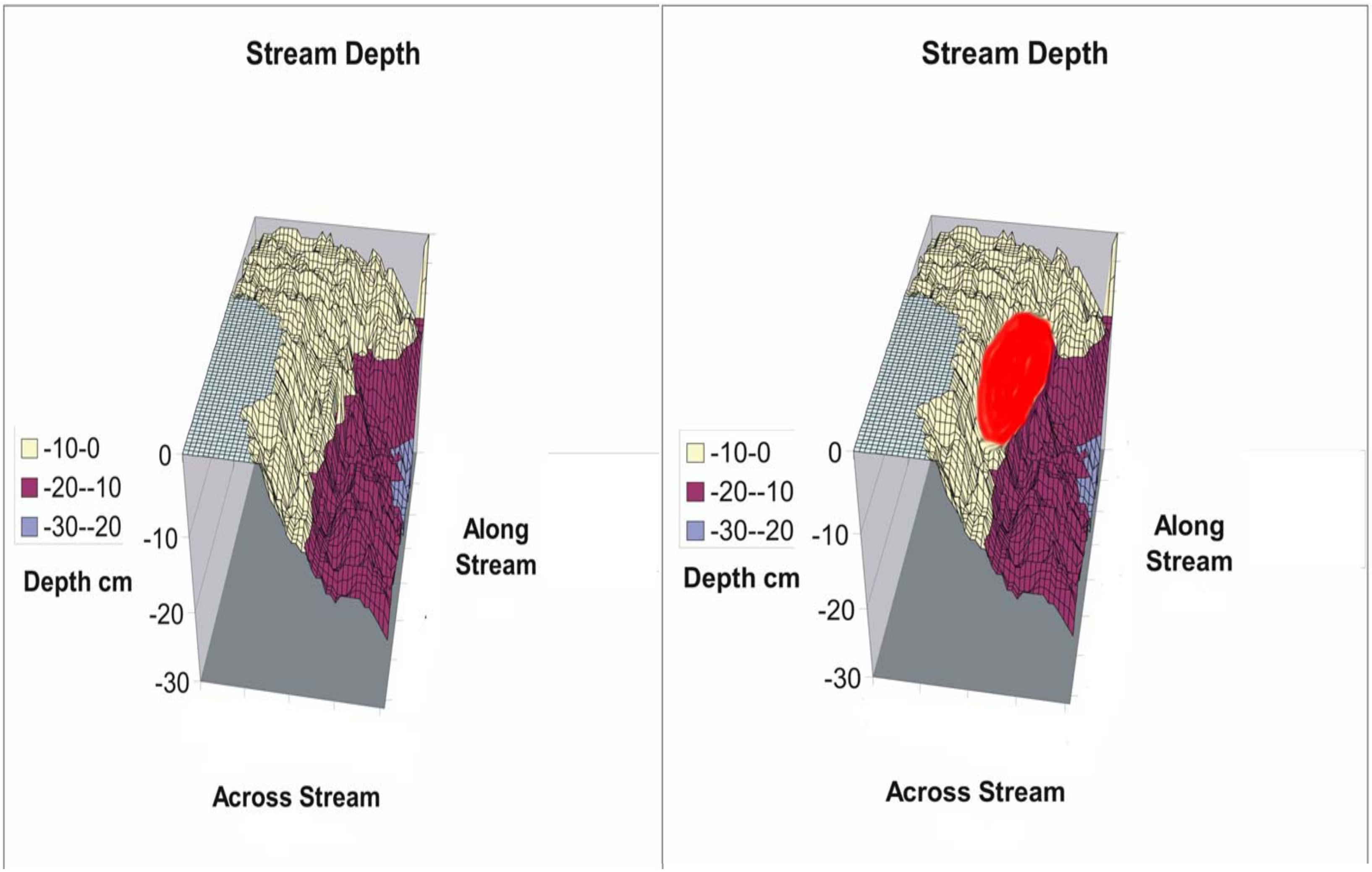
Photo 33. Fry habitat, SAR at mouth of Sunnyslope Creek, May 2002

All of the fry found here were over the dark silt material. Photo 34 shows a close up view of the fry in the foreground of Photo 33. The depth at these spots was about 5cm. Note the rippled appearance of the water surface and the strands of green algae, indicating that the position of fry is adjacent to slowly flowing water that could bring plankton food items within reach of the fry without subjecting them to the continuous impact of flowing water. Fry appeared to be usually above the bottom, about midway up the water column.

Photo 34. Close up view of sucker fry at position of sticks from foreground of Photo 35, SAR at mouth of Sunnyslope Creek, May 2002.

In this small patch of stream (205 cm wide by 365 cm along stream flow), sucker fry were found in depths of 5-10 cm primarily on a small shelf between the shore and the deeper water. This is shown graphically in Figure 10.

Figure 10. The left graph below is a map of the river depths; the graph on the right is the same except that the orange area represents the general area in which sucker fry were found. In this sample, it is clear that fry are not dispersed randomly, but are clustered in a specific area.



We also hypothesize that exposure to the sun in shallow water could also be a positive factor that the fry may be picking out. Photo 35 shows fry habitat at Mission Blvd Bridge in the afternoon. Note the sticks indicating the location of fry and the shadow of the bridge. Counts of fry in the shade and in the sun may suggest a greater concentration of fry in the sun than in the shade. There were 21 fry in 7.3meters of shaded stream edge (2.9 fry per meter) and 52 fry were found in 12.5 meters of sunny stream edge (4.2 fry/meter). The stream edge observed was judged to be approximately uniform with regard to other probable important factors for fry habitat and the amount fry habitat.

Photo 35. Sucker Fry habitat at Mission Blvd. Bridge, May 2002.

Figure 36. Juvenile sucker habitat, SAR at mouth of Sunnyslope Creek, May 2002. Pink streamer indicates position of fish at 13.5cm depth

A. What We Know About Sucker Fry.

The following is a summary of what we know or think we know about Santa Ana sucker fry in the Santa Ana River.

1. Breeding may begin as early as late January, perhaps in response to warm water periods.

2. Breeding may be mainly or even exclusively in side channels (e.g. Sunnyslope Creek) early in the season because water here warms faster and there may be less chance of eggs/fry being washed out by high flow because rain events may not impact all channels as much as the mainstem.

3. Fry and probably eggs in gravel are eliminated by high flow events.

4. Breeding is in specific sites with spawning gravel of specific characteristics adjacent to breeding adult holding habitat characterized by deep points in the stream, at the edge of stream, or adjacent to some cover such as vegetation or undercut banks.

5. Eggs spend some number of days in gravel, hatch as yolk sack fry and stay in gravel until at least 12mm SL; so, fry found that are much smaller are probably not suckers.

6. Fry initially appear at this size or larger at the edge of the stream, usually in very shallow depth (3-10 cm), often over dark silt that matches their color where flow is negligible, and in the proximity of emergent vegetation.

7. Fry are often found along the edge of a sand bar or bank, just down stream from vegetation that protrudes into the flowing water, producing areas of negligible flow where silt settles out on the bottom.

8. The position of fry is in the approximate middle of the water column, adjacent to flowing water that may bring planktonic food items within reach. Actual feeding habits are not known.

9. Fry may take refuge in edge vegetation at night and/or during cloudy conditions and times of increased flow.

10. Fry emerge from vegetation during sunny conditions and "bask" in the sun. Their dark color may serve multiple functions: crypsis, heat absorption, and UV protection.

11. Fry may selectively occupy shallow edgewater habitat that is exposed most directly to the afternoon sun when water temperatures are highest. In our study area this is the north side of the stream or individual channel of the mainstem.

12. The deeper flowing water of any channel is probably a barrier for fry so they cannot get across to bask on both sides.

13. Fry may drift at night (or other times) but we have not yet tested this. Other species of suckers are known to drift.

14. SAS newly transformed into juveniles are about the same standard length as the largest fry, and are found in depths greater than 10cm. on the bottom over sandy substrate, often in small depressions in the bottom contours adjacent to the fry habitat.

VIII. CONCLUSIONS.

Summary of SMEA's Approach

The primary questions that SMEA has been attempting to answer relate to three major issues:

- **What is the status of the Santa Ana Sucker in the Santa Ana River?**
  This is a fundamental question. We need to know the distribution of the sucker, its population size, population structure, and population trends. These data will ultimately be important in determining the current status of the

sucker, but the data will also provide a baseline against which success and failure of enhancement and restoration efforts can be measured.

- **What habitat(s) is/are preferred by the various life stages of the Santa Ana sucker?**
  One of the critical goals of the conservation program is to be able to enhance and restore Santa Ana sucker habitat. This goal serves two functions: (1) it will allow the enhancement/restoration of stream reaches to aid in the recovery of the sucker, and (2) if projects necessitate work in the channel, we will be able to determine what channel characteristics are the most import to restore or maintain in order to support a healthy sucker population.

- **What are the critical life history attributes of the Santa Ana sucker?**
  It is important to understand critical life history attributes such as: (1) time of reproduction, (2) dispersal of fry or young-of-the-year, and (3) adult migration. Such data will provide insight into such diverse concerns as project timing and connectivity (patterns of gene flow) within the Santa Ana River.

Current Status of Our Knowledge

A. What is the Status of the Santa Ana sucker in the Santa Ana River?

- ✓ The Santa Ana River from just downstream of Mission Boulevard upstream to Rialto Drain holds the largest most continuously distributed deme of Santa Ana suckers.
- ✓ Sunnyslope Creek and Rialto Drain were important reproductive sites for the Santa Ana sucker during 2001, but were not so important during 2002.
- ✓ There was considerable mainstem reproduction in 2002.
- ✓ Santa Ana suckers can be successfully pit tagged, which will provide a useful tool in studying the Santa Ana sucker.
- ✓ SMEA's population estimate for Santa Ana sucker from about 600 meters downstream of Mission Boulevard upstream to Rialto Drain was 6,503-6,809 fish in 2001 and 8,262-10,251 in 2002.
- ✓ There were an estimated 6,288-6,584 adult fish in 2001, but only 2,379-2,952 adult fish in 2002.
- ✓ There was a major demographic shift: In 2001 96.70% of the fish captured during the population estimate were adults and 3.30% were YOY, but in 2002 only 28.80% were adult and 71.20% were YOY.
- ✓ Larval production was higher in 2002 than in 2001.
- ✓ An apparently abnormally large number of Santa Ana sucker YOY appeared at River Road during 2002.

B. What habitats are preferred by the various life stages of the Santa Ana sucker?

- ✓ Suckers spawn over medium gravel in water approximately 0.5 meters in depth, and with a flow of 0.20-0.24 m/sec.
- ✓ Sucker spawning habitat must contain a deeper, more protected area adjacent to the spawning area for fish to utilize when not spawning or between spawning bouts.
- ✓ Larval suckers utilize shallow (5-10 cm) water in low flow areas with a silt bottom. Emergent or aquatic vegetation does not appear to be a requirement but is commonly present.
- ✓ Recently transformed young are found in slightly deeper water than are the larvae, and they are associated with a particular habitat structure – the bottom sand is rippled and the young are found in the depression.
- ✓ Larval suckers may be selecting a position relative to the sun, basking?
- ✓ Juvenile suckers are often found over mid-channel gravel, but in areas such as River Road where the water is shallow, they are found in the deeper channels along the river margin. Juvenile suckers are also found in the deeper holes along with adults.
- ✓ Adult suckers are most frequently encountered in deeper holes along the margins of the river.

C. What are the critical life history attributes of the Santa Ana sucker?

- ✓ The timing of larval appearance and observations of spawning indicate that suckers in the Santa Ana River, typically, breed from mid-March through late April.
- ✓ Larval suckers are only present for approximately 1.5 months.
- ✓ Based on Saiki's (2000) data, and SMEA's 2001 data, most suckers may not survive past 1+, meaning that they have only a single reproductive season. Due to annual variability in year class composition in Santa Ana sucker from the San Gabriel River, more data are needed. 2002 data suggest an additional year class.
- ✓ In 2001 there was evidence of adult migration into Sunnyslope Creek
- ✓ Based on the recapture in 2002 of fish marked in 2001, the adults show, at least, seasonal site fidelity and migrate; or they are resident to a short stretch of stream.
- ✓ Based on the adult recapture data, the adults that were tagged in 2001 and recaptured in 2002 had grown an average of 34mm SL and increased in weight by 26.5 grams.

IX. QUESTIONS.

- ➢ Is there significant sucker reproduction in the mainstem? Swift (2001) argued mainstem reproduction because of the broad larval distribution in the mainstem. In 2001, larvae appeared in the mainstem significantly later than they appeared in the tributaries. This raises the potential of larval drift accounting for larvae in the mainstem.

- Can we increase larval production? Now that SMEA has been able to characterize Santa Ana sucker spawning habitat in the tributaries, there is the potential to create more spawning habitat and increase larval production.

- Where were the juveniles (see Photo 22) in 2001? Swift (2001) reported large numbers of juveniles, but such large numbers were not observed in 2001 by SMEA.

- To what degree does the size of the sucker deme upstream of Mission Boulevard fluctuate from year to year, and is it stable? SMEA made one population estimate based on three 100-meter sections. As this is repeated year after year the question will be answered.

- What are the specific characteristics of preferred adult habitat? Even upstream of Mission Boulevard where suckers are common, there is considerable variation in sucker density. What determines this mosaic of habitat occupation?

- Do suckers in the Santa Ana River normally survive only two years? Based on SMEA's experience in the West Fork of the San Gabriel River, several years of data will be necessary to answer this question without sacrificing fish to examine otoliths.

- Do the cichlids in the Santa Ana River compete for algal resources with the Santa Ana sucker? The potential for competition over food resources exists.

X. PROGRAM TASKS FOR 2002/2003.

The following are the recommended focal tasks for the 2002/2003 field season for the Santa Ana Sucker Conservation Program.

Task 1. Prepare to enhance sucker breeding/spawning habitat in Sunnyslope Creek during the 2003/2004 field season.

Subtask 1A. Obtain approval from USFWS
Subtask 1B. Obtain approval from California Department of Fish and Game
Subtask 1C. Obtain approval from County Parks
Subtask 1D. Determine measures of success

This task responds to Item II-A-2 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

This task is the precursor to the first attempt to actually improve sucker habitat in the Santa Ana River. In addition to obtaining the requisite permission, the project must be carefully designed in order to facilitate an accurate assessment of the success of the enhancement. The enhancement will be based on data collected at observed reproductive sites in the Santa Ana River.

What do we know? – Based on the two previous field seasons SMEA has been able to collect structural data at two separate reproductive sites in the Santa Ana River Drainage (habitat type, current velocity, substrate, adjacent habitat, depth, *etc.*). These data will be used to select the enhancement site and design the enhancement.

Task 2. Studies of Larval Suckers

Subtask 2A. Determine movement of larvae, particularly downstream drift
Subtask 2B. Characterize habitat of larval suckers
Subtask 2C. Determine the diet of larval suckers

This task responds to Items II-A-2 and II-C-3 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

To the extent that habitat needs must be defined prior to any attempt at enhancement this task will collect the data necessary to define potential habitat enhancement for larval suckers and define habitat that must be restored following perturbation. Data on larval drift will begin to provide insight into the connectivity of different portions of the stream. Dietary data will be a precursor to looking at dietary overlap between Santa Ana suckers and non-native fishes of the Santa Ana River.

What do we know? – Based on preliminary data collected during the 2001/2002 field season, larval suckers are selecting a stream margin site with particular structure and substrate characteristics. These data are somewhat preliminary but will be firmed up during the current field season. Diets of the various life stages of Santa Ana sucker have only been generally characterized, and the data may not be applicable to the Santa Ana River. Downstream drift is known to be an important life history characteristic in other sucker species.

Task 3. Studies of Young-of-the-Year (YOY) Suckers

Subtask 3A. Determine movement of YOY suckers, particularly downstream drift
Subtask 3B. Characterize habitat of YOY suckers
Subtask 3C. Determine the diet of YOY suckers

This task responds to Items II-A-2 and II-C-3 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

To the extent that habitat needs must be defined prior to any attempt at enhancement this task will collect the data necessary to define potential habitat enhancement for YOY suckers and define habitat that must be restored following perturbation. Data on YOY drift will begin to provide insight into the connectivity of different portions of the stream and may help explain occurrences such as the apparently unusually large number of YOY suckers that were found at River Road last summer. Dietary data will be a precursor to looking at dietary overlap between Santa Ana suckers and non-native fishes of the Santa Ana River.

What do we know? – Currently we know very little about these tasks. Preliminary data and anecdotal data from the 2001/2002 field season suggest that YOY may show considerable downstream movement. Our understanding of their habitat preference is very limited. However, studies by SMEA on the San Gabriel River have devised a methodology which proved to be successful in characterizing YOY habitat in the upper San Gabriel River. Diets of the various life stages of Santa Ana sucker have only been generally characterized, and the data may not be applicable to the Santa Ana River.

Task 4. Studies of Adult Suckers

Subtask 4A. Determine movement of adult suckers (placed under tagging also)

Subtask 4B. Characterize habitat of adult suckers

Subtask 4C. Determine the diet of adult suckers

This task responds to Items II-A-2 and II-C-3 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

To the extent that habitat needs must be defined prior to any attempt at enhancement this task will collect the data necessary to define potential habitat enhancement for adult suckers and define habitat that must be restored following perturbation. Data on adult sucker movement will begin to provide insight into the connectivity of different portions of the stream. Dietary data will be a precursor to looking at dietary overlap between Santa Ana suckers and non-native fishes of the Santa Ana River.

What do we know? – Currently we know very little about these tasks. Preliminary data and anecdotal data from the last two field seasons suggest that adult suckers may show little movement. Our understanding of their habitat preference is very limited. However, studies by SMEA on the San Gabriel River have devised a methodology which proved to be successful in characterizing adult habitat in the upper San Gabriel River. Diets of the various life stages of Santa Ana sucker have only been generally characterized, and the data may not be applicable to the Santa Ana River.

Taken together tasks 2, 3, and 4 will determine the habitat preferences of the various life stages of the Santa Ana sucker in the Santa Ana River, which will allow future attempts at habitat enhancement and restoration. Thus, this information can be used in the future to perform habitat enhancement and restoration experiments on tasks analogous to those proposed in Task 1. The "A and C" components of these tasks begin to address the importance of downstream movement of larvae and YOY and adult movement, while the dietary data will provide the groundwork for future tasks which examine dietary overlap between the Santa Ana sucker and non-native fishes.

Task 5. Population Estimate/Tagging

Subtask 5A. Estimate population size at the three standard sites

Mission Boulevard
Highway 60
Riverside Avenue

Subtask 5B. Estimate population size at River Road

Subtask 5C. Tag all fish captured during population estimates

Subtask 5D. Use tagged fish to determine movement patterns of adult suckers

This task responds to Items II-A-2, II-C-1 and II-A of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

What do we know? – SMEA currently has two years of population data. Population trends cannot be reliably determined from two data points. In fact, the two years of data that we do have suggest significant differences in population structure have occurred. This year's data will begin to provide an insight into the result of such a demographic change, but only long term monitoring will allow an accurate assessment of population trends and population dynamics. Initial recovery of tagged adult Santa Ana suckers suggest some form of site fidelity. The data do not currently allow us to distinguish seasonal site fidelity from the potential that the adults do not move very much within the mainstem. We do possess some data suggesting that adults do move up creeks such as Sunnyslope Creek during the reproductive season.

Task 6. Snorkeling Surveys

Subtask 6A. Snorkeling survey of Sunnyslope Creek

Subtask 6B. Snorkeling survey of mainstem

This task responds to Items II-C-1 and II-A of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

What do we know? – The snorkeling data provide the broadest coverage of the suckers in the Santa Ana River. These data allow SMEA to determine overall patterns of occurrence/density and provide another semi-quantitative dataset on the status of the sucker. The snorkeling of Sunnyslope Creek allows SMEA to ascertain the degree to which adults migrate into the creek or are year-round residents (another way of looking at adult movement).

Task 7. Determine the Diet of the Adult Stages of Exotic Fishes

Subtask 7A. Determine the importance of predation on larvae

Subtask 7B. Determine the importance of predation on YOY

This task responds to Item II-B of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

What do we know? – Non-native fish species are still considered a threat to the Santa Ana sucker. In other systems where interactions between native fishes and non-natives have been studied, declines in the natives have been attributable to the presence of the non-natives. Preliminary data collected by Swift did not show evidence of predation on the sucker by non-natives, but the dataset was relatively small. The sample size needs to be increased. Gut content analysis will also broadly determine the diets of non-native fish, these data will provide the initial dataset, which will subsequently be expanded to examine dietary overlap between various life stages of the non-natives and the life stages of the Santa Ana sucker. Exotic control programs are typically time-consuming and costly. Before making exotic fish control a priority, it will be important to try and ascertain the importance of such a program compared to other management alternatives.

It is not expected that all goals or definitive answers to the questions proposed for investigation in the above Tasks will be fully achieved this year. All of the Tasks should be pursued to the extent that time, access to sites, environmental conditions, permit restrictions and budgetary constraints allow.

XI. POTENTIAL ACTIVITIES FOR YEAR 7 OF THE CONSERVATION PROGRAM.

The year 7 implementation activities as currently envisioned are the year 5 activities outlined in the Conservation Plan (Baskin and Haglund 1999). Funding restrictions during years 1-3 have resulted in a delay in completing the tasks as originally conceived. The primary focus in year 7 should be the evaluation of the success of created habitat and the refinement of habitat design. This should be coupled with annual monitoring.

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- City of San Bernardino Municipal Water Department (Rapid Infiltration & Extraction Facility)
- Orange County Flood Control District
- Orange County Water District, County of Orange Public Facilities & Resources Department
- Riverside County
- Riverside County Flood Control and Water Conservation District
- San Bernardino County Flood Control District

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Appendix 1

Length-weight data and pit tag numbers from the fish captured in 2001

List of the length (SL mm) and weight (g) of the fish caught (N=88) in the 100-meter stream reach upstream of Mission Boulevard (Site 1) on 15 June 2001.

LENGTH	WEIGHT	PIT TAG NUMBER
102	18.8	4264610758
113	25.9	426502050D
140	40.4	4263187801
107	27.4	425F623D68
113	29.8	42616B2D21
109	21.0	4264603D43
98	19.5	42656F2620
110	27.1	42631A7519
102	22.5	42645F0977
119	33.9	42645B1060
116	20.6	4261784118
116	33.7	4264743268
115	28.0	4262014F3A
113	27.6	4264525A28
107	24.8	4265707F06
118	25.7	42645E2D7A
102	21.4	4264533E5C
111	27.5	4264666E38
109	23.1	4261627E72
114	28.0	426204114D
113	27.0	426200201F
118	29.5	4262104704
118	32.9	4262006820
102	19.1	426210684C
115	22.9	4261561F5C
116	29.0	42620E2865
109	22.8	4264712F71
112	28.5	4265041E49
107	25.5	42615B5215
132	39.2	4263245D1B
119	29.3	42655E0062
112	26.9	426600274E
126	36.3	4262032A1E
99	21.4	4261680723
115	30.6	426578585F
111	28.2	42632A2F17
105	23.2	42616F102F
103	23.5	426204190B
110	27.7	4264595B2F
101	21.8	426205324D
105	21.4	4262076B48

135	42.5	426169220D
121	30.4	4264584A66
107	25.3	42615E4164
110	24.2	42617B2111
113	27.7	42621D077D
108	23.8	4262003B30
116	27.9	42645F4F20
120	32.4	42657F3F57
107	20.1	42615C705D
101	22.0	4264634D34
102	17.6	42633C717F
102	20.7	4259292F4C
117	29.8	426557543C
102	22.4	426501387C
110	27.3	42633F6172
103	20.8	4264680850
119	29.9	4264646037
105	23.8	4261600774
112	26.7	42620C611E
122	35.6	4265771571
109	24.0	
106	19.2	42617C0C12
116	31.3	426209526C
112	26.3	42657B1013
107	24.1	4261672708
110	24.4	42615D6952
107	24.2	426560B6C
110	28.4	4264511935
116	28.1	42616A7A3F
115	28.5	42616F1722
117	29.4	4265781377
123	36.7	425F6F1C07
105	20.9	4262087B1E
111	26.9	42645D2076
114	29.7	426500267E
102	20.1	4262026847
120	32.5	4265523270
102	21.9	42645A3360
101	19.0	42633D5746
102	21.0	426209360C
127	35.9	4265057B1E
112	26.2	42646C155D
110	22.3	4265621208
106	21.0	42620A294A

123	33.4	4266012D28
110	28.2	4264655C02
100	19.8	4261665970

List of the length (SL mm) and weight (g) of the fish caught (N=144) in the 100-meter stream reach upstream of Highway 60 (Site 2) on 15 June 2001.

LENGTH	WEIGHT	PIT TAG NUMBER
104	18.9	426505004B
152	65.8	4265610D4E
108	25.5	42617A4268
103	20.1	42650A4139
110	25.7	42615A635F
110	29.3	4261641E63
112	25.3	4262001907
98	15.7	42617E3343
125	35.7	42620E1B0F
101	18.1	4261663641
110	22.3	4264775F1E
108	26.3	4264517604
111	22.3	4265083A0B
94	16.5	4262110064
111	24.3	4262131467
99	19.1	4261775D12
102	18.3	4261614B45
114	25.2	4265092A61
107	19.5	4261796949
120	28.0	42645D1128
108	21.2	42620A7A5A
98	18.1	4262002859
133	40.7	426207776A
109	20.9	426604580D
111	22.4	4267106F79
161	69.9	42634F4571
125	37.4	42645F1761
99	16.4	4264726F7B
122	32.2	42617D517E
120	29.3	426472792B
120	33.5	42645C064F
96	16.6	4262127D6C
110	28.6	42617B542C
108	18.8	426179075B
116	32.0	4262027F34

118	31.1	4264571615
116	29.8	426460066F
111	25.7	42645E391E
105	17.8	42616B151A
122	29.5	426466644A
106	19.9	4262007C44
112	28.7	42600A5939
105	24.0	42615B6E34
112	26.8	4261582175
103	21.1	42616D2F7E
119	32.7	4263220F43
114	28.7	42647B712E
120	29.9	4264761B69
104	18.9	4264765E29
103	20.3	425F6B356D
104	22.2	4261616017
116	28.0	426508436A
117	28.4	42620E7107
109	23.8	426608125D
113	28.9	426162230A
101	17.8	4264725B1C
104	17.8	4262021A77
106	19.3	42620A594E
126	33.7	42645B3B32
110	23.9	4262112A15
111	26.2	42615A7321
107	24.1	42620A1052
110	21.7	42617C4D48
103	19.4	426164184D
107	24.7	4265734459
110	23.8	426461486A
122	33.7	4264625D5E
105	24.0	42563D6B0A
100	16.8	42645B0713
121	30.8	42546A1179
120	31.0	42620B7D43
105	21.7	4264622D5A
116	27.2	426458452D
116	31.8	426502604E
122	36.2	42615A7115
103	20.2	426479237A
110	27.0	4261777474
111	25.2	42620C6613
108	19.8	4263355D63

123	34.4	42647D6018
109	21.3	425F686945
105	20.5	42647B200A
115	28.2	42617A126F
101	20.2	425F7F5F05
107	22.9	4262087742
117	26.4	4264585B3B
100	19.1	4265794150
102	20.1	42616D6D33
112	25.2	4262011658
98	20.8	4264745860
106	24.7	4264687977
96	19.4	42617A772C
108	26.7	4262033B43
99	18.0	4265661A42
109	20.3	42650A622D
118	36.8	425F627D11
120	39.4	4261731715
115	26.8	42617C4320
111	24.6	4262003558
41	1.2	
48	2.1	
110	23.9	426453342E
112	24.1	42620A467B
109	28.9	4261660E7A
96	20.4	4264667868
112	20.3	426165330B
100	17.4	42633C2756
107	18.0	4264766D43
100	17.6	42616F1D50
116	25.6	42645D7507
107	23.4	42645C5A14
127	33.0	4262055C5F
105	20.3	42616D0D49
109	19.4	4264550C7E
116	29.4	426213241A
113	26.5	4264563721
107	20.6	42646D7D75
123	34.3	4265581360
117	28.7	4262112253
117	30.8	425F7A2B03
113	23.6	4264596F48
104	21.4	4266015449
106	28.4	4265633431

107	26.5	42654E3247
105	21.5	4262007402
127	39.0	426501632A
135	44.0	4262092672
115	31.3	4264694158
119	31.4	4265584C2C
117	33.4	42617B5A44
101	20.7	4265031C02
57	4.0	
40	1.1	
122	32.7	4261684C0B
121	36.4	42620B3920
122	34.9	42616C7026
117	25.0	4262091E49
132	37.6	42615B2106
121	35.0	42633C6A50
102	20.2	42646C0E72
118	30.0	4264574612
106	22.7	4264711D38
127	36.0	4261790D29
49	2.4	
49	1.9	
52	2.2	
105	20.4	4265777111
41	1.4	
113	24.6	4262113714
113	25.3	42616B6B76
114	23.5	4265035D58
94	15.5	4265660808
116	27.0	42647A4B35
112	26.2	42617B0031
102	18.6	42655C0A77
102	18.4	42617D1F6F
105	17.6	42620C2B15
100	17.1	42646E4E6C
103	24.0	426460266C
99	19.2	42647A5A68
113	30.1	4266093C22
108	26.1	4264542A47
109	24.2	42650B2E1C
112	26.9	42660A7074
105	21.5	4265656922
130	40.2	4261634A01
112	28.6	4265541B7D

116	31.0	4262104C55
105	20.9	426001170C
103	18.7	4264666935
124	36.9	4265504609
127	34.7	42616F2345
99	20.9	4265006056
92	19.7	
153	60.8	

List of the length (SL mm) and weight (g) of the fish caught (N=9) in the 100-meter stream reach downstream of Riverside Avenue (Site 3) on 16 June 2001.

LENGTH	WEIGHT	PIT TAG NUMBER
124	37.5	4261646702
115	32.6	4261710538
113	31.8	4261566C4F
124	45.1	4265060501
121	33.8	4264757877
113	33.8	42650D6903
116	33.3	4261597748
131	42.5	4265591479
129	39.5	4262075D18
54	2.8	
42	1.4	
60	4.4	
61	3.8	

Appendix 2

Discussion of the triple pass sequential depletion method of population estimation

The following discussion was presented to a group of agency personnel and concerned scientists that wanted to standardize Santa Ana sucker monitoring techniques throughout its range.

Discussion of Proposed Santa Ana Sucker Monitoring Protocol

By
Thomas R. Haglund, Ph.D.
Jonathan N. Baskin, Ph.D.

Introduction.
The following is a discussion of the potential alternatives considered in establishing a Santa Ana sucker monitoring protocol and a recommendation for establishing a protocol.

Population Estimation Methods To Be Considered.

1. Electrofishing
2. Snorkeling
3. Mark-Recapture
4. Seining
5. Underwater Camera

General Considerations.
Estimation of population sizes in streams presents significant sampling problems when the entire stream must be censused. Since it is seldom feasible to survey the entire stream, two-stage sampling designs are necessary. A random or systematic selection of sampling units is selected during the first stage, and the population of fish within each of these is estimated during the second stage. Hankin (1984) concluded that errors in the estimation of fish numbers within selected units (second stage errors) are likely to be small compared with errors that arise due to variation in fish numbers between these units (first stage errors).

The necessity of stratification by habitat type and location could be evaluated following one or more sampling rounds. Observations by Haglund and Baskin (unpubl. data) clearly indicate stratification by habitat type is necessary, and surveys conducted by Haglund and Baskin in 1991 throughout the upper San Gabriel River drainage suggest that location may be relevant because fish abundance appears to decrease with gradient.

In concept, all methods of population estimation are simple, but their application to natural populations has stimulated the development of a large body of statistical and mathematical models (e.g. Seber, 1973; Ricker, 1975).

Electrofishing – Sequential Removal
Electrofishing is an efficient capture method that is widely used to obtain reliable population estimates of salmonid fishes. Although it has been used less frequently on smaller nonsalmonid fishes, it can be an effective technique for the study of small nonsalmonids if properly used. The technique tends to collect larger fishes more readily than smaller ones but the controls on the newer electrofishers allow adjustments that reduce size selectivity and enhance the efficacy of this technique for use on smaller riverine fish species. Stream

conditions such as conductivity of the water, temperature, and depth can affect the efficiency of electroshocking. However, it still remains a technique of choice for salmonids, and is becoming so for other fishes occupying similar habitats because it is less affected by boulder-rubble substrates, aquatic vegetation and undercut banks - all conditions likely to be encountered in a productive trout stream (where Santa Ana suckers occur).

Standard censusing with an electrofisher involves the use of successive removal-depletion techniques. The removal-depletion method of population analysis (Zippin, 1958) assumes that:

1. No animal can move in or out of the sampling area.
2. Each animal has an equal chance of being captured.
3. The probability of capture is constant over all removal passes.

These assumptions are readily reached if (1) size selectivity is reduced through proper adjustment of the electrofisher, (2) the sample area is blocked to prevent fish from leaving the area, (3) a consistent proportion of the population is captured during each pass, and (4) timing devices are used on the electrofishers to insure that capture effort is the same on all removals (Platts et al, 1983). During electrofishing it is imperative that a downstream blocking net be in place, as well as an upstream blocking net to insure that fish did not leave the sampling area; in our experience fish will attempt to leave the area.

Although a two-step removal method (Seber and LeCren, 1967) is frequently used to reduce effort, and because of the simplicity of population estimate calculations, it is less reliable than methods using additional removals. Multiple-removal methods provide more accurate estimates of the population size (Zippin, 1958). A three-step removal procedure is a good compromise between reliability of the population estimate and effort.

The Zippin method is based on a maximum likelihood model (Moran, 1951) which has the probabilities reduced to easily read graphs or to computer programs. In order to calculate a population estimate the following quantities must be calculated:

$$T = \sum_{i=1}^{k} U_i \qquad (T = U_1 + U_2 + \ldots + U_k)$$

where:

T = total number of fish collected
U_i = number of fish collected in the ith removal
k = the number of removals

Next the ratio (R) must be determined from the following formula:

$$R = \frac{\sum_{i=1}^{k} (i-1)\, U_i}{T}.$$

The population estimate is then determined by :

$$eN = \frac{T}{Q}$$

where:
Q = the proportion of the fish captured during all removals. Q can be determined from a graph (Platts et al, 1983) or it is calculated by the computer program.

This method allows the measurement of length-weight data which can be used to determine fish condition (Saiki 2000) and age class distribution. In the case of the Santa Ana sucker, the sizes of Santa Ana sucker age classes were determined by Drake and Sasaki (1987) for the West Fork of the San Gabriel River.

Age class	Santa Ana sucker Length (mm)
YOY	0 - 70
1+	71 - 130
2+	131 - 160
3+	161 - 185
4+	186 -

These data are relatively similar to the data presented in Greenfield *et al.* (197) for the lowland Santa Clara River population. Thus age class structure of the population can be determined if length data are collected.

This technique has been criticized due to potential injury related mortality of electroshocked fish. However, in our experience mortality is minimal if electrofishers are carefully adjusted and the fish are properly held during the removal period. In fact, Santa Ana suckers are less subject to injury than are rainbow trout.

Snorkeling Counts.
Hankin and Reeves' (1988) snorkeling surveys of salmonids in Cummins Creek, Oregon is a frequently used example of a snorkeling study design. Habitat units must be classified (*e.g.* riffle, pool, glide), and the stream may be further stratified based on location (*e.g.* lower,

middle or upper). The second order of stratification is only necessary if sampling occurs over significant changes in stream orders or physical changes (*i.e.* gradient or channel conformation).

Habitat units must be classified over the stream length to be studied, and their areas estimated/calculated. Next, units to be sampled must be determined. Multiple units of each habitat type must be sampled within each stream unit.

Independent counts of fish should be made by a team of two observers in each unit to be sampled. Observers enter downstream of the unit to be counted and proceed upstream, identifying species and age class (rough estimate) and counting individual fish. Observers should position themselves along the stream midline and coordinate their upstream movements. Counts must be made at a time of day when visibility is good. In the Hankin and Reeves' (1988) study the technique was variably effective dependent on species and age class.

Observer counts must be standardized for each species/age class and habitat type. Standardization is accomplished by selecting a subsample of each habitat type (using about one of every three or four of each habitat type as the subsample). Standardization is accomplished by electrofishing using a Moran-Zippin successive removal method (Seber 1973), which provides a population estimate independent of the diver counts. This is considered the optimal standardization method because many authors consider sequential removal by electroshocking a more accurate method of population size estimation (*e.g.* Gunderson 1993).

The number of fish in habitat unit i can be estimated by:

$$P_i = d_i R$$

Where P_i = estimated population size in habitat unit i
d_i = mean observer count in habitat unit i
$R = \sum_i P_{\text{ei}} / \sum_i d$ where P_{ei} is the population estimate obtained in selected units by electrofishing

An analysis of the data in the Hankin and Reeves (1988) study demonstrated that the number of fish present was poorly correlated with the area of each habitat unit, so the total number of fish within a habitat type/location stratum (P_h) was estimated using the formula below:

$$P_h = \frac{N}{n} \sum_{i=1}^{n} P$$

Where P = estimated population size for the i^{th} sampling unit in habitat type h
N = total number of habitat units of type h present in the survey area
n = number of habitat units of type h in the systematic sample

The variance of this estimate is a function of the variance of *R*, between-observer variance, and the variance in population size between habitat units. Hankin and Reeves (1988) an estimator for *Var(P)*, which takes all these sources of variance into account.

A more complex estimator, incorporating a measure of the size of each primary unit selected, may be preferable to the one presented above if the population size in the habitat units is highly correlated with area (Hankin 1984).

The potential advantage of snorkeling is that the total number of habitat units for which fish numbers can be estimated is increased by the use of the technique. This increased first stage sampling fraction can result in a reduction of total errors of estimation because the variance contributions associated with second stage sampling (within habitat units) are expected to be relatively small.

The potential drawbacks with snorkeling surveys are that the suckers are highly substrate associated so they are more difficult to locate, and experienced observers will be required. In the Hankin and Reeves (1988) study steelhead trout in pools were more closely associated with the substrate, this was interpreted as making them more difficult to observe; the result was that observer counts were not highly correlated with removal estimates. Additionally, snorkeling surveys do not allow collection of length-weight data, which may be used to evaluate fish condition. The length data can also be used to examine age class composition, and such data may be valuable in evaluating the status of the population, particularly over time.

Mark-Recapture Estimates.
Mark/recapture is one of the most common, easily performed and reliable methods of estimating fish population size. Mark/recapture is based on a simple principle. A sample of fish, n_1, is taken from the population at time 1, each fish is given a recognizable, nondeliterious mark that will distinguish it from uncaptured individuals, and then the sample is returned to the population. At time 2, another sample, n_2, is taken. The separation between time 1 and time 2 samples must be sufficient for the marked individuals to redistribute themselves among the population in the sampling area. We have found collection of the two samples 24 hours apart is appropriate. In the second sample *m* individuals are found which were previously marked. It is then assumed that the proportion of marked fish in the second sample is the same as the proportion of marked fish in the total population, *N*. Therefore:

$$n_1/N = m/n_2$$

and an estimate of *N*, *eN*, can be calculated as:

$$eN = n_1 n_2/m$$

This is the Petersen estimate of population size. It is the simplest form of mark/recapture, requiring only two samples and one type of mark. This method avoids the stress, and potential mortality, associated with the multiple captures that are necessary for other mark/recapture methods. The method makes the following assumptions (Seber, 1973; Bejon, 1979):

1. The marks are not lost in the period between the two samples and are correctly recognized in recaptured specimens.
2. Being caught, handled and marked has no effect on the probability that the individual will be recaptured.
3. Capture, handling and marking have no effect on the probability that the individual will die or emigrate.
4. All fish, marked and unmarked, have the same probability of dying or emigrating.
5. The population is sampled at random.

These assumptions may be difficult to meet in a riverine system if emigration is high. The fish can be marked with Sudan Brown Y, a vital dye that is taken up by all tissues but rapidly metabolized from muscle while remaining for several days in the bony elements. This dye persists sufficiently to allow recognition of individuals of these species for several days following staining (Baskin and Haglund, Unpubl. data). In laboratory tests the dye did not induce mortality in stained fishes over a seven day examination period (Baskin, Unpubl. data). Using this method, the fish are stained by placing them in a container and allowing them to swim in water containing the dye (2ml saturated aqueous solution/liter water) for approximately one hour. This methodology reduces the handling of the fish to an absolute minimum.

It is difficult to determine if the probability of capture is affected by previous encounter, but either seining or electroshocking can provide a random sample of fishes from the area being studied. Previous experience with this technique has shown that 24 hours allows a sufficient time interval for the fish to redistribute themselves within the capture area (the fish are manually released throughout the capture area following marking). Furthermore, mortality and emigration are minimized by using a 24 hour recapture period.

This technique allows the collection of length-weight data, however seining would be a difficult capture technique, so electroshocking would be necessary. As a result, this technique doesn't offer an advantage over depletion with an electroshocker.

Seining Estimates.
Seining will not be discussed in any detail here. Seining as a technique in the frequently swift, deep cobble substrate areas occupied by Santa Ana suckers is not an efficient capture technique, and reproducibility of effort is difficult. Techniques requiring seining are not recommended.

Population Estimates Using Underwater Cameras.
Although this sounds like a nice high tech solution to the sampling problem, it will likely be expensive, and there are many unknowns. Camera sleds have been successfully used in deepwater marine environments. Success is based on the assumption that there is neither avoidance of or attraction to the camera sled. Therefore reports of successful surveys usually involve sedentary species. Because this technique was largely developed as a marine

technique, transects were used. In a small stream two cameras (equivalent to two underwater observers) would have to be moved upstream. The cameras could either be mounted to provide two slightly different views as with the underwater observers or the two cameras could be forward facing and mounted in stereo configuration. Unless the cameras used are video cameras, there is the problem of photo interval and area calculation. Additionally because of the stratification recommended in the introduction, there would have to be surveys of different habitat boundaries, and we are not sure that habitat type boundaries would be readily discernable, particularly in still photos. Additionally, as previously mentioned, a technique that can produce length-weight data instead of just population size will be more useful in studying and understanding short and long term population trends.

Conclusion.
Based on the preceding discussion we recommend the use of a sequential removal technique using a backpack electroshocker to monitor Santa Ana sucker populations. If accord can be reached on this point, we will provide a more detailed protocol based on the recommended methodology.

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