# *San Marino Environmental Associates*

# Results of the Year 1 Implementation of the Santa Ana Sucker Conservation Program For the Santa Ana River

**Thomas R. Haglund, Ph.D.**
**Jonathan N. Baskin, Ph.D.**
**Camm C. Swift, Ph.D.**

**Prepared for SAWPA 2001**

# San Marino Environmental Associates

# Results of the Year 1 Implementation of the Santa Ana Sucker Conservation Program For the Santa Ana River

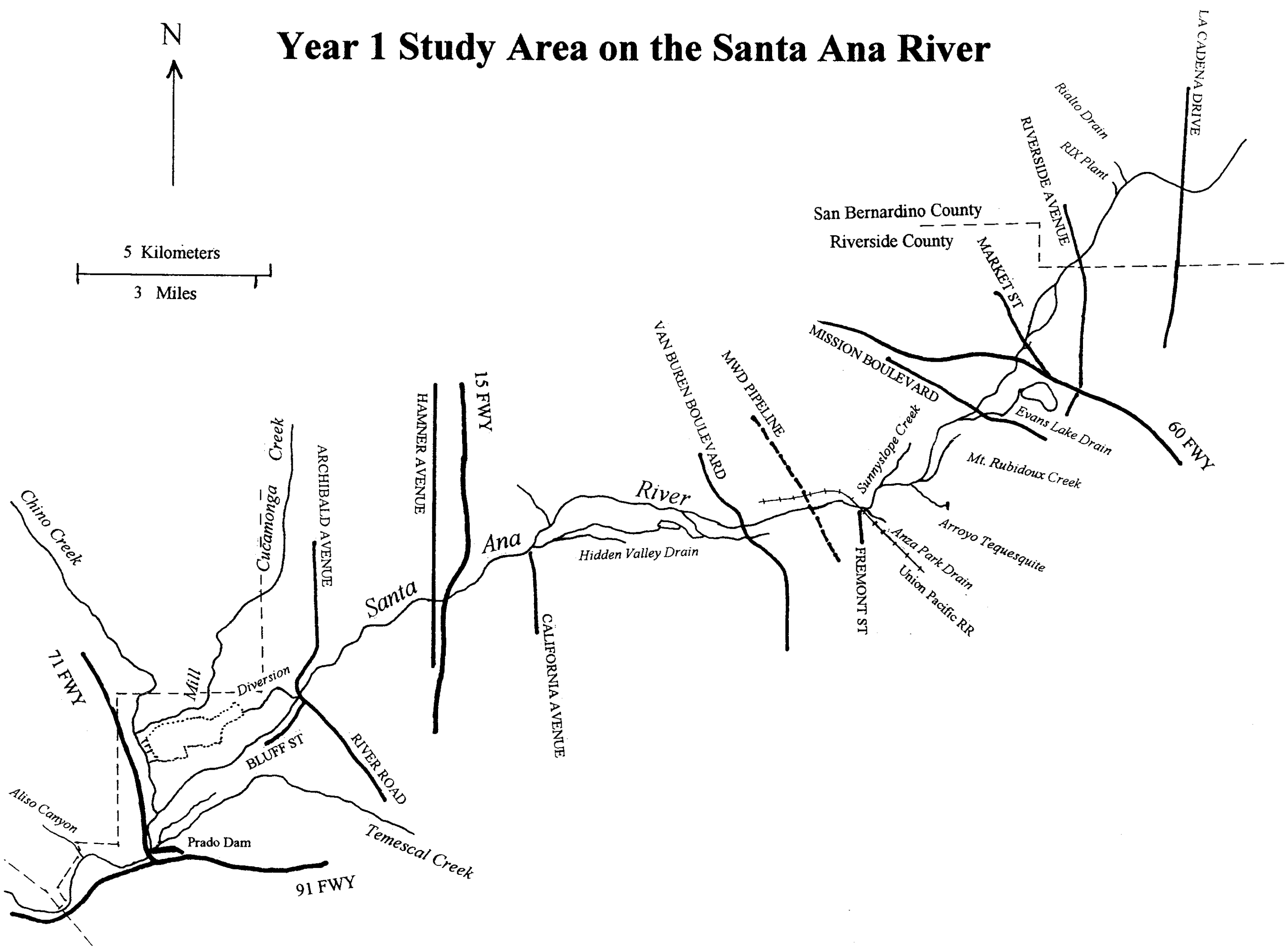
**Final Report**

Prepared For:
**Santa Ana Watershed Project Authority**
11615 Sterling Avenue
Riverside, CA 92503

Prepared By:
Thomas R. Haglund, Ph.D.
Jonathan N. Baskin, Ph.D.
Camm C. Swift, Ph.D.
**San Marino Environmental Associates**
560 South Greenwood Avenue
San Marino, CA 91108-1270

**2001**

# Year 1 Study Area on the Santa Ana River



# Table of Contents

## 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 (Discussion 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 specific enough data 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 particular reference to a stream diversion below River Road, Norco.
2. Document areas and timing of spawning with reference to 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. Larval 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; with fish and insects being 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 juveniles, although slightly less important to adults. A pattern mirrored 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 these data are combined with the distributional data, they suggest that exotic predators do not currently have a very significant impact on Santa Ana suckers (except potentially mosquitofish). The potential impact of the Mozambique-type cichlids as a food competitor needs to be examined, as does the potential for mosquitofish to act as a larval predator.

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 the effective population size and genetic heterozygosity can be maintained. This will in turn, reduce the chances of extirpation, 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 exists within each of the drainages of its historic range, the distribution within each drainage has become significantly reduced. It was this reduction in the species historic distribution that has lead 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 Conservation Program for the Santa Ana sucker in the Santa Ana River as 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 so as to begin the recovery of the Santa Ana sucker in the Santa Ana River.

This document is a report on the activities carried out, and the data collected during the first year (2000/2001) 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. 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. a*l. (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), as 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 introduced Santa 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. And 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 than 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 almost upstream 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 1 IMPLEMENTATION OF THE CONSERVATION PROGRAM.

The work plan submitted by SMEA identified the following tasks. These tasks are based to a large extent on the original suggestions for the first year of a Conservation Program, which were suggested in the Conservation Plan prepared by SMEA. Modifications are primarily the result of a reduced budget compared to that envisioned in the Conservation Plan, and a late start.

TASK 1. Reproductive Monitoring

- Focus on Sunnyslope and Rialto Drains
- Buy Temperature loggers and install one in each drain and in the mainstem between the two drains
- On visits, measure water quality in the drain

- Measure flow in the drain
- Survey drain for substrate distribution
- Collect flow, rainfall, and temperature data
- Surveillance

TASK 2. Population Estimates
- Establish Protocols
- Tagging Experiment
- Population size, focus on one stream reach – consider mark-recapture rather than sequential depletion – potentially less stress on fish – but not as precise an estimate
- This should be done in December and again in the spring
- Population structure – measure lengths and weights during population estimates
- Number of individuals breeding at the two sites – estimate by observation and ratio of tagged and untagged fish
- Determine population size variation --- this can only be done over several years!
- Already consulted with Glen Knowles on PIT tagging

TASK 3. Migration.
- Largely based on the capture of marked fish. So fish marked in December will be captured during reproductive surveillance and generalized sampling
- Places a great deal of emphasis on Task 2.

TASK 4. Project Management

TASK 5. Data Management and Quality Control
- Data sheets to insure all data collected in the field
- Use of trained individuals who will commit years to the project
- Data entry into the computer checked by another person
- Analytical calculations double-checked
- Reports read and edited by the core team members to assure accuracy, clarity, and consensus

TASK 6. Report Preparation.
Report containing:
- Report of activities
- Report of data
- Report of interpretations
- Report of protocols
- Recommendations for next year.

TASK 7. Meetings and Presentations.

Modifications to the work plan began with the elimination of a December tagging session, due to delays in obtaining permission from U.S. Fish and Wildlife Service. Therefore, more time was allocated to reproductive surveillance, and this time was spent studying fry, which was not part of the original work plan. Additionally, the anticipated protocol for the population estimates was modified (more time intensive methodology), and a snorkeling survey similar to that of Swift (2001) was added to the work plan.

All work conducted as part of the first year implementation of the 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.

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, 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 offer 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. 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. Folding meter stick provided for scale.


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

## IV. TAGGING FEASABILITY STUDY.

Once SMEA had determined the optimal technology, it was decided to conduct a study to ascertain the affect 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. 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, and 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 (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. 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 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.

| | 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.

| | 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 15 and 16 June 2001, SMEA personnel shocked three 100-meter sections of stream in order to capture and tag the Santa Ana suckers from these stream reaches. The primary goals of these collections were to provide population estimates of Santa Ana sucker from these three stream sections, to begin to develop a population of tagged suckers, so that their movement/migration in the stream can be recognized and documented, and 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=88) in the 100-meter stream reach upstream of Mission Boulevard on 15 June 2001.

| LENGTH | WEIGHT |
|---|---|
| 102 | 18.8 |
| 113 | 25.9 |
| 140 | 40.4 |
| 107 | 27.4 |
| 113 | 29.8 |
| 109 | 21.0 |
| 98 | 19.5 |
| 110 | 27.1 |
| 102 | 22.5 |
| 119 | 33.9 |
| 116 | 20.6 |
| 116 | 33.7 |
| 115 | 28.0 |
| 113 | 27.6 |
| 107 | 24.5 |

| | |
|---|---|
| 118 | 25.7 |
| 102 | 21.4 |
| 111 | 27.5 |
| 109 | 23.1 |
| 114 | 28.0 |
| 113 | 27.0 |
| 118 | 29.5 |
| 118 | 32.9 |
| 102 | 19.1 |
| 115 | 22.9 |
| 116 | 29.0 |
| 109 | 22.8 |
| 112 | 28.5 |
| 107 | 25.5 |
| 132 | 39.2 |
| 119 | 29.3 |
| 112 | 26.9 |
| 126 | 36.3 |
| 99 | 21.4 |
| 115 | 30.6 |
| 111 | 28.2 |
| 105 | 23.2 |
| 103 | 23.5 |
| 110 | 27.7 |
| 101 | 21.8 |
| 105 | 21.4 |
| 135 | 42.5 |
| 121 | 30.4 |
| 107 | 25.3 |
| 110 | 24.2 |
| 113 | 27.7 |
| 108 | 23.8 |
| 116 | 27.9 |
| 120 | 32.4 |
| 107 | 20.1 |
| 101 | 22.0 |
| 102 | 17.6 |
| 102 | 20.7 |
| 117 | 29.8 |
| 102 | 22.4 |
| 110 | 27.3 |
| 103 | 20.8 |

| | |
|---|---|
| 119 | 29.9 |
| 105 | 23.8 |
| 112 | 26.7 |
| 122 | 35.6 |
| 109 | 24.0 |
| 106 | 19.2 |
| 116 | 31.3 |
| 112 | 26.3 |
| 107 | 24.1 |
| 110 | 24.4 |
| 107 | 24.2 |
| 110 | 28.4 |
| 116 | 28.1 |
| 115 | 28.5 |
| 117 | 29.4 |
| 123 | 36.7 |
| 105 | 20.9 |
| 111 | 26.9 |
| 114 | 29.7 |
| 102 | 20.1 |
| 120 | 32.5 |
| 102 | 21.9 |
| 101 | 19.0 |
| 102 | 21.0 |
| 127 | 35.9 |
| 112 | 26.2 |
| 110 | 22.3 |
| 106 | 21.0 |
| 123 | 33.4 |
| 110 | 28.2 |
| 100 | 19.8 |

Table 5. 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 on 15 June 2001.

| LENGTH | WEIGHT |
|---|---|
| 104 | 18.9 |
| 152 | 65.8 |
| 108 | 25.5 |
| 103 | 20.1 |
| 110 | 25.7 |
| 110 | 29.3 |
| 112 | 25.3 |

| | |
|---|---|
| 98 | 15.7 |
| 125 | 35.7 |
| 101 | 18.1 |
| 110 | 22.3 |
| 108 | 20.3 |
| 111 | 22.3 |
| 94 | 16.5 |
| 111 | 24.3 |
| 99 | 19.1 |
| 102 | 18.3 |
| 114 | 25.2 |
| 107 | 19.5 |
| 120 | 28.0 |
| 108 | 21.2 |
| 98 | 18.1 |
| 133 | 40.7 |
| 109 | 20.9 |
| 111 | 22.4 |
| 161 | 69.9 |
| 125 | 37.4 |
| 99 | 16.4 |
| 122 | 32.2 |
| 120 | 29.3 |
| 120 | 33.5 |
| 96 | 16.6 |
| 110 | 28.6 |
| 108 | 18.8 |
| 116 | 32.0 |
| 118 | 31.1 |
| 116 | 29.8 |
| 111 | 25.7 |
| 105 | 17.8 |
| 122 | 29.5 |
| 106 | 19.9 |
| 112 | 28.7 |
| 105 | 24.0 |
| 112 | 26.8 |
| 103 | 21.1 |
| 119 | 32.7 |
| 114 | 28.7 |
| 120 | 29.9 |
| 104 | 18.9 |

| | |
|---|---|
| 103 | 20.3 |
| 104 | 22.2 |
| 116 | 28.0 |
| 117 | 28.4 |
| 109 | 23.8 |
| 113 | 28.9 |
| 101 | 17.8 |
| 104 | 17.8 |
| 106 | 19.3 |
| 126 | 33.7 |
| 110 | 23.9 |
| 111 | 26.2 |
| 107 | 24.1 |
| 110 | 21.7 |
| 103 | 19.4 |
| 107 | 24.7 |
| 110 | 23.8 |
| 122 | 33.7 |
| 105 | 24.0 |
| 100 | 16.8 |
| 121 | 30.8 |
| 120 | 31.0 |
| 105 | 21.7 |
| 116 | 27.2 |
| 116 | 31.8 |
| 122 | 36.2 |
| 103 | 20.2 |
| 110 | 27.0 |
| 111 | 25.2 |
| 108 | 19.8 |
| 123 | 34.4 |
| 109 | 21.3 |
| 105 | 20.5 |
| 115 | 28.2 |
| 101 | 20.2 |
| 107 | 22.9 |
| 117 | 26.4 |
| 100 | 19.1 |
| 102 | 20.1 |
| 112 | 25.2 |
| 98 | 20.8 |
| 106 | 24.7 |

| | |
|---|---|
| 96 | 19.4 |
| 108 | 26.7 |
| 99 | 18.0 |
| 109 | 20.3 |
| 118 | 36.8 |
| 120 | 39.4 |
| 115 | 26.8 |
| 111 | 24.6 |
| 41 | 1.2 |
| 48 | 2.1 |
| 110 | 23.9 |
| 112 | 24.1 |
| 109 | 28.9 |
| 96 | 20.4 |
| 112 | 20.3 |
| 100 | 17.4 |
| 107 | 18.0 |
| 100 | 17.6 |
| 116 | 25.6 |
| 107 | 23.4 |
| 127 | 33.0 |
| 105 | 20.3 |
| 109 | 19.4 |
| 116 | 29.4 |
| 113 | 26.5 |
| 107 | 20.6 |
| 123 | 34.3 |
| 117 | 28.7 |
| 117 | 30.8 |
| 113 | 23.6 |
| 104 | 21.4 |
| 106 | 28.4 |
| 107 | 26.5 |
| 105 | 21.5 |
| 127 | 39.0 |
| 135 | 44.0 |
| 115 | 31.3 |
| 119 | 31.4 |
| 117 | 33.4 |
| 101 | 20.7 |
| 57 | 4.0 |
| 40 | 1.1 |

| | |
|---|---|
| 122 | 32.7 |
| 121 | 36.4 |
| 122 | 34.9 |
| 117 | 25.0 |
| 132 | 37.6 |
| 121 | 35.0 |
| 102 | 20.2 |
| 118 | 30.0 |
| 106 | 22.7 |
| 127 | 36.0 |
| 49 | 2.4 |
| 49 | 1.9 |
| 52 | 2.2 |
| 105 | 20.4 |
| 41 | 1.4 |
| 113 | 24.6 |
| 113 | 25.3 |
| 114 | 23.5 |
| 94 | 15.5 |
| 116 | 27.0 |
| 112 | 26.2 |
| 102 | 18.6 |
| 102 | 18.4 |
| 105 | 17.6 |
| 100 | 17.1 |
| 103 | 24.0 |
| 99 | 19.2 |
| 113 | 30.1 |
| 108 | 26.1 |
| 109 | 24.2 |
| 112 | 26.9 |
| 105 | 21.5 |
| 130 | 40.2 |
| 112 | 28.6 |
| 116 | 31.0 |
| 105 | 20.9 |
| 103 | 18.7 |
| 124 | 36.9 |
| 127 | 34.7 |
| 99 | 20.9 |
| 92 | 19.7 |
| 153 | 60.8 |

Table 6. 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 on 16 June 2001.

| LENGTH | WEIGHT |
|---|---|
| 124 | 37.5 |
| 115 | 32.6 |
| 113 | 31.8 |
| 124 | 45.1 |
| 121 | 33.8 |
| 113 | 33.8 |
| 116 | 33.3 |
| 131 | 42.5 |
| 129 | 39.5 |

In addition to the suckers tagged as part of the population estimate, 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) and weight (g) of each of the fish captured and tagged during the above tagging sessions is shown below in Table 7.

Table 7. List of the length (SL mm) and weight (g) of the all fish caught and tagged (N=83) after the tagging associated with the 15/16 June 2001 population estimates.

| LENGTH | WEIGHT |
|---|---|
| 16 June 2001<br>Under the Riverside Avenue bridge | |
| 128 | 39.8 |
| 120 | 36.8 |
| 108 | 22.6 |
| 122 | 33.7 |
| 122 | 36.1 |
| 124 | 36.7 |
| 121 | 32.5 |
| 137 | 48.9 |
| 111 | 27.6 |
| 121 | 36.4 |
| 105 | 22.0 |
| 105 | 19.6 |

| | |
|---|---|
| 121 | 34.4 |
| 109 | 25.3 |
| 119 | 31.7 |
| 104 | 20.3 |
| 104 | 23.6 |
| 112 | 25.4 |
| 117 | 30.3 |
| 112 | 28.5 |
| 148 | 61.0 |
| 126 | 40.0 |
| 111 | 32.7 |
| 107 | 27.3 |
| 107 | 23.7 |
| 110 | 24.2 |
| 122 | 32.6 |
| 119 | 30.2 |
| 137 | 43.6 |
| 120 | 32.4 |
| 108 | 23.4 |
| 18 June 2001<br>Under the Riverside Avenue bridge | |
| 123 | 35.3 |
| 112 | 26.1 |
| 123 | 35.9 |
| 129 | 39.8 |
| 112 | 31.0 |
| 112 | 31.4 |
| 115 | 29.7 |
| 113 | 29.2 |
| 18 June 2001<br>100-150 m downstream of Hwy 60 | |
| 125 | 38.7 |
| 113 | 26.2 |
| 123 | 34.1 |
| 120 | 30.9 |
| 105 | 16.2 |
| 126 | 37.0 |
| 103 | 23.6 |
| 105 | 24.6 |
| 125 | 35.6 |
| 116 | 30.2 |
| 116 | 24.1 |

| | |
|---|---|
| 120 | 27.9 |
| 111 | 23.9 |
| 104 | 20.7 |
| 18 June 2001<br>Site 1, upstream of Mission Blvd | |
| 120 | 29.5 |
| 103 | 20.9 |
| 109 | 23.4 |
| 22 June 2001<br>Sunnyslope Creek | |
| 121 | 30.6 |
| 111 | 32.4 |
| 107 | 24.2 |
| 127 | 34.5 |
| 107 | 21.0 |
| 112 | 24.8 |
| 111 | 20.7 |
| 114 | 28.4 |
| 115 | 27.3 |
| 141 | 49.1 |
| 109 | 21.3 |
| 113 | 27.6 |
| 115 | 29.6 |
| 120 | 31.0 |
| 102 | 21.8 |
| 108 | 21.7 |
| 99 | 18.5 |
| 122 | 35.0 |
| 116 | 25.7 |
| 27 July 2001<br>MWD Crossing | |
| 110 | 25.0 |
| 97 | 15.0 |
| 98 | 17.0 |
| 102 | 19.6 |
| 115 | 31.0 |

## A. Population Estimates.

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. However, because it is difficult to meet the assumptions of a mark-recapture in a riverine system, SMEA used 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, then returned to these localities on 18 June to attempt to recapture the marked fish, and associated unmarked fish. 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 data that are presented and discussed here. The three sites used in this study were described above. The data from the triple pass depletion are presented in Table 9.

Table 9. The number of suckers captured in each of the three passes, at each of the three sampling on 16 June 2001.

| Pass # | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| 1 | 57 | 123 | 5 |
| 2 | 21 | 25 | 4 |
| 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 = 9 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 10.

Table 10. 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 | 9 | 0.32 | 8-10 |

Based on the data presented above, one would estimate that there is an average of 85-89 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 6,503-6,809 Santa Ana suckers.

## B. Migration.

As mentioned above, the study of migration must wait for year 2 of the Conservation Program implementation because of the delay in obtaining permission to tag the suckers. During year 1 there were very few recaptures, but there were no large-scale collections that would have likely resulted in recapture.

Only four fish were recaptured during 2001. 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 8.

Table 11. 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 study year as more fish are tagged it is anticipated that the recapture rate will increase.

## C. 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.

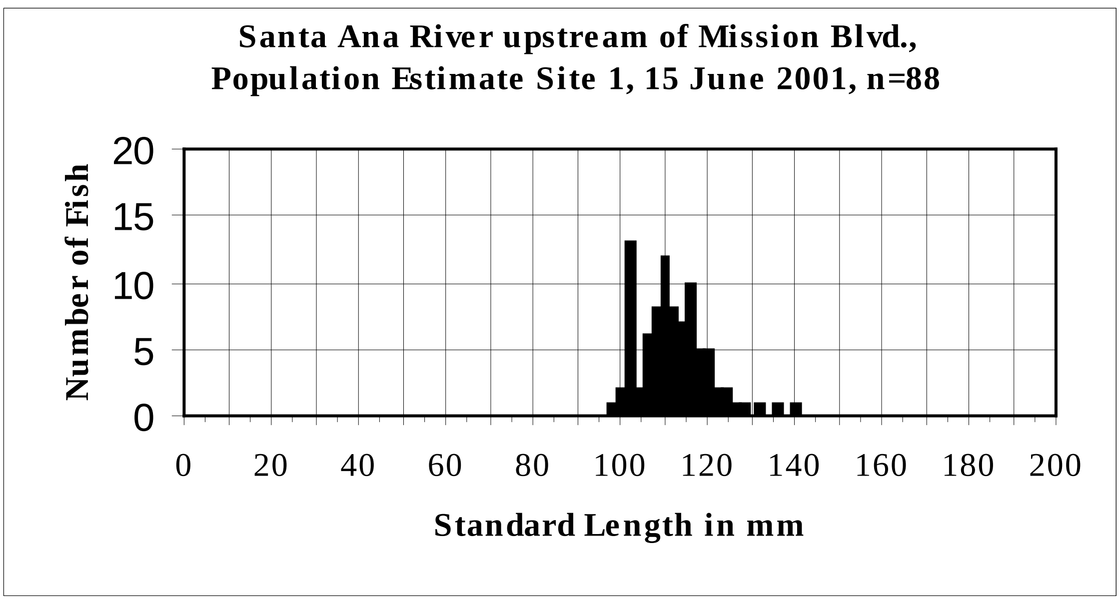
Greenfield *et al* (1970) and Sasaki and Drake (1987) provided date on the approximate size ranges of the various year classes in the Santa Clara River and the San Gabriel River, respectively. Saiki's (2000) data can also be used to estimate size classes of suckers in the Santa Ana River. These data are presented in Table 12.

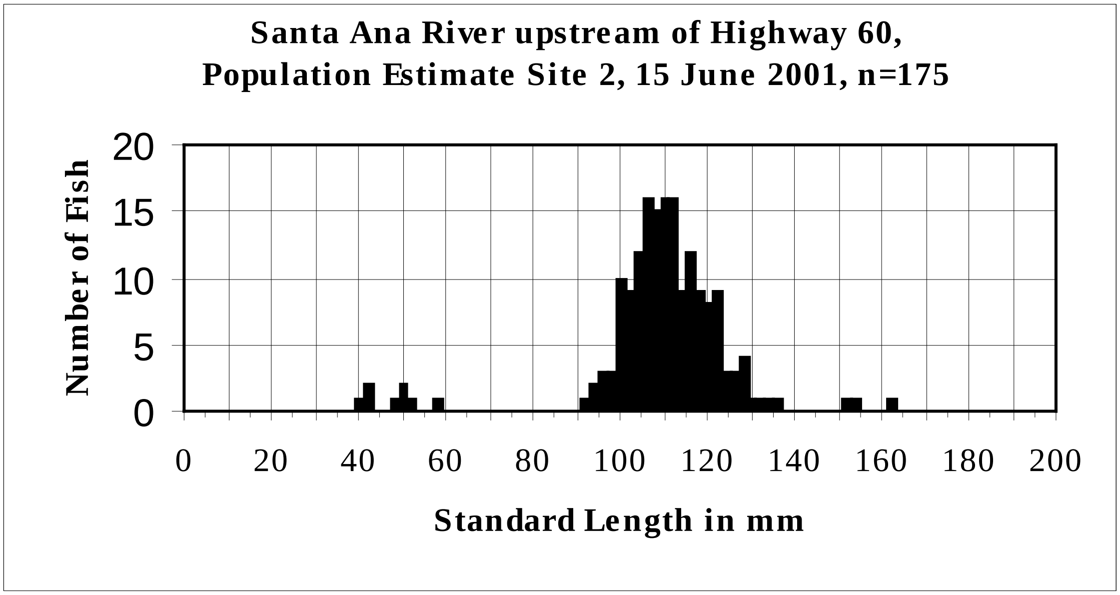
Table 12. Estimated lengths (SL mm) of the various age classes in the Santa Clara River, San Gabriel River and Santa Ana River.

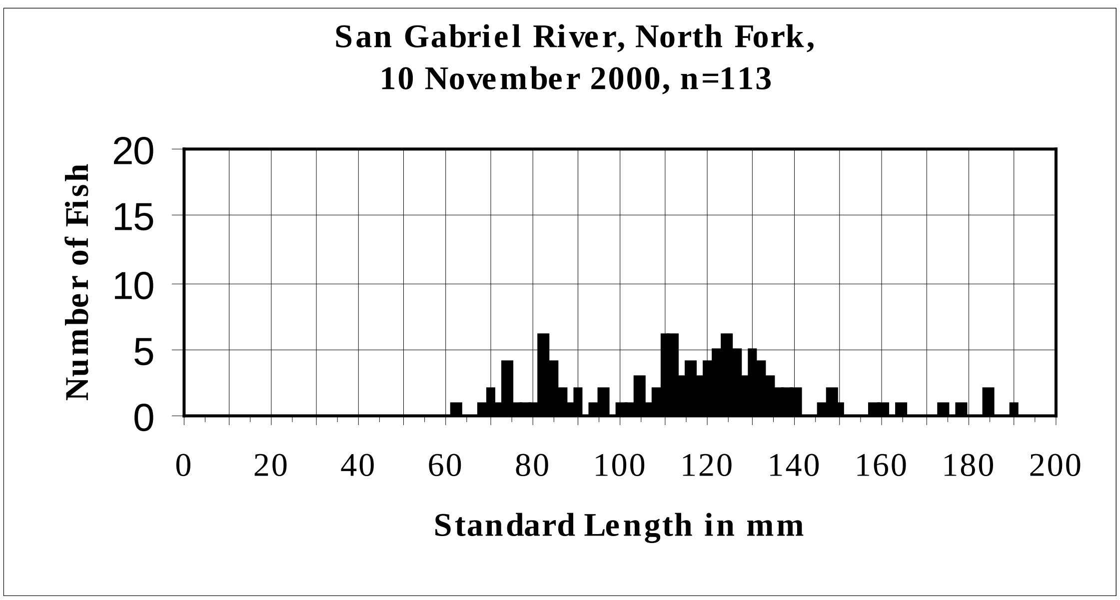
| Age Class | Santa Clara River | San Gabriel River | Santa Ana River |
|---|---|---|---|
| 0+ | 0-51 | 0-70 | 0-80 |
| 1+ | 52-77 | 71-130 | 81-120 |
| 2+ | 77-140 | 131-160 | 121+ |
| 3+ | 140+ | 161-185 | |
| 4+ | | 186+ | |

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 clearly shows at least three year classes, while the Site 1 histogram may only show one year class. A size-frequency histogram for a sample of Santa Ana suckers from the San Gabriel River 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.




Santa Ana River upstream of Highway 60,
Population Estimate Site 2, 15 June 2001, n=175
Number of Fish
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
Standard Length in mm


San Gabriel River, North Fork,
10 November 2000, n=113
Number of Fish
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
Standard Length in mm

## 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 16. Sunnyslope Creek

Photo 17. Rialto Drain

Photo 18. 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 19. Tuberculation is visible on the anal fin of this sucker.

Tables 13-18 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 13. 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 14. 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 15. 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 16. 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 17. 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 18. 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 19 below.

Table 19. 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 |

## 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 it's (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 I 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 20. Sunnyslope Creek, where spawning was observed on 15 April 2001.

Photo 21. Rialto Drain, where spawning was observed on 31 March 2001.

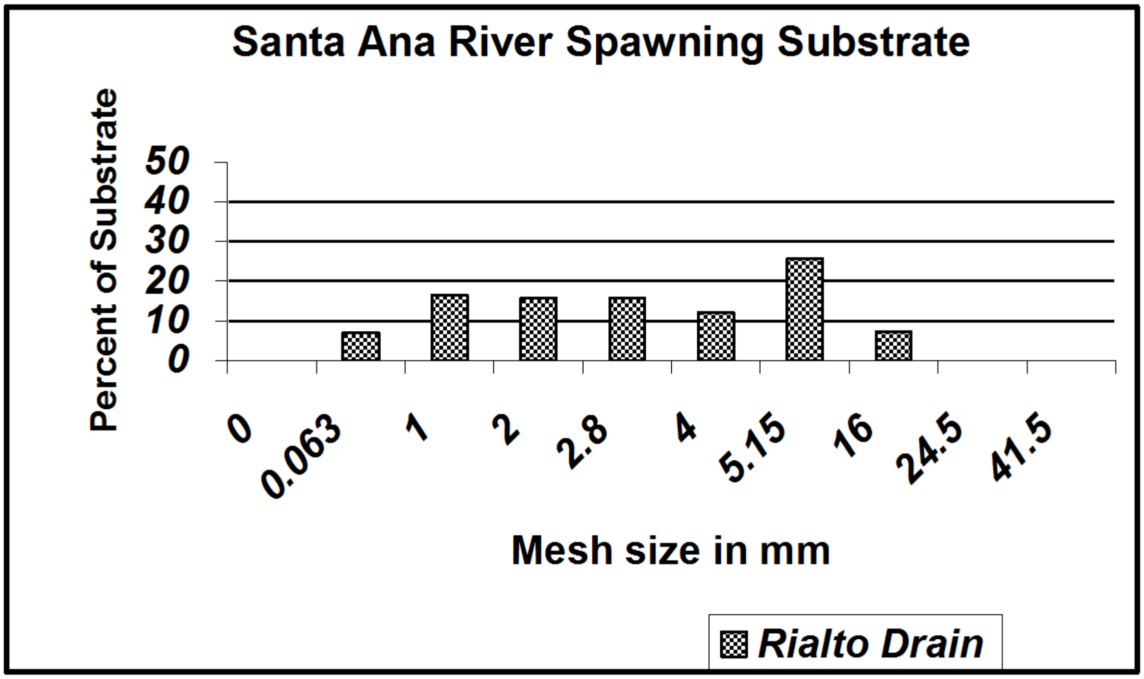
Based on these two observations it appears that the suckers prefer deeper water adjacent to spawning gravel. The spawning gravel in both cases was approximately 0.5 meter deep and the flows were similar (0.20 and 0.24 m/sec). The substrate in both cases was dominated by medium gravel.

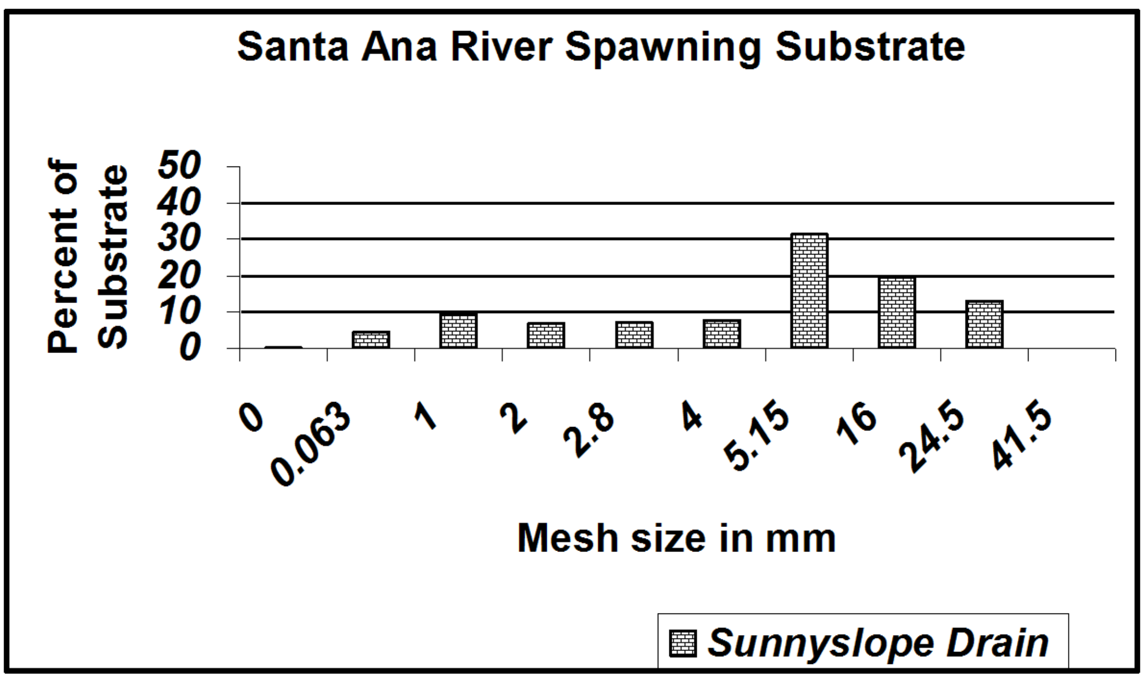
**D. Analysis of Spawning Gravels**

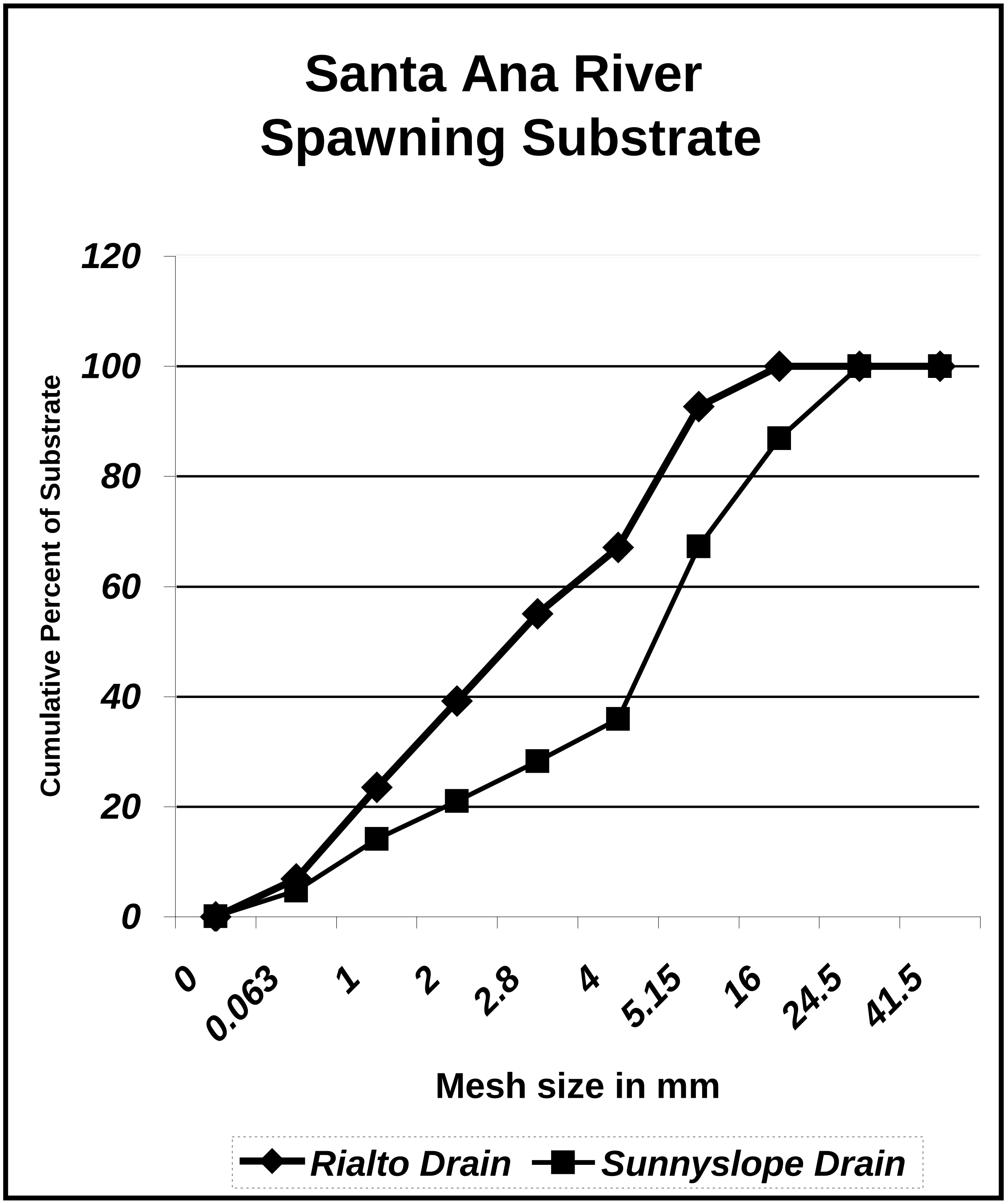
A sample of gravel was collected from each of the two spawning sites and analyzed for particle size. The histograms for particle size are shown below along with their cumulative percent curves.

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.


Santa Ana River Spawning Substrate
Percent of Substrate
50
40
30
20
10
0
0
0.063
1
2
2.8
4
5.15
16
24.5
41.5
Mesh size in mm
Rialto Drain


Santa Ana River Spawning Substrate
Percent of Substrate
50
40
30
20
10
0
0
0.063
1
2
2.8
4
5.15
16
24.5
41.5
Mesh size in mm
Sunnyslope Drain


Santa Ana River
Spawning Substrate
Cumulative Percent of Substrate
120
100
80
60
40
20
0
0
0.063
1
2
2.8
4
5.15
16
24.5
41.5
Mesh size in mm
Rialto Drain
Sunnyslope Drain

## 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 22. 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 about the size they transform and settle to the substrate (15 mm TL).

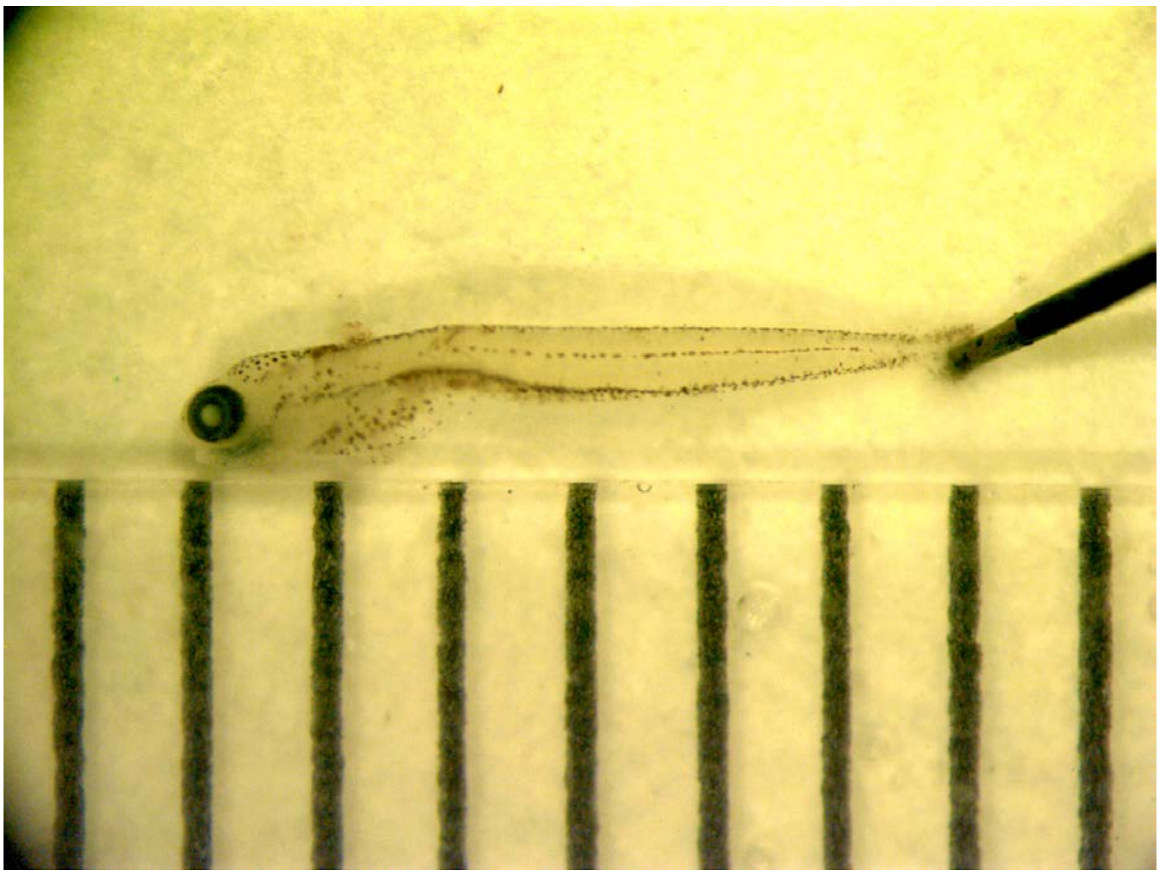


Photo 23. Santa Ana sucker fry at 6 mm TL from Rialto Drain.

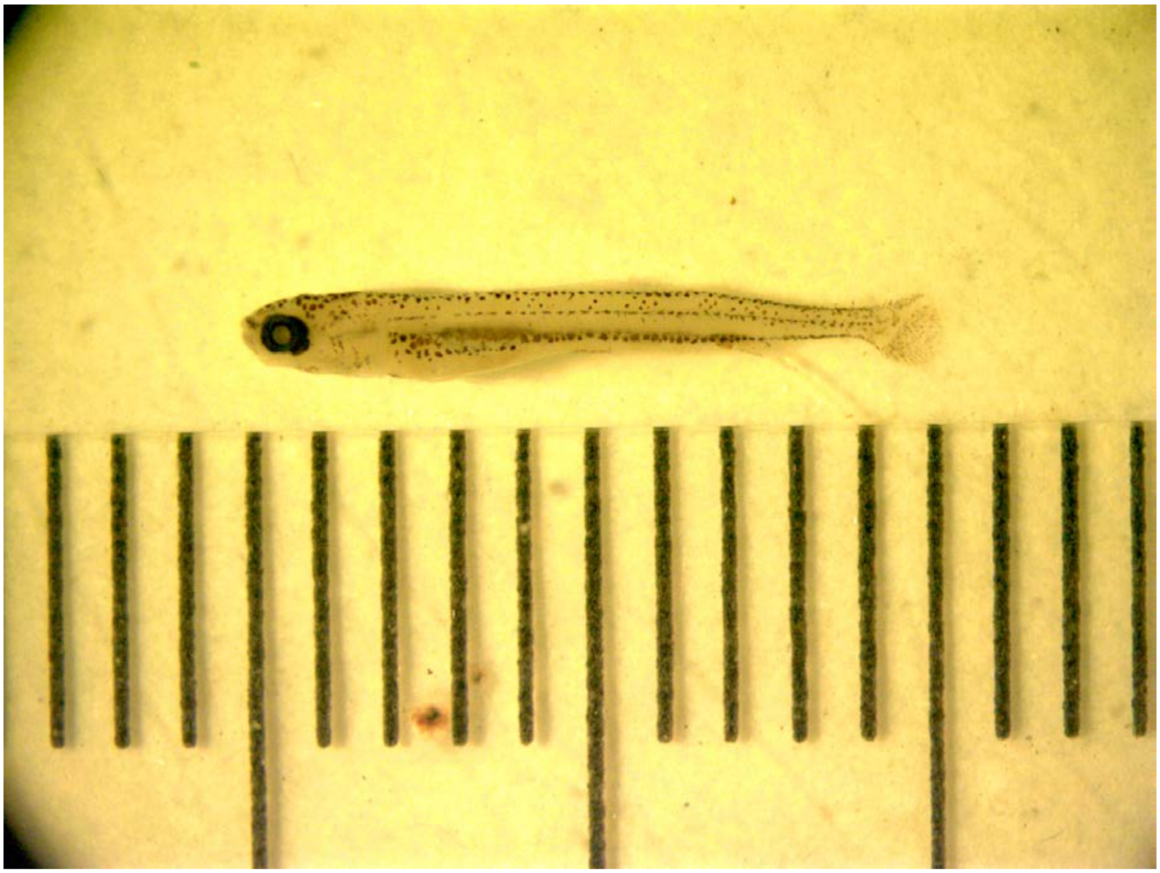


Photo 24. Santa Ana sucker fry at 10mm TL from Rialto Drain.

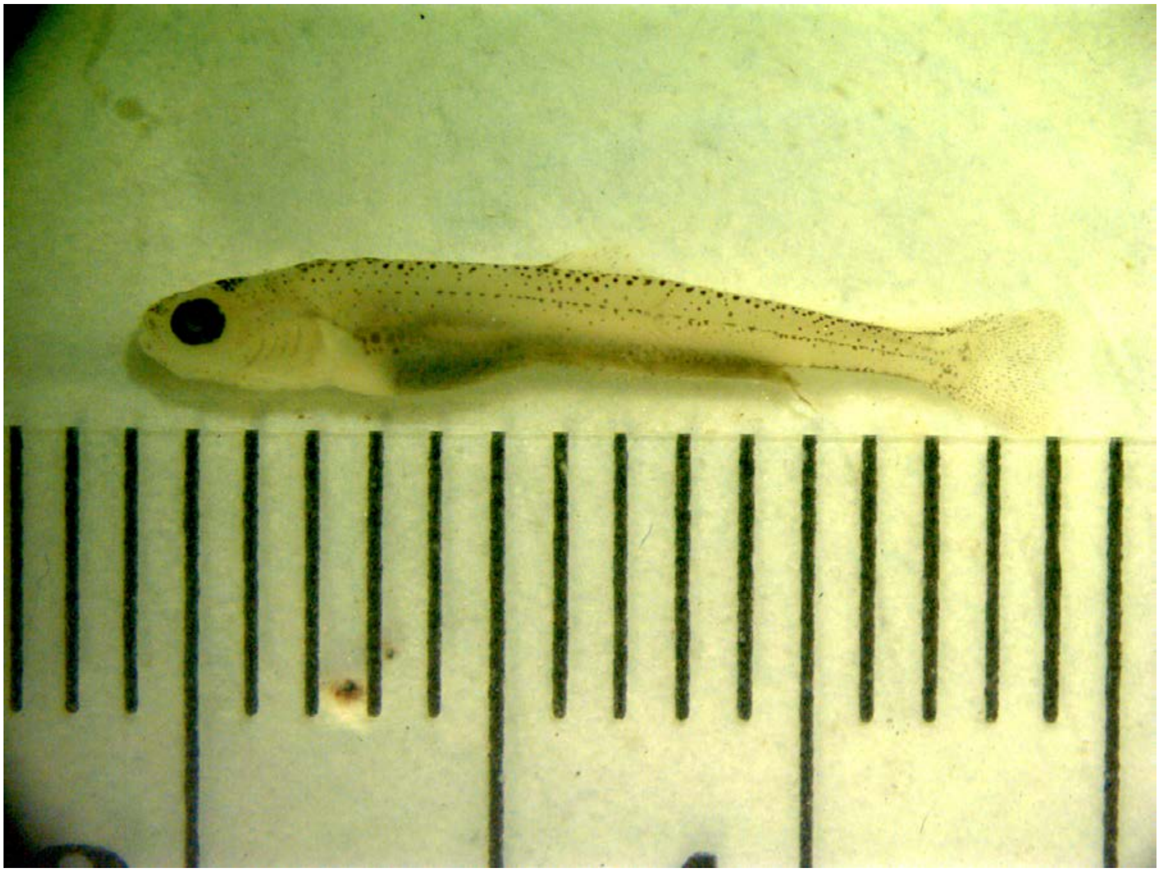


Photo 25. Santa Ana sucker fry at 15mm TL from Evans Lake Drain.

**VII. CORRELATES OF REPRODUCTIVE TIMING.**

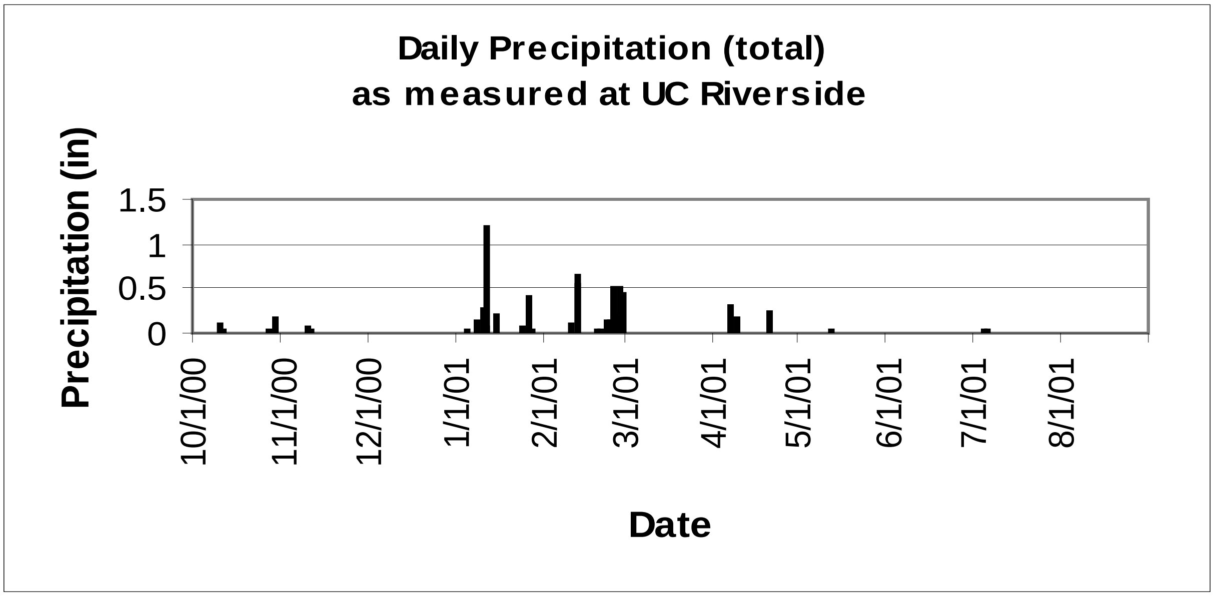
Reproduction in fishes is associated with environmental cues. Most often these cues involve rainfall, stream flow, day length, temperature *etc.*

The following tables and graphs summarize potential environmental correlates. Although one year's data will be insufficient to discern a pattern, these data lay the groundwork for the collection of future data. The data is self explanatory and presented in tabular and graphical form.

## A. Rainfall.

Table 20. NOAA rainfall data as measured at the U.C. Riverside Citrus Experimental Station. Rainfall is expressed in inches. Gray cells indicate that data was unavailable.

| | 2000 | | | 2001 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jly | Aug |
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | 0.01 | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 0.03 | | | | | | 0.04 | |
| 6 | | | | | | | | | | 0.02 | |
| 7 | | | | | 0.01 | | 0.31 | | | 0.01 | |
| 8 | | | | 0.15 | | | | | | | |
| 9 | | | | 0.01 | | | 0.17 | | | | |
| 10 | 0.11 | 0.07 | | 0.26 | 0.09 | | | | | | |
| 11 | 0.04 | 0.03 | | 1.21 | | | | | | | |
| 12 | | | | 0.06 | 0.66 | | | 0.04 | | | |
| 13 | | | | | 0.55 | | | | | | |
| 14 | | | | 0.01 | | | | | | | |
| 15 | | | | 0.22 | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | 0.04 | | | | | | |
| 20 | | | | | 0.02 | | | | | | |
| 21 | | | | | | | 0.23 | | | | |
| 22 | | | | | | | | | | | |
| 23 | | | | | 0.14 | | | | | | |
| 24 | | | | 0.08 | 0.15 | | | | | | |
| 25 | | | | | 0.51 | | | | | | |
| 26 | 0.01 | | | 0.42 | 0.22 | | | | | | |
| 27 | 0.04 | | | 0.02 | 0.50 | | | | | | |
| 28 | | | | | 0.46 | | | | | | |
| 29 | 0.17 | | | | | | | | | | |
| 30 | 0.05 | | | | | | | | | | |
| 31 | | | | | | | | | | | |
| Total | 0.42 | 0.10 | 0 | 2.47 | 3.35 | | 0.71 | 0.05 | 0 | 0.07 | 0 |

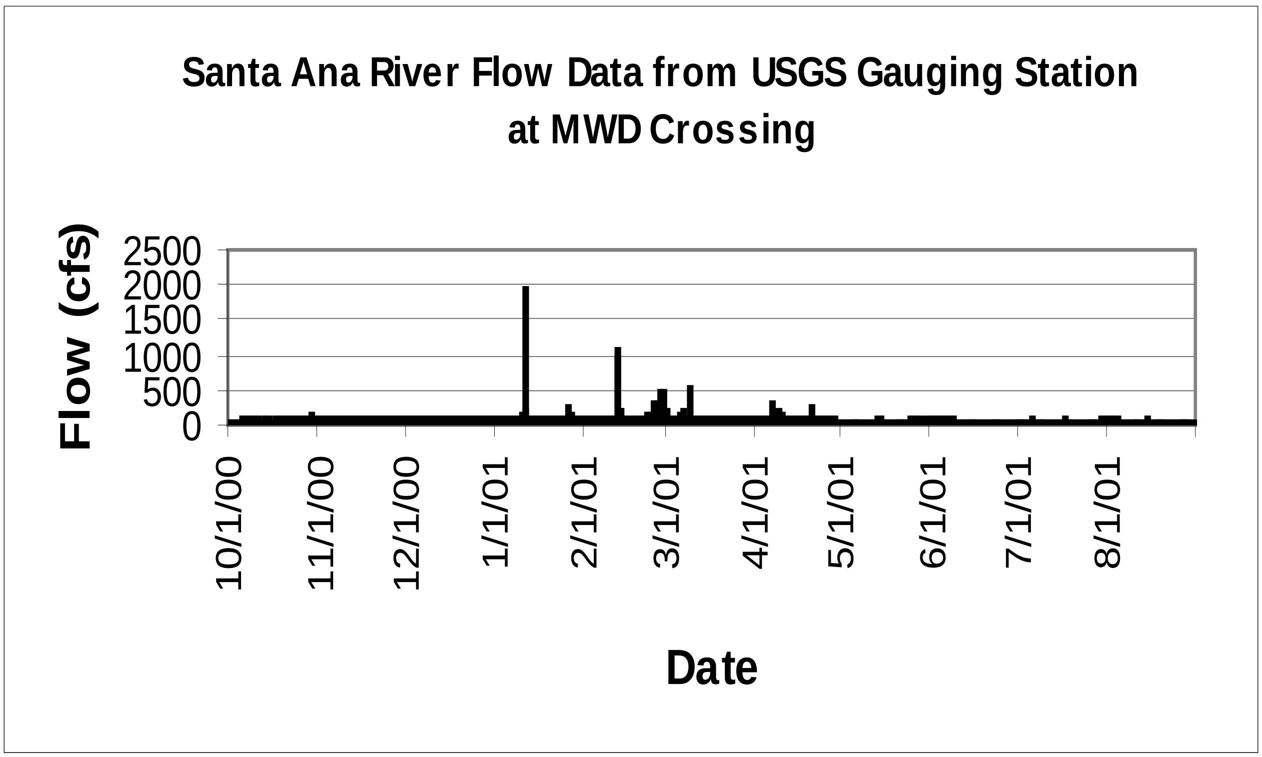



**B. Streamflow Data**

Table 21. Stream flow data from MWD Crossing supplied by Carmen Burton (USGS)

| | 2000 | | | 2001 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jly | Aug |
| 1 | 80 | 98 | 103 | 95 | 105 | 210 | 94 | 79 | 85 | 74 | 84 |
| 2 | 80 | 84 | 100 | 88 | 92 | 117 | 93 | 79 | 91 | 71 | 87 |
| 3 | 81 | 102 | 98 | 91 | 82 | 109 | 90 | 75 | 101 | 72 | 83 |
| 4 | 81 | 99 | 97 | 92 | 95 | 103 | 95 | 75 | 90 | 71 | 87 |
| 5 | 97 | 97 | 92 | 93 | 88 | 111 | 97 | 77 | 88 | 75 | 83 |
| 6 | 116 | 94 | 95 | 88 | 93 | 163 | 92 | 76 | 88 | 83 | 75 |
| 7 | 100 | 85 | 101 | 89 | 98 | 233 | 303 | 76 | 90 | 77 | 76 |
| 8 | 99 | 97 | 100 | 98 | 102 | 111 | 127 | 77 | 84 | 69 | 75 |
| 9 | 99 | 100 | 94 | 111 | 101 | 93 | 216 | 79 | 86 | 69 | 76 |
| 10 | 100 | 97 | 100 | 145 | 104 | 549 | 189 | 75 | 77 | 69 | 73 |
| 11 | 104 | 104 | 102 | 1960 | 104 | 125 | 105 | 75 | 76 | 63 | 78 |
| 12 | 77 | 101 | 102 | 244 | 1070 | 105 | 97 | 80 | 77 | 69 | 72 |
| 13 | 101 | 101 | 101 | 127 | 981 | 121 | 93 | 83 | 77 | 65 | 80 |
| 14 | 98 | 98 | 98 | 110 | 199 | 92 | 101 | 75 | 74 | 78 | 77 |
| 15 | 98 | 97 | 98 | 110 | 120 | 90 | 88 | 87 | 74 | 74 | 88 |
| 16 | 79 | 99 | 101 | 110 | 95 | 97 | 99 | 80 | 71 | 81 | 76 |
| 17 | 94 | 100 | 105 | 108 | 100 | 89 | 95 | 78 | 74 | 88 | 74 |
| 18 | 94 | 101 | 109 | 96 | 95 | 87 | 101 | 64 | 61 | 73 | 67 |
| 19 | 95 | 106 | 107 | 92 | 93 | 93 | 109 | 60 | 64 | 76 | 72 |
| 20 | 92 | 101 | 107 | 90 | 125 | 84 | 105 | 59 | 65 | 70 | 65 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 97 | 106 | 107 | 88 | 114 | 100 | 256 | 57 | 68 | 68 | 69 |
| 22 | 96 | 99 | 106 | 91 | 105 | 106 | 96 | 70 | 73 | 58 | 60 |
| 23 | 95 | 102 | 103 | 93 | 164 | 116 | 93 | 69 | 72 | 71 | 56 |
| 24 | 92 | 107 | 105 | 112 | 162 | 97 | 90 | 70 | 72 | 73 | 64 |
| 25 | 84 | 98 | 102 | 114 | 315 | 107 | 92 | 82 | 70 | 58 | 64 |
| 26 | 94 | 101 | 99 | 271 | 340 | 101 | 86 | 89 | 67 | 64 | 63 |
| 27 | 100 | 98 | 97 | 157 | 467 | 93 | 92 | 92 | 68 | 73 | 66 |
| 28 | 94 | 105 | 99 | 129 | 493 | 98 | 84 | 86 | 63 | 76 | 64 |
| 29 | 95 | 114 | 94 | 125 | | 102 | 88 | 81 | 70 | 76 | 67 |
| 30 | 142 | 101 | 96 | 109 | | 101 | 81 | 80 | 74 | 85 | 68 |
| 31 | 101 | | 102 | 107 | | 98 | | 85 | | 86 | 72 |
| Mean | 95.13 | 99.73 | 100.65 | 175.26 | 217.93 | 125.84 | 114.90 | 74.19 | 76.33 | 72.74 | 72.94 |



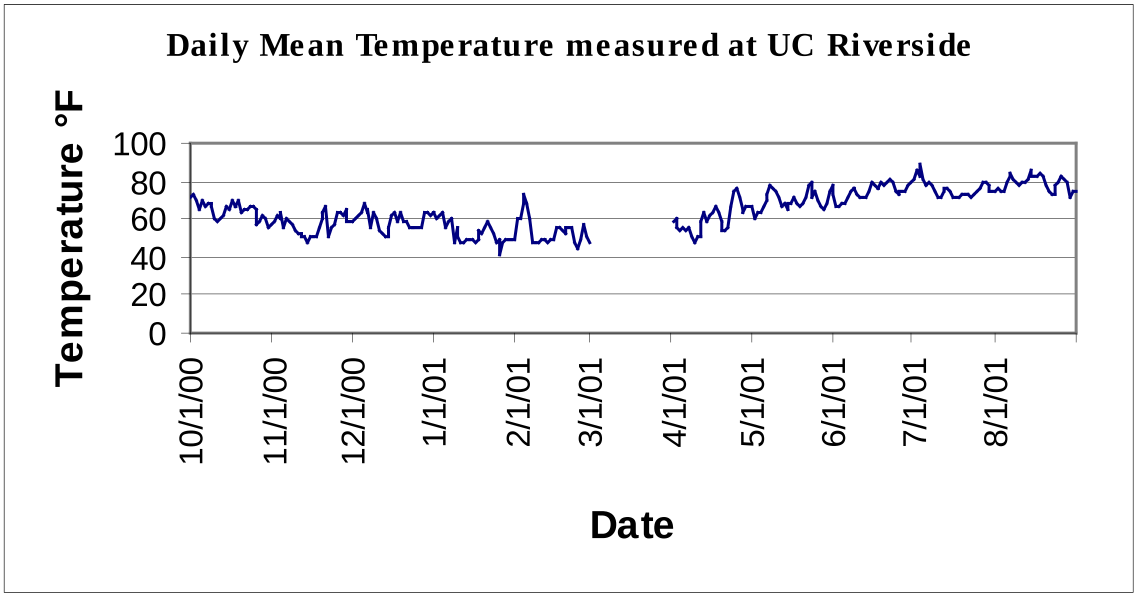
## C. Air Temperature Data.

Table 22. NOAA temperature data from the U.C. Riverside Citrus Experimental Station. Note that data from March are not available. Mn is the daily minimum temperature, Mx is the daily maximum temperature, and Me is the daily mean temperature. The mean daily minimum, daily maximum and daily mean for the month is provided in the last row of the table.

| Day | 2000 | | | | | | | | | 2001 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | October | | | November | | | December | | | January | | | February | | | March | | |
| | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me |
| 1 | 56 | 88 | 72 | 42 | 76 | 59 | 43 | 74 | 59 | 46 | 81 | 64 | 48 | 74 | 61 | | | |
| 2 | 57 | 89 | 73 | 45 | 79 | 62 | 43 | 78 | 61 | 43 | 78 | 61 | 43 | 79 | 61 | | | |
| 3 | 58 | 82 | 70 | 46 | 76 | 61 | 41 | 82 | 62 | 42 | 81 | 62 | 49 | 87 | 68 | | | |
| 4 | 60 | 70 | 65 | 49 | 78 | 64 | 44 | 81 | 63 | 44 | 83 | 64 | 55 | 90 | 73 | | | |
| 5 | 57 | 82 | 70 | 41 | 69 | 55 | 53 | 85 | 69 | 43 | 66 | 55 | 50 | 86 | 68 | | | |
| 6 | 62 | 70 | 66 | 53 | 67 | 60 | 51 | 77 | 64 | 42 | 74 | 58 | 48 | 74 | 61 | | | |
| 7 | 62 | 74 | 68 | 47 | 69 | 58 | 51 | 78 | 65 | 46 | 74 | 60 | 37 | 56 | 47 | | | |
| 8 | 55 | 80 | 68 | 40 | 74 | 57 | 48 | 63 | 56 | 42 | 54 | 48 | 34 | 59 | 47 | | | |
| 9 | 55 | 77 | 66 | 40 | 68 | 54 | 56 | 69 | 63 | 43 | 66 | 55 | 34 | 61 | 48 | | | |
| 10 | 53 | 69 | 61 | 44 | 61 | 53 | 53 | 66 | 60 | 42 | 59 | 51 | 40 | 58 | 49 | | | |
| 11 | 50 | 65 | 58 | 43 | 62 | 53 | 42 | 66 | 54 | 42 | 51 | 47 | 40 | 59 | 50 | | | |
| 12 | 49 | 72 | 61 | 35 | 66 | 51 | 44 | 61 | 53 | 41 | 53 | 47 | 45 | 52 | 49 | | | |
| 13 | 45 | 79 | 62 | 33 | 69 | 51 | 36 | 65 | 51 | 35 | 62 | 49 | 43 | 52 | 48 | | | |
| 14 | 47 | 85 | 66 | 32 | 63 | 48 | 41 | 61 | 51 | 36 | 64 | 50 | 38 | 62 | 50 | | | |
| 15 | 47 | 82 | 65 | 35 | 67 | 51 | 42 | 67 | 55 | 41 | 56 | 49 | 38 | 62 | 50 | | | |
| 16 | 48 | 91 | 70 | 34 | 68 | 51 | 45 | 79 | 62 | 40 | 54 | 47 | 39 | 70 | 55 | | | |
| 17 | 50 | 83 | 67 | 37 | 65 | 51 | 42 | 83 | 63 | 40 | 58 | 49 | 41 | 68 | 55 | | | |
| 18 | 57 | 75 | 66 | 37 | 74 | 56 | 44 | 74 | 59 | 39 | 69 | 54 | 45 | 62 | 54 | | | |
| 19 | 57 | 83 | 70 | 36 | 85 | 61 | 46 | 80 | 63 | 34 | 70 | 52 | 43 | 62 | 53 | | | |
| 20 | 52 | 76 | 64 | 45 | 82 | 64 | 40 | 78 | 59 | 38 | 73 | 56 | 49 | 63 | 56 | | | |
| 21 | 58 | 71 | 65 | 49 | 84 | 67 | 40 | 76 | 58 | 43 | 75 | 59 | 42 | 68 | 55 | | | |
| 22 | 52 | 78 | 65 | 41 | 61 | 51 | 37 | 73 | 55 | 44 | 68 | 56 | 46 | 65 | 56 | | | |
| 23 | 53 | 78 | 66 | 39 | 71 | 55 | 39 | 72 | 56 | 37 | 68 | 53 | 41 | 52 | 47 | | | |
| 24 | 55 | 78 | 67 | 40 | 74 | 57 | 38 | 72 | 55 | 40 | 54 | 47 | 39 | 49 | 44 | | | |
| 25 | 51 | 78 | 65 | 41 | 85 | 63 | 43 | 68 | 56 | 37 | 62 | 50 | 45 | 54 | 50 | | | |
| 26 | 49 | 65 | 57 | 45 | 83 | 64 | 39 | 72 | 56 | 35 | 47 | 41 | 46 | 67 | 57 | | | |
| 27 | 52 | 65 | 59 | 45 | 79 | 62 | 35 | 77 | 56 | 39 | 54 | 47 | 45 | 57 | 51 | | | |
| 28 | 52 | 71 | 62 | 45 | 84 | 65 | 43 | 85 | 64 | 41 | 59 | 50 | 44 | 52 | 48 | | | |
| 29 | 53 | 67 | 60 | 43 | 73 | 58 | 40 | 87 | 64 | 42 | 58 | 50 | | | | | | |
| 30 | 46 | 66 | 56 | 41 | 74 | 58 | 42 | 81 | 62 | 37 | 62 | 50 | | | | | | |
| 31 | 42 | 71 | 57 | | | | 41 | 84 | 63 | 39 | 61 | 50 | | | | | | |
| Mean | 52.9 | 76.1 | 64.5 | 41.4 | 72.9 | 57.1 | 43.3 | 74.6 | 59.0 | 40.4 | 64.3 | 59.0 | 43.1 | 64.2 | 53.7 | | | |

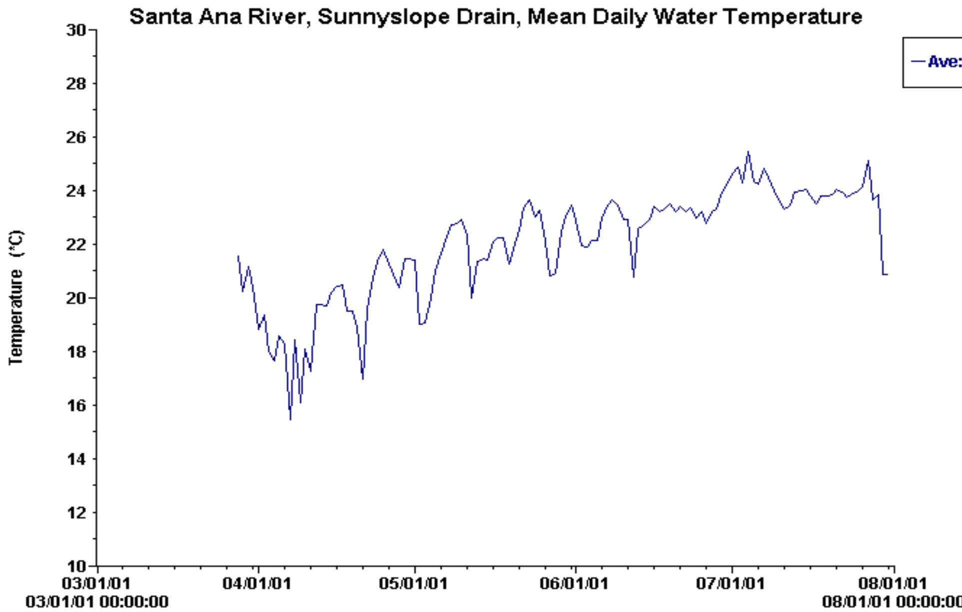
Table 22 (continued). NOAA temperature data from the Riverside Citrus Experimental Station. Note that data from March are not available. Mn is the daily minimum temperature, Mx is the daily maximum temperature, and Me is the daily mean temperature. The mean daily minimum, daily maximum and daily mean for the month is provided in the last row of the table.

| Day | 2001 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | April | | | May | | | June | | | July | | | August | | |
| | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me | Mn | Mx | Me |
| 1 | 55 | 63 | 59 | 50 | 84 | 67 | 60 | 85 | 73 | 64 | 97 | 81 | 59 | 88 | 74 |
| 2 | 53 | 69 | 61 | 53 | 66 | 60 | 60 | 72 | 66 | 66 | 103 | 85 | 60 | 92 | 76 |
| 3 | 48 | 62 | 55 | 46 | 81 | 64 | 60 | 74 | 67 | 67 | 96 | 82 | 58 | 92 | 75 |
| 4 | 48 | 60 | 54 | 46 | 82 | 64 | 57 | 78 | 68 | 75 | 103 | 89 | 55 | 95 | 75 |
| 5 | 46 | 65 | 56 | 48 | 84 | 66 | 52 | 83 | 68 | 69 | 93 | 81 | 59 | 101 | 80 |
| 6 | 43 | 65 | 54 | 49 | 90 | 70 | 55 | 89 | 72 | 68 | 87 | 78 | 63 | 100 | 82 |
| 7 | 47 | 62 | 55 | 53 | 93 | 73 | 58 | 91 | 75 | 65 | 92 | 79 | 66 | 101 | 84 |
| 8 | 39 | 62 | 51 | 57 | 99 | 78 | 59 | 92 | 76 | 62 | 92 | 77 | 66 | 96 | 81 |
| 9 | 39 | 56 | 48 | 58 | 94 | 76 | 59 | 92 | 76 | 60 | 88 | 74 | 62 | 96 | 79 |
| 10 | 40 | 62 | 51 | 56 | 92 | 74 | 56 | 90 | 73 | 58 | 86 | 72 | 60 | 95 | 78 |
| 11 | 44 | 58 | 51 | 54 | 90 | 72 | 56 | 86 | 71 | 55 | 88 | 72 | 62 | 97 | 80 |
| 12 | 48 | 70 | 59 | 58 | 74 | 66 | 60 | 83 | 72 | 53 | 94 | 74 | 62 | 95 | 79 |
| 13 | 51 | 76 | 64 | 59 | 78 | 69 | 60 | 81 | 71 | 57 | 95 | 76 | 64 | 97 | 81 |
| 14 | 43 | 75 | 59 | 49 | 81 | 65 | 53 | 96 | 75 | 59 | 92 | 76 | 66 | 103 | 85 |
| 15 | 48 | 75 | 62 | 52 | 83 | 68 | 58 | 99 | 79 | 60 | 88 | 74 | 63 | 103 | 83 |
| 16 | 47 | 79 | 63 | 53 | 84 | 69 | 58 | 97 | 78 | 58 | 85 | 72 | 62 | 101 | 82 |
| 17 | 44 | 88 | 66 | 56 | 85 | 71 | 55 | 97 | 76 | 54 | 88 | 71 | 63 | 103 | 83 |
| 18 | 51 | 77 | 64 | 59 | 78 | 69 | 56 | 96 | 76 | 55 | 88 | 72 | 66 | 102 | 84 |
| 19 | 47 | 69 | 58 | 58 | 76 | 67 | 60 | 99 | 80 | 56 | 89 | 73 | 66 | 98 | 82 |
| 20 | 43 | 65 | 54 | 55 | 81 | 68 | 58 | 96 | 77 | 56 | 89 | 73 | 63 | 92 | 78 |
| 21 | 46 | 61 | 54 | 58 | 85 | 72 | 61 | 99 | 80 | 56 | 90 | 73 | 59 | 88 | 74 |
| 22 | 39 | 72 | 56 | 59 | 96 | 78 | 63 | 98 | 81 | 55 | 91 | 73 | 59 | 86 | 73 |
| 23 | 45 | 88 | 67 | 60 | 99 | 80 | 62 | 97 | 80 | 55 | 88 | 72 | 56 | 90 | 73 |
| 24 | 53 | 96 | 75 | 59 | 85 | 72 | 56 | 92 | 74 | 58 | 87 | 73 | 58 | 95 | 77 |
| 25 | 57 | 94 | 76 | 61 | 89 | 75 | 57 | 89 | 73 | 59 | 89 | 74 | 60 | 98 | 79 |
| 26 | 61 | 83 | 72 | 62 | 77 | 70 | 58 | 89 | 74 | 57 | 94 | 76 | 63 | 101 | 82 |
| 27 | 52 | 78 | 65 | 59 | 72 | 66 | 57 | 90 | 74 | 60 | 97 | 79 | 61 | 100 | 81 |
| 28 | 53 | 72 | 63 | 58 | 72 | 65 | 56 | 92 | 74 | 61 | 98 | 80 | 60 | 97 | 79 |
| 29 | 53 | 80 | 67 | 58 | 80 | 69 | 59 | 94 | 77 | 61 | 92 | 77 | 58 | 85 | 72 |
| 30 | 49 | 85 | 67 | 55 | 92 | 74 | 61 | 97 | 78 | 62 | 87 | 75 | 58 | 90 | 74 |
| 31 | | | | 58 | 96 | 77 | | | | 59 | 88 | 74 | 56 | 92 | 74 |
| Mean | 47.7 | 72.2 | 60.0 | 55.4 | 84.5 | 69.9 | 58.0 | 90.4 | 74.2 | 60.0 | 91.4 | 75.7 | 61.1 | 95.8 | 78.4 |




**D. Water Temperature Data.**

SMEA placed water temperature loggers in Sunnyslope Drain, Rialto Drain and the mainstem Santa Ana River at mission Boulevard. The data below are only from the Sunnyslope Creek logger, and it failed so that only a short temporal dataset is available. The Rialto logger was lost when material was dumped along the edge of the drain, and the mainstem logger was buried by moving sand. Water temperature loggers will need to be set again in 2002.




**E. Discussion of the Environmental Correlates of Reproduction.**

With only one year's data as mentioned previously, it is difficult to say very much. However, a couple of simple observations can be made, and these can become hypotheses to be tested in 2002 and beyond. It is clear the sucker spawning took place during rising air and water temperatures, apparently after a minimum had been reached. Reproduction took place after the major rains and their associated flows. This is a typical pattern in fishes, which migrate to reproductive areas on the declining flows. This pattern is typical of some suckers. Thus, a weakly supported hypothesis can be generated that suggests that sucker migrate to their reproductive areas following the high winter flows, and spawning is triggered by rising temperatures.

## VIII. CONCLUSIONS.

At this point it is relevant to ask, "What do we know?" and "What do we think we know?"

**A. What we know.**

- 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.

- Based on Swift's (2001) data, and that collected by SMEA this year, suckers in the Santa Ana River breed from mid-March through late April based on the appearance of larvae.

- Santa Ana suckers can be successfully tagged with PIT tags.

**B. What we think we know.**

- SMEA's population estimate for Santa Ana sucker from about 600 meter 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, and with a flow of 0.20-0.24 m/sec.

- That 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.

## 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 the 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.

Figure 26. A young-of-the-year (YOY) Santa Ana sucker.

## X. PROGRAM TASKS FOR 2001/2002.

### TASK 1. Sucker Reproduction.

This Task involves collection of information to follow through on last year's results, and to collect information that may allow estimation of the degree to which fry production and survival is limiting recruitment. One Subtask to be included here is the creation of new reproductive habitat and an evaluation of the success of the effort. This Task will include some, but not all, of the following subtasks. Subtasks designated with an * are new tasks for 2001/2002.

| | |
|---|---|
| Subtask 1-1 | Determine timing of sucker reproduction.<br>Examine developmental readiness for reproduction at several localities. |
| Subtask 1-2 | Determine environmental correlates of reproduction.<br>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. Determine if reproduction is occurring in the mainstem. Include detailed characterization of specific egg-laying sites.<br>*****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 evaluate use of constructed habitat versus "natural" habitat. |
| Subtask 1-5 | *****Search for tagged individuals. A couple of attempts should be made to see if we can capture any of last year's tagged fish on the reproduction sites, focusing on Rialto Drain given the location of fish tagged previously. (All suckers captured during any Task will be checked for tags.) |
| Subtask 1-6 | *****Determine habitat characteristics where fry are found and compare to areas not used by fry. |
| Subtask 1-7 | *****Document fry growth at one or more sites. |
| Subtask 1-8 | *****Study fry drift.<br>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 from tributaries. |
| Subtask 1-9 | *****Batch mark fry to help determine movement. |

### TASK 2. Population Estimates and Migration.

This Task includes the annual population estimate, an activity that will be performed annually in order to track population size of the Santa Ana sucker. This Task also includes the study of population structure in order to evaluate recruitment, and the study of sucker movement in the Santa Ana River. Subtasks designated with an * are new tasks for 2001/2002.

| | |
|---|---|
| Subtask 2-1 | Refine protocols for population estimation. Focus only on sequential recapture and eliminate mark-recapture |
| Subtask 2-2 | Estimate population size in some occupied habitat. Use sequential depletion method as was done last year. |
| Subtask 2-3 | Determine population structure. Using data on age-length relationships, assess the year class composition of fish captured |
| Subtask 2-4 | Determine numbers of adults in breeding sites. Use surveys seining/snorkeling surveys to estimate the relative number of adults on the reproductive sites. |
| Subtask 2-5 | *****Compare population size from previous year |
| Subtask 2-6 | *****Begin to examine year class survival. This will be done by examining year class composition from this year's sample and comparing it to the year class composition of last year's sample. |
| Subtask 2-7 | Tag more individuals. Most tagging will occur in association with the population estimate. This task is for those unique opportunities such as accompanying the USGS riled team, or other field teams, to examine and tag the specimens they catch. |
| Subtask 2-8 | *****Determine if there is a breeding migration by examining for the presence of tagged fish in the breeding creeks early, before reproduction, then checking for them again following initiation of reproduction. |
| Subtask 2-9 | *****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 2-10 | *****Examine site fidelity in stream. Determine if fish tagged in the reproductive creeks stay there. |
| Subtask 2-11 | *****Sample sites to determine size frequency data at several sites in the Santa Ana River and in Santa Clara and San Gabriel (Santa Clara and San Gabriel at no cost – other work) |
| Subtask 2-12 | *Compare age structure to that of Santa Clara River based on historical SMEA data from other studies. |
| Subtask 2-13 | *Locate habitat used by juveniles. |

**TASK 3. Examine habitat preference and snorkeling surveys for generalized distribution data.**

This Task includes a snorkel survey that was initiated by Swift in 1999/2000, and continued as part of SMEA's 2000/2001 work. This Task would also initiate the collection of habitat preference data with the purpose of being able to design adult habitat in the mainstem Santa Ana River.

| | |
|---|---|
| Subtask 3-1 | *****Examine habitat preference in the Santa Ana River. Use the techniques developed on the San Gabriel River by SMEA personnel to identify and define preferred adult and juvenile habitat. |
| Subtask 3-2 | *****Compare data to SMEA data from the San Gabriel River. |

Subtask 3-3 *****Use habitat preference data to design instream modifications for implementation in 2002/2003.
Subtask 3-4 Use snorkeling surveys to determine distribution and relative abundance of suckers from Mission Avenue to RIX outflow.

**TASK 4. Administration, Data Management, Updates, and Reporting.**
This task includes all the project/data management and reporting activities.

Subtask 4-1 Meeting attendance
Subtask 4-2 *Interim reports
Subtask 4-3 Data management
Subtask 4-4 Data analysis
Subtask 4-5 Project management
Subtask 4-6 Plans for 2002/2003
Subtask 4-7 Prepare SMEA Final Report
Subtask 4-8 Input to Annual Report

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 6 OF THE CONSERVATION PROGRAM.

The year 6 implementation activities as currently envisioned are the year 5 activities outlined in the Conservation Plan (Baskin and Haglund 1999). Funding restrictions during year 1 and those anticipated in year 2 will result in a delay in completing the tasks as originally conceived. The primary focus in year 6 should be the evaluation of the success of created habitat, and the refinement of habitat design. This should be coupled with annual monitoring.

## XII. LITERATURE CITED.

Baskin, J.N. and T.R. Haglund. 2000. Santa Ana sucker survey/seining in the Santa Ana River. Unpubl report prepared for USACOE, Los Angeles District, under subcontract to Aspen Environmental Group. 8p.

Baskin, J.N. and T.R. Haglund. 2001. Survey for the Santa Ana sucker at the Van Buren bridge, Riverside County, California. Unpubl. report for the Riverside Co. Dept of Transportation, under subcontract to LSA Associates. 4p.

Bruton, M.N. and R.E. Boltt. 1975. Aspects of the biology of *Tilapia mossambica* Peters (Pisces: Cichlidae) in a natural freshwater lake (Lake Sibaya, South Africa). J. Fish Biol. 7:423-445.

Deinstadt, J.M., E.J. Pratt, F.G. Hoover and S. Sasaki. 1990. Survey of fish populations in southern California streams:1987. Calif. Dept. Fish and Game, Inland Fish. Div. Admin. Rpt. 90-1. 56p.

Drake, D.P. and S. Sasaki. 1987. West Fork San Gabriel River Los Angeles County, field study report. Unpubl. Report, Calif. Dept. Fish, Game. Inland Fisheries Branch, Long Beach.

Greenfield, D.W. 1973. Introgressive hybridization between *Gila orcutti* and *Herperoleucus symmetricus* (Pisces: Cyprinidae) in the Cuyama River basin, California. II: Ecological Aspects. Copeia 1973:417-427.

Greenfield, D.W., S.T. Ross, and D.G. Deckert. 1970. Some aspects of the life history of the Santa Ana Sucker, Catostomus (Pantosteus) santaanae (Snyder). *Calif. Fish Game* 56:166-179.

Harrington, R.W. and E.S. Harrington. 1961. Food selection among fishes invading a high subtropical salt marsh from the onset of flooding through the progress of a mosquito brood. Ecology 42:646-656.

Keast, A. 1966. Trophic relationships in the fish fauna of a small stream. Univ. Mich. Great Lakes Res. Div. Pub. 15:51-79.

Kennedy, T.B. and G.L. Vinyard. 1997. Drift ecology of western catostomid larvae with emphasis on Warner suckers, *Catostomus warnerensis* (Teleostei). Env. Biol. Fish. 49:187-195.

Lewis, W.M., G.E. Gunning, E. Lyles, and W.L. Bridges. 1961. Food choice of largemouth bass as a function of availability and vulnerability of food items. Trans. Amer. Fish. Soc. 90(3):277-280.

Man, H.S.H. and I.J. Hodgkiss. 1977. Studies on the ichthyofauna in Plover Cove Reservoir, Hong Kong: feeding and food relations. J. Fish. Biol. 11:1-13.

Miller, E.E. 1966. Yellow bullhead. p. 479-480. *In* A. Calhoun (ed.) Inland Fisheries Management, Calif. Dept. Fish, Game.

Moyle, P.B. 1976. *Inland Fishes of California*. University of California Press, Berkeley. 405p.

Nelson, J.S. 1994. *Fishes of the World*. John Wiley & Sons, Inc., New York. 600p.

Prentice, E.F., T.A. Flagg, C.S. McCutcheon. 1990a. Feasibility of using implantable Passive integrated transponder (PIT) tags in salmonids. Amer. Fish Soc. Symposium 7:317-322.

Prentice, E.F., T.A. Flagg, C.S. McCutcheon, D.F. Brastow, and D.C. Cross. 1990b. Equipment, methods, and an automated data-entry station for PIT tagging. Amer. Fish Soc. Symposium 7:335-340.

Saiki, M.K. 2000. Water quality and other environmental variables associated with variations in population densities of the Santa Ana sucker. Unpubl report to SAWPA from USGS/BRD, Western Fisheries Research Center. 117p.

Smith, G.R 1966. Distribution and evolution of the North American catostomid fishes of the subgenus Pantosteus, genus Catostomus. *Univ. Mich. Mus. Zool. Misc. Publ.* 129:1-33.

Snyder, J.O. 1908. Description of Pantosteus santa-anae, a new species of fish from the Santa Ana River, California. *Proc.U.S. Natl. Mus.* 59:23-28.

Swift, C.C. 2001. The Santa Ana sucker in the Santa Ana River: distribution, relative abundance, spawning areas, and the impact of exotic predators. Unpubl report to SAWPA from Larry Munsey International. 94p.

Swift, C.C., T.R. Haglund and M. Ruiz. 1990. Status of freshwater fishes of southern California with recommendations for preserves to maintain their existence. Unpubl. report Calif.Dept. Fish and Game, Inland Fish. Div. 215p.

Swift, C.C., T.R. Haglund and M. Ruiz. 1993. The status and distribution of the freshwater fishes of southern California. *Bull. Southern California Acad. Sci.* 92(3): 101-167.