The Status and Distribution of Unarmored Threespine Stickleback in the Angeles National Forest

2001 Final Report

Prepared for:

U.S. Forest Service, Angeles National Forest

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By Manna Warburton and Robert Fisher

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Introduction

In 2001, the U.S. Geological Survey / Biological Resources Discipline / Western Ecological Research Center was contracted to monitor the population of unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) (UTS) in San Francisquito Canyon in the Angeles National Forest by the US. Forest Service. In 1970 the unarmored threespine stickleback was listed as an endangered species. Historically found throughout Southern California, within Los Angeles County it is now restricted to a small portion of the upper Santa Clara River drainage (Bell, 1978). The decline of the stickleback is mainly attributed to channelization of stream habitat linked with urbanization. The remaining populations of this endangered fish still face many threats including urban development, dewatering and increased flows on habitat where they occur outside the boundaries of the forest and pollution, predation by non-native species and exotic diseases within the forest boundaries.

Our goals for this project were to:

1. Determine the distribution of UTS within the Angeles National Forest (***define the survey area***).

2. Assess techniques for detecting and quantifying UTS populations in order to develop a protocol for future monitoring (***standardize survey techniques***).

3. Determine the status of UTS populations where they were detected on Forest Service land (***implement a monitoring strategy***).

BRD biologists conducted multiple field surveys within available habitat in an effort to monitor stickleback where they occurred on Forest Service land. During these field surveys we detected populations of unarmored threespine stickleback in San Francisquito Canyon in two wetted portions of the canyon (except during high flow conditions, San Francisquito Canyon is not continuously wetted). Additional populations of UTS within the Santa Clara River system are known from Escondido and Soledad Canyon. Because these populations did not occur within the Forest boundaries they were not included in this report. A separate population of partially armored threespine stickleback (*Gasterosteus aculeatus microcephalus*) from Bouquet Canyon was detected as well. This population was of less interest because of its status as an introduced species within the drainage and was therefore also excluded from the report.

Materials and Methods

Survey Area

In order to assess the extent of UTS occurrence on the Angeles National Forest we surveyed available stream habitat within the Santa Clara watershed within the forest boundaries. Streams surveyed included wetted portions of Bouquet Canyon, Elizabeth Lake Canyon, and San Francisquito Canyon (Table 1, Map 1). A survey of the Santa

Clara River done by Micheal Bell in 1975 detected UTS in San Francisquito Canyon, but he did not include Elizabeth Lake Canyon or Bouquet Canyon in his survey (Bell, 1978).

The survey locations within San Francisquito Canyon where UTS occurred are referred to as the "Dam Reach" and the "Drinkwater Reach". The Dam reach begins at the foundation of the broken Saint Francis dam and extends downstream for approximately 500 meters (Map 2). The Drinkwater reach begins at the outfall of the Drinkwater reservoir where it enters San Francisquito Canyon and can extend downstream from as little as 130 meters to approximately 2 kilometers depending on outfall rates from the reservoir and current weather conditions (Map 3). An additional wetted portion within San Francisquito Canyon that did not contain UTS but did posses appropriate habitat began near the Los Angeles Water and Power Powerhouse number one in Clearwater Canyon and extended for one kilometer up and downstream from the confluence with Clearwater (Map 4).

Table 1. Drainages Surveyed

Watershed	Site	Date	UTS detected
Santa Clara River	Bouquet Canyon	10/26/2001	No
Santa Clara River	Elizabeth Lake Canyon	10/25/2001	No
Santa Clara River	Soledad Canyon	10/26/2001	No*
Santa Clara River	San Francisquito Canyon	12/4/2000	Yes
Santa Clara River	San Francisquito Canyon	8/15/2001	Yes
Santa Clara River	San Francisquito Canyon	10/23/2001	Yes
Santa Clara River	San Francisquito Canyon	10/25/2001	Yes
Santa Clara River	San Francisquito Canyon	10/30/2001	Yes
Santa Clara River	San Francisquito Canyon	1/16/2002	Yes
Santa Clara River	San Francisquito Canyon	2/2/2002	Yes
Santa Clara River	San Francisquito Canyon	5/2/2002	Yes

*Forest Service portions of Soledad Canyon dry on survey date

Survey Techniques

In preparing to monitor UTS in San Francisquito Canyon, we discovered an information gap regarding which techniques would be best for monitoring. Specifically, there were no papers addressing the value of the available techniques in addressing the life history requirements of this sensitive native fish. Specific life history traits of stickleback that affect how surveys are conducted include territoriality and nesting behavior exhibited by male stickleback and the stickleback's annual lifecycle. In order to fill this gap and standardize methods for monitoring UTS, we tested several techniques on a population of partially armored stickleback in a different drainage prior to implementing them in San Francisquito Canyon. These techniques and their appropriateness under specific habitat conditions are discussed below in detail (Table 2).

Table 2. Monitoring / Survey Techniques and their utility under different habitat conditions and parameters

	Creek Condition							
Survey Type	**Wade-able**	**Non Wade-able**	**Surface Disturbed**	**Surface Calm**	**Clear**	**Turbid**	**Is the Technique Quantifiable**	**Does the Technique involve Potential Take**
Electro-fishing	yes	no	yes	yes	yes	yes	yes	yes
Seining	yes	no	yes	yes	yes	yes	yes	yes
Minnow Trapping	yes	yes	yes	yes	yes	yes	yes	yes
Visual Survey	yes	yes	no	yes	yes	no	no	no

Electro-fishing surveys:

Electro-fishing is considered to be the most effective method for sampling fish communities in streams (Bagenal, 1978; Plafkin et al. 1989) although larger fish are more susceptible to capture than smaller ones (Reynolds, 1983). Electro-fishing effort is also readily quantifiable with shocking time recorded in seconds automatically by most shocking equipment. Electro-fishing has several drawbacks, including training requirements, potential hazards from electrical shock, the inability to sample non-wadeable stream environments and the potential to injure survey animals (Meador et al. 1993). As taken from the fish inventory module of the Sensitive Habitat Inventory and Mapping handbook:

> Electrofishing is generally considered to be the most reliable fish capture technique. It also has significant potential to harm individual fish. Therefore, good electrofishing techniques, professional judgment and common sense should be used when electrofishing. Where possible, use techniques other than electrofishing when conditions permit (e.g., seine nets in low gradient, uniform, fine substrate channel), and when two techniques must be used, use electrofishing second.

Electro-fishing for UTS:

Electro-fishing surveys are appropriate for the detection of unarmored threespine stickleback in wadeable freshwater environments, and they were employed when CDFG biologist Tim Hovey accompanied USGS personnel during surveys for UTS. In areas where stickleback are considered threatened or endangered, or there is a management concern for a given population, electro-fishing should be used in moderation. Shocker settings can dramatically influence mortality of shocked animals and should therefore only be employed by personnel experienced with the shocking equipment.

Seine net surveys:

Seining is an effective survey technique for freshwater fish monitoring of small-size fish species in stream environments (Meador et al. 1993). In such environments smaller fish are extremely susceptible to capture by seine nets. Seining in conjunction with electro-fishing surveys can be highly effective in detecting all or most of the species present within the survey area. Seining can also give limited information regarding species density when data is collected properly. In order to quantify seining and extrapolate population densities from data collected, the approximate area covered and the number and species of all fish captured by each seine haul must be recorded. Physical conditions within the survey area must also be appropriate. Complex substrates including bottoms composed of boulder and cobble and excessive woody material in the stream channel reduce seine haul catch success and in some cases catchability of certain species. However, soft aquatic vegetation can often work to the opposite effect and enhance catchability of animals within the survey area. Although highly effective, seining has the disadvantage of being fairly disruptive to the local habitat, and vigorous seining can cause short-term alteration of surveyed areas.

Seining for UTS:

Seine net surveys are appropriate for the detection of unarmored threespine stickleback in all freshwater environments, and they were employed during the survey and monitoring activities in San Francisquito Canyon and elsewhere. In areas where stickleback are considered threatened or endangered, or there is a management concern for a given population, seining indiscriminately can lead to take through habitat disturbance or trampling of nesting males. One way to minimize habitat disturbance is by restricting seining activities to late fall, when aquatic vegetation is reduced, and UTS are not engaged in breeding activities.

Minnow Trap Surveys:

Surveying by minnow trap is a relatively effective technique for freshwater fish monitoring in low flow environments (Mason & Knight, 2001). Traps by their very nature will exclude certain size classes of animals from detection, and the size of the focal animals must be kept in mind while choosing an appropriate trap. Traps also have the liability of potentially trapping aquatic air breathing animals and drowning them. In order to prevent this, traps must be set at the waterline in order to allow trapped animals the ability to breathe. An additional liability is that trapped aquatic animals are forced into close proximity and mortality can result (pers. obs.). This may be due to intraspecific predation or through interspecific aggression. The position of the trap within the microhabitat can greatly affect catch rates and it is difficult to estimate overall population density through trapping success. Because of the variable success of trapping and different susceptibility of species to trapping, absence data gathered in this manner is often unreliable. One advantage of trapping is the low level of disturbance caused by trapping activities. In areas where seining and visual surveys cannot be employed, trapping is a viable alternative.

Minnow Trapping for UTS:

Minnow trapping is an appropriate technique for the detection of unarmored threespine stickleback in freshwater environments. Its major drawback is that animals are forced into close proximity, and that interspecific aggression may cause mortality. In areas where stickleback are considered threatened or endangered, or there is a management concern for a given population, the chance of trap mortality may not be acceptable.

Visual Surveys:

Visual surveys can be highly effective tools for monitoring freshwater fish species under certain circumstances. However, if conditions are not appropriate for visual surveys, they can often lead to false negative conclusions regarding the presence of a specific species or to exclude species from detection during a survey. Physical and biological conditions that affect detectability of animals during surveys include water transparency or clarity, lighting conditions, vegetative cover in the water, density of the riparian community immediately adjacent to the stream channel and complexity of the substrate composing the channel. Any one of these factors or a combination of all can create conditions where visual surveys become inappropriate. Good indicators for the lack of appropriate conditions when conducting a survey are visual obscurement of the bottom of the stream channel for any reason. If the investigator cannot observe the channel bottom, he or she will likely be unable to observe fish in the area. When these conditions persist for greater than 50% of the survey area, additional sampling techniques should be employed. When conditions are optimal for visual surveys, i.e.: clear water, a lack of obscuring vegetation, and simple substrates, investigators should spend from 5 to 10 minutes at the beginning of the survey area getting acquainted with and developing a search image for the focal species. A good search image will enhance detection even when conditions become sub-optimal. However, for visual surveys to detect most or all species within a given area, a greater sample effort must be made, with more time spent at individual locations and more locations sampled. Different fish species have different swimming and behavioral patterns, and sitting quietly near a specific location for more than a few minutes will allow greater chances of detecting more cryptic species. As an addendum, dip netting in conjunction with visual surveys can often confirm the identity of fish observed, increasing the confidence of information supplied by visual surveys. Snorkel surveys are a type of visual survey that can be employed in waterways generally greater than a foot in depth and will provide enhanced detection of fish species.

Visual Surveys for UTS:

Visual surveys are appropriate for the detection of unarmored threespine stickleback in smaller (tertiary) stream systems. Stickleback swimming behavior consists of burst swimming upon disturbance followed by freezing in place on or near submerged refugia. This behavior makes visual identification fairly easy although when stickleback are disturbed, they often dive into the substrate, obscuring themselves in mud or algae (pers. obs.). This was the survey type most employed during monitoring activities in San Francisquito Canyon, and conditions for visual surveys were optimal throughout the survey season. Snorkel surveys were conducted in San Francisquito Canyon but were restricted to limited portions of the stream because the vast majority of the reach was too shallow to be suitable for such surveys.

Monitoring Strategy

In implementing the discussed techniques we first identified monitoring objectives as different survey techniques will address different management concerns as well as supply different information about a given population. The first monitoring objective was to identify the distribution or spatial extent of UTS on Forest land. The second objective was to assess the health of those populations that were detected. Population health was assessed through presence / absence within survey reaches and population density when available. The presence or absence of exotic aquatic organisms and invasive plant species was compared with UTS distributions on a microhabitat scale to assess reach habitat quality with regards to UTS. In monitoring the UTS population at San Francisquito Canyon, seining was the primary technique in areas where UTS did not overlap with California red-legged frogs (CRLF). In areas where UTS did share habitat with CRLFs, visual surveys were employed in an effort to minimize habitat disturbance. Intensive dip netting was also used to augment visual surveys, but as addressed above, only to confirm the identity of fish observed during these surveys. Although density estimates are valuable in assessing population health, the limited distribution of the species coupled with its co-occurrence with CRLFs prohibited the intensive seining required for such an endeavor.

Moribund specimens taken for parasite analysis were transported live to San Diego State University where they were examined. The methodology followed for parasite analysis of native and non-native fish in the Angeles National Forest is reported elsewhere (Warburton et al. 2002).

Results

In our assessment of sampling methodologies we came to the conclusion that all tested methods were appropriate under certain conditions. All four methods were employed in monitoring UTS in San Francisquito Canyon. Visual surveys were the primary method of surveying for UTS because environmental conditions were appropriate during most survey efforts and there were no potential take issues associated with this technique. Furthermore, visual surveys were appropriate for initial monitoring efforts when we were determining the extent of UTS occurrence on the Angeles National Forest. Seining was employed as a supplemental technique to provide quantitative estimates of population densities when environmental conditions were appropriate. Minnow traps were employed in areas where seining could not be employed. Samples of non-sensitive species were collected from all survey locations for parasite analysis. When moribund UTS were detected, they were also taken for parasite analysis. The employment of a variety of survey techniques enhanced our ability to detect fish and inventory available habitat. This was due to sample biases different techniques may have towards excluding certain size classes or species from detection (Mason & Knight, 2001). When multiple techniques are employed, sample biases of a single technique won't skew sample data.

Distribution of Unarmored Threespine Stickleback in Angeles National Forest:

Unarmored threespine stickleback were detected in San Francisquito Canyon at the Dam reach and the Drinkwater reach but they were not detected in the Power-Station reach. UTS were not detected at any other survey locations on Forest Service property. UTS were detected at all sites within the Dam and Drinkwater survey reaches. Although stickleback were detected at all sites within survey reaches, they were not detected on every visit to a given survey location and their distribution within each reach appeared to fluctuate over time and microhabitat condition. Factors that appeared to have an effect on distribution were presence / absence of exotic plant and animal species (giant reed, crayfish, green sunfish) and the extent of available wetted habitat, which fluctuated over time (increasing during the survey period).

Effective Survey Techniques:

A variety of survey techniques were employed and these techniques had varying levels of success in detecting UTS when they occurred (Table 3). Of the techniques employed (electro-fishing, seining, minnow trapping, visual surveys) only electro-fishing was successful in detecting UTS each time it was employed. Of the remaining techniques, visual surveys were most successful, and when employed in conjunction with seining, capable of detecting UTS at all but 1 survey location.

Overview of UTS in San Francisquito Canyon:

Dam Reach

Survey Date	**UTS detected (#surveyed/#detected)**	**Sites Surveyed (Map 2)**	**Disease**	**Exotic Species**	**Native Species**
12/4/2000	Yes (2/2)	1,2	Ich, Lernea, Bothriocephalus	GAAF, PRCL, LECY, CAAU	GIOR
8/15/2001	Yes (2/2)	2,4	Ich, Lernea	LECY	GIOR, RAAU, HYRE
10/30/2001	Yes (3/4)	2,3,4,5	Ich, Lernea	GAAF	GIOR
2/2/2002	Yes (3/5)	1,2,3,4,5	none observed	LECY	GIOR
5/2/2002	Yes (4/5)	1,2,3,4,5	none observed	none observed	GIOR, RAAU, HYRE

Drinkwater Reach

Survey Date	**UTS detected (#surveyed/#detected)**	**Sites Surveyed (Map 3)**	**Disease**	**Exotic Species**	**Native Species**
12/4/2000	Yes (1/1)	1	none observed	PRCL	none observed
8/15/2001	Yes (1/2)	1,2	Lernea	PRCL, LECY	GIOR
10/30/2001	Yes (2/4)	1,2,3,4	none observed	PRCL, LECY	GIOR
1/16/2002	Yes (1/1)	3	none observed	none observed	GIOR
5/2/2002	No (0/3)	1,2,3	none observed	LECY	GIOR

Four letter species codes:

CODE	**Scientific Name**	**Common Name**
GAAF	Gambusia affinis	mosquitofish
PRCL	Procambarus clarkii	crayfish
LECY	Lepomis cyanellus	green sunfish
CAAU	Carasius auratus	goldfish
GIOR	Gila orcutti	arroyo chub
RAAU	Rana aurora	California red-legged frog
HYRE	Hyla regilla	pacific treefrog

In San Francisquito Canyon we observed at least 8 parasite species infecting both native and exotic fish captured during surveys (Warburton, 2002). Because of the diverse and unexplored nature of parasite distributions, we report the incidence of the three parasites known to be exotic and of commercial significance. Parasites of commercial significance are capable of causing population level effects such as localized die-offs and or extinctions.

Discussion

Distribution of Unarmored Threespine Stickleback in Angeles National Forest:

Based on the current survey effort and a comparison with data from past surveys for stickleback in the Santa Clara River, San Francisquito Canyon appears to be the only remaining location where UTS occur on the Angeles National Forest (Bell, 1978; Swift et al. 1993). During years of high flow and continuous wetting, UTS may move into portions of Soledad Canyon that are within the Angeles National Forest boundaries. However, they are currently restricted to wetted portions outside of the Forest boundaries.

Effective Survey Techniques:

In a review of current sampling techniques we propose to continue monitoring UTS using a combination of visual surveys, seining and trapping. Seining is the preferred technique because of the ability to extrapolate population density estimates. However, seining should be restricted to periods outside the breeding season (April-July). During this period, sampling will continue to take place using traps to minimize disturbance of nesting males.

Status of UTS in San Francisquito Canyon:

The San Francisquito populations of this state and federally endangered species are threatened by human manipulation of surface water availability, the presence and spread of exotic species including a deliberate attempt by an unknown individual to seed the drainage with *Corbicula fluminea* (a small freshwater clam), and the presence of highly virulent exotic parasites.

The surveyed areas underwent dramatic changes during the two years we were conducting monitoring activities. Within the Dam reach we initially observed a system heavily loaded with both exotic fish and parasites. This condition changed over the course of a year to a situation under which adult fish of any species besides UTS were rare or undetectable. Following this observed depression in fish densities we observed CRLF egg masses, and surveys conducted in the second year of monitoring have revealed correspondingly high densities of CRLF tadpoles. Although not certain, we suspect disease played a factor in the observed fluctuations in fish species populations during the survey period. Within the Drinkwater reach we initially observed a system where UTS were present in very low densities and the available habitat was dominated by exotic species. During the survey period the Drinkwater reach increased in length and UTS took advantage of the situation, becoming abundant throughout the newly wetted reach. This situation did not persist though, and following an initial population increase, stickleback became less common over the course of the survey period. This may have been due to crayfish recruiting into the new habitat over time, as crayfish may prey on and exclude stickleback from habitats where they co-occur (pers. obs.).

Human activities appear to be having a dramatic effect on available surface water in the Drinkwater Reach. We attributed the increase in wetted stream reach to an increase in outfall from Drinkwater reservoir. This increase in available habitat has resulted in a rapid expansion of population size and distribution of UTS within this reach. However, this wetted habitat exists below several barriers to upstream migration and if the outfall rate from Drinkwater is reduced at some time in the future, it will result in take of UTS in the form of drying of occupied habitat. Surveys within the portions of this reach currently understood to be permanent show it to be occupied primarily by exotic aquatic species, while UTS are virtually undetected within these portions. This distribution makes the status of the Drinkwater reach population of UTS highly dependent on outfall from Drinkwater Reservoir.

Management Recommendations

Taking a view of the status of this animal that encompasses its distribution throughout southern California, we consider it to be highly imperiled and for which management action of some kind is required to insure its continued existence. Within San Francisquito Canyon, which may be one of the only protected habitats remaining, the population appears to be maintaining a stable distribution, although population densities appear to be fluctuating. There are several management actions that have the ability to positively affect stickleback populations in San Francisquito Canyon. These are as follows:

Monitoring of UTS in the future:

Because of the diverse issues facing UTS populations in San Francisquito Canyon, we propose to continue monitoring both the Dam and Drinkwater reaches using the techniques described above at two-month intervals. Monitoring would include visual surveys of the entire reach coupled with seining or trapping of named sites within the survey reach.

Exotic Animal Species Removal:

Exotic species removal activities could have a large impact on the viability of UTS and CRLF populations. We observed that green sunfish and crayfish excluded both red-legged frogs and UTS from pools they occupied. We also observed increased densities of CRLF tadpoles in environments where the exotic fish population was reduced through exotic species removal efforts. Continued exotic species removal within the dam reach would benefit both UTS and CRLFs. The outfall from Drinkwater reservoir is a potential source of exotic species introduction into the Drinkwater reach and there is currently little that could be done to change this. It may be possible to work with LAWP to insert mechanical barriers in an effort to prevent future introductions.

Exotic Plant Species Removal:

In visual surveys in San Francisquito Canyon in the Drinkwater reach, we observed that UTS were present in lower numbers or undetectable in areas of the drainage that possessed a vegetative component dominated by giant reed (*Arrundo donax*). Submerged aquatic vegetation was often excluded from reaches dominated by giant reed due to the thick canopy created by stands of the invasive weed. Submerged aquatic vegetation provides refugia, nesting substrate and may enhance forage for UTS. When this submerged aquatic vegetation component is missing, it may decrease habitat value for UTS, leading to local declines in population density. In addition we noted increased densities of exotic aquatic species that may potentially prey on UTS reaches dominated by giant reed, further degrading the value of this habitat for UTS. Based on these observations we recommend that Arrundo control efforts already taking place in the drainage be continued and enhanced if possible.

Transplantation Experiment:

During our surveys UTS were not detected within the Powerstation reach. The reach contained almost 2 kilometers of prime habitat, and although we have detected exotic species, habitat complexity throughout the reach is such that a significant portion of it may be useable by UTS. In order to expand the range of stickleback as well as ensure against local extinction, it may be advisable to transplant individuals from the downstream portions into this reach in an attempt to establish a third population of UTS within San Francisquito Canyon.

We recommend moving individuals from the downstream portion of the Drinkwater reach where they currently persist below barriers to upstream migration. It may be that we could salvage stranded animals if pools in the downstream reach begin to dry back in mid-summer. We would propose moving as many animals as could be recovered from these areas into the “Women’s Club” location of the Powerstation reach. This reach is heavily vegetated and the artificial manipulation of the stream channel in this location has created a large, slow moving pond that would be ideal for UTS.

Citations:

Bagenal, T. 1978. Methods for assessment of fish production in fresh waters: Oxford, Blackwell Scientific Publications, 365pp.

Bell, M.A. 1978. Fishes of the Santa Clara system, southern California. Contributions in Science. L.A. Co. Natural History Museum, 295, 20pp.

Mason, B., and R. Knight. 2001. Sensitive Habitat Inventory and Mapping. Community Mapping Network, Vancouver, British Columbia. M. Johannes, Editor. 315pp + viii.

Meador, M. R., T. F. Cuffney, and M. E. Gurtz. 1993. Methods for sampling fish communities as part of the national water-quality assessment program. U. S. Geological Survey, Open File Report. 93-104, iv + 40 pp. (revised 1998 or 1999)

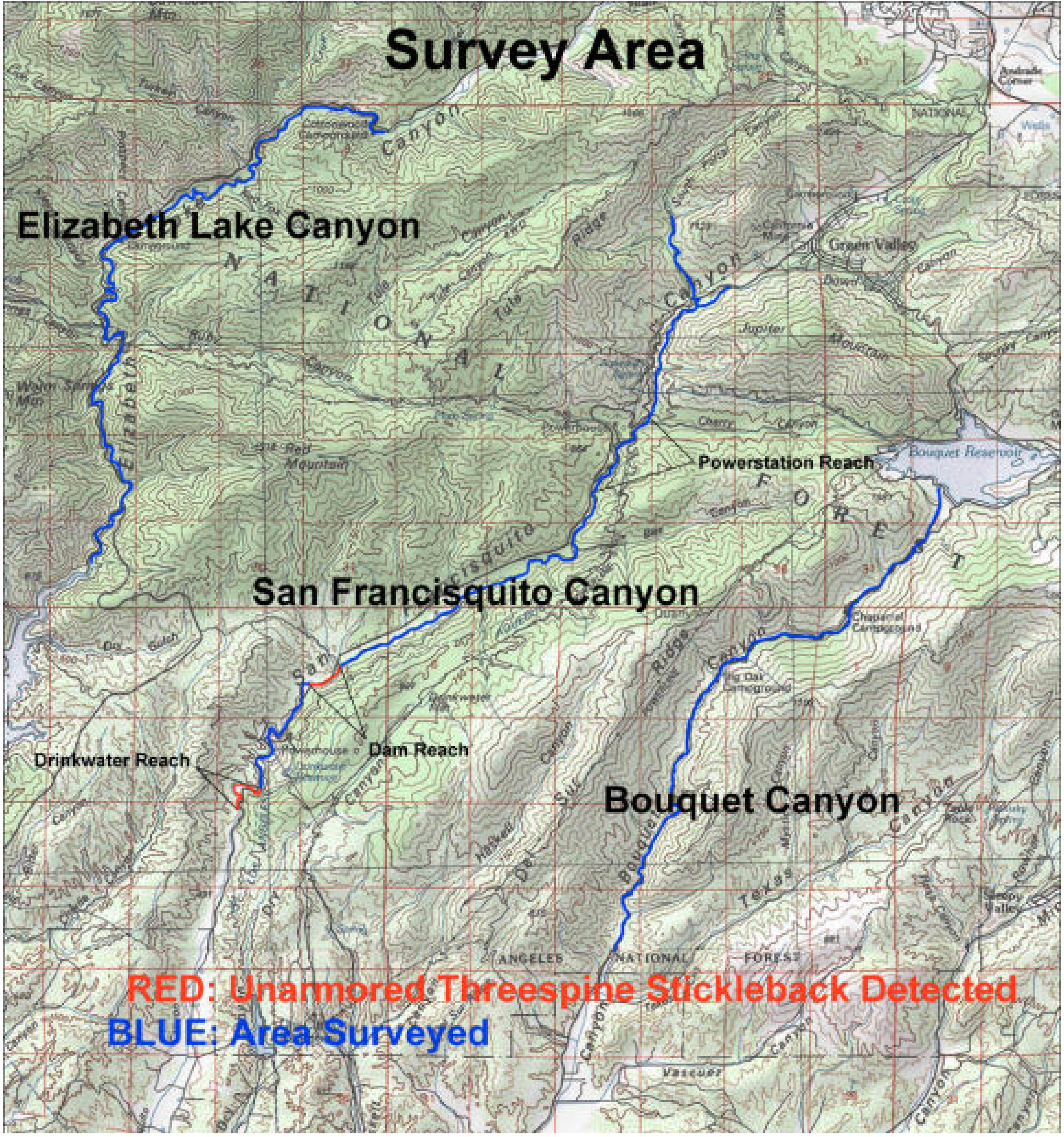
Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., and R.M. Huges. 1989. Rapid bioassessment protocols for use in streams and rivers: U.S. Environmental Protection Agency, EPA, 444pp.

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

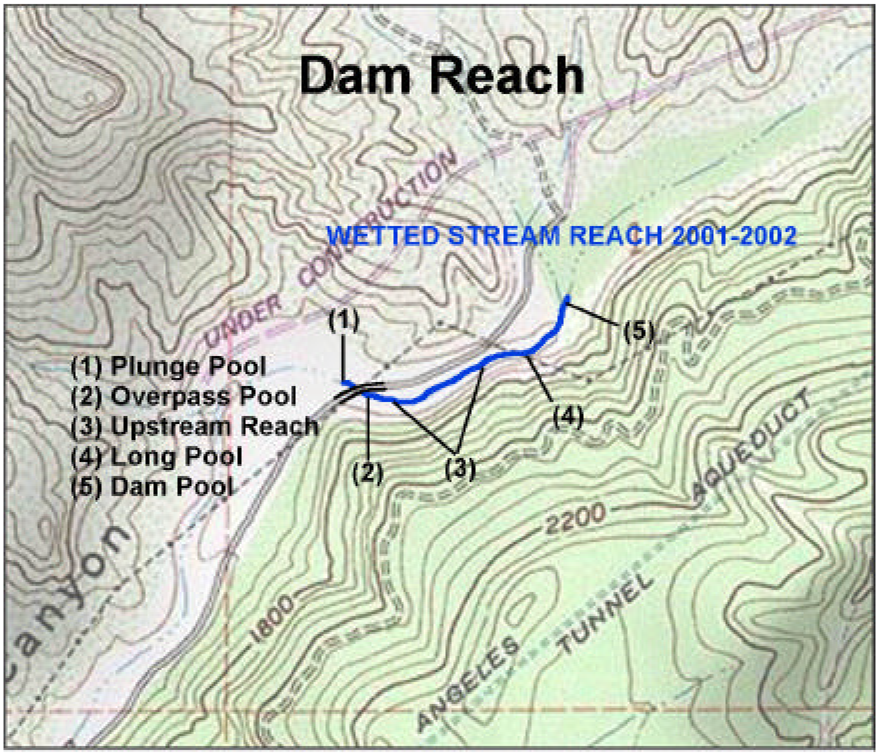
Warburton, M.L., Kuperman, B., Matey, V., and R.N. Fisher. 2002. Parasite analysis of native and non-native fish in the Angeles National Forest. U. S. Geological Survey, Open File Report. 16pp.

Appendix

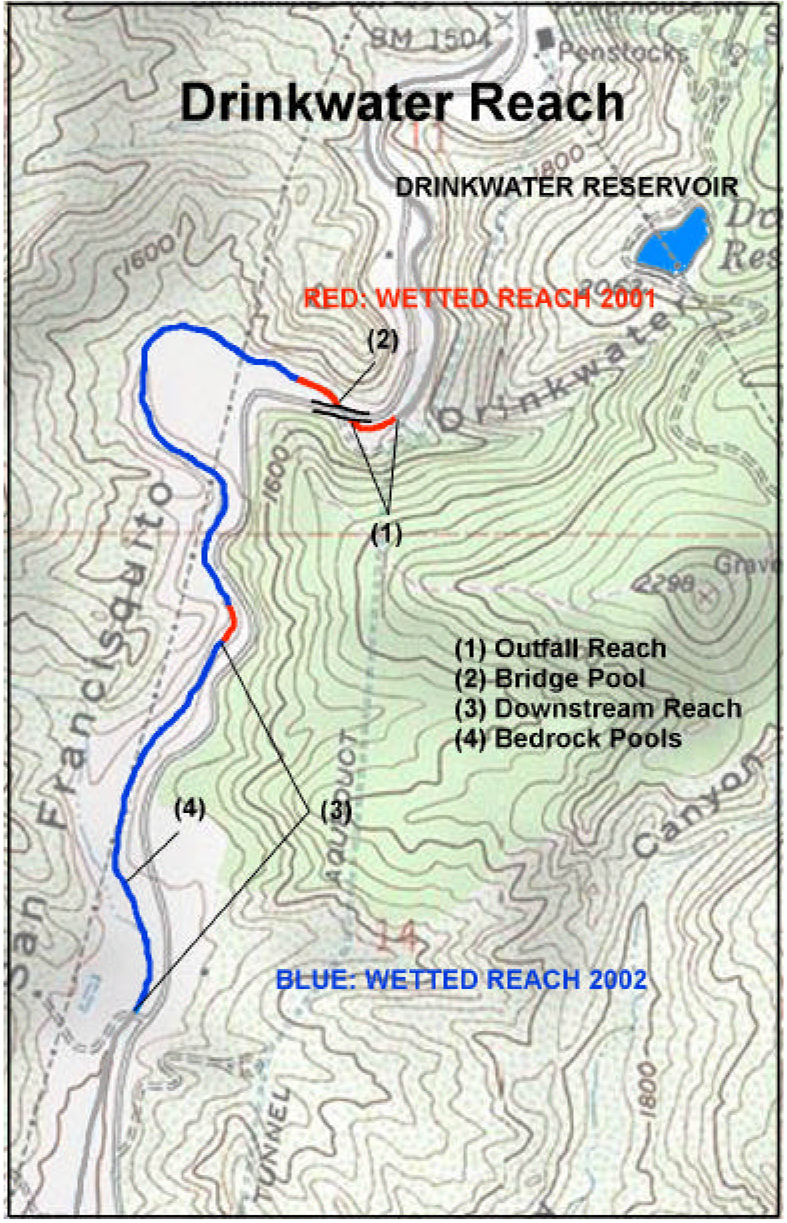
Map 1. Total Survey Area



Map 2. Dam Reach



Map 3. Drinkwater Reach



Map 4. Powerstation Reach

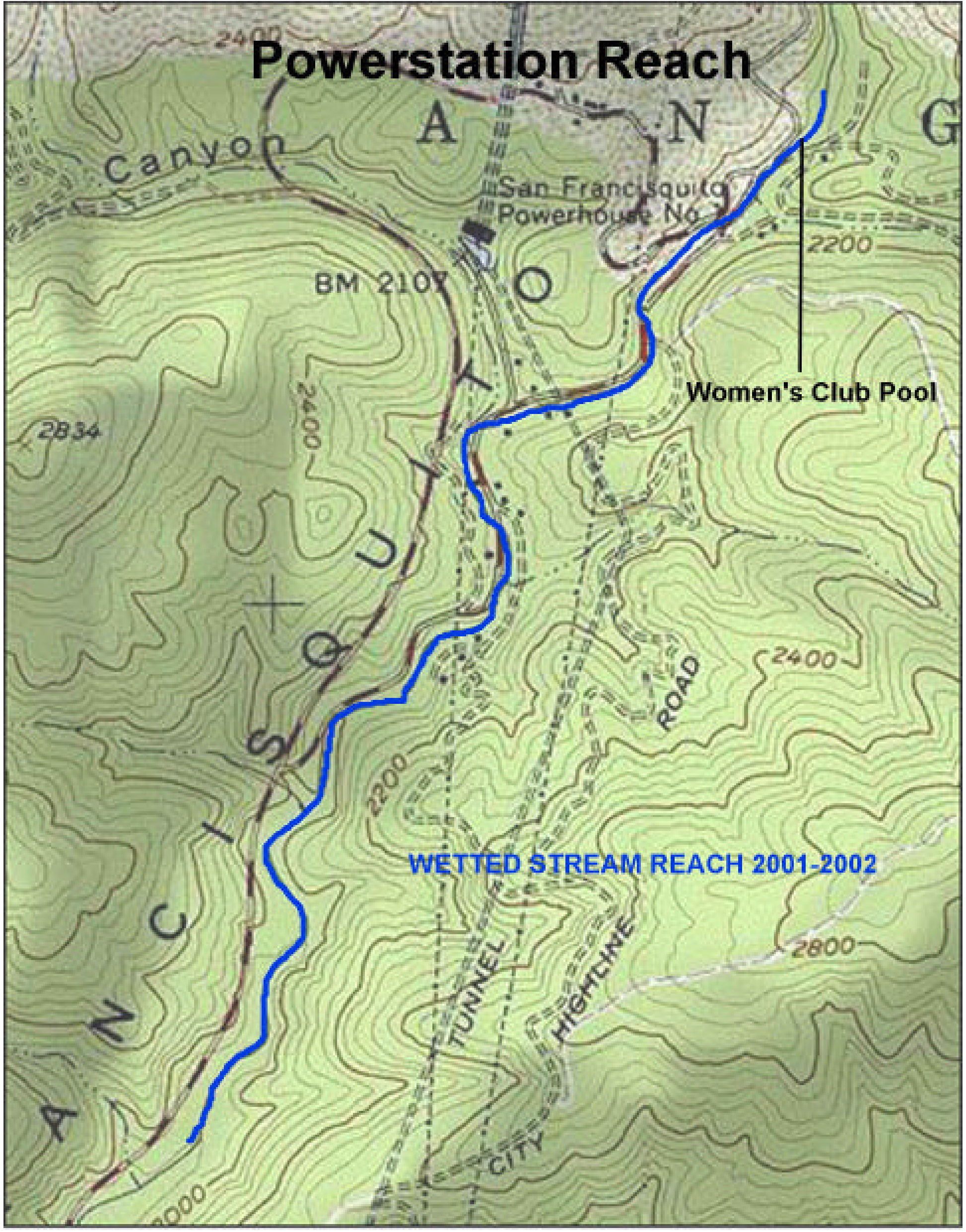


Table 3. Survey Techniques and Rates of Success

						Minnow Traps		Seine		Visual		Dipnetting		Electroshocking	
Drainage	**Reach**	**Site**	**Present?**	**# survey methods conducted**	**# survey methods found UTS**	**# conducted**	**# times detected**	**# conducted**	**# times detected**	**# conducted**	**# times detected**	**# conducted**	**# times detected**	**# conducted**	**# times detected**
Bouquet Canyon			N	2	0			1	0	1	0				
Elizabeth Lake Canyon			N	2	0			1	0	1	0				
San Francisquito Canyon	Powerstation Reach		N	2	0			1	0	1	0				
San Francisquito Canyon	Dam Reach	Dam Pool	Y	2	2	1	1			1	1				
San Francisquito Canyon	Dam Reach	Long Pool	Y	2	2	1	1	1	1						
San Francisquito Canyon	Dam Reach	Overpass Pool	Y	5	2	1	0	4	4	3	0	2	0	1	1
San Francisquito Canyon	Dam Reach	Plunge Pool	Y	5	2	1	0	1	0	1	0	1	1	1	1
San Francisquito Canyon	Dam Reach	Upstream Reach	Y	3	1	1	1			2	2	1	0		
San Francisquito Canyon	Drinkwater Reach	Bridge Pool	Y	2	1	1	0	5	1						
San Francisquito Canyon	Drinkwater Reach	Downstream Reach	Y	4	3	1	0	3	1	2	2	1	1		
San Francisquito Canyon	Drinkwater Reach	bedrock pools	Y	1	1			2	2						
San Francisquito Canyon	Drinkwater Reach	Outfall Reach	Y	3	1	2	0	5	0					1	1
						9	3	24	9	12	5	5	2	3	3
				Positive											
				Negative		33%		38%		42%		40%		100%	