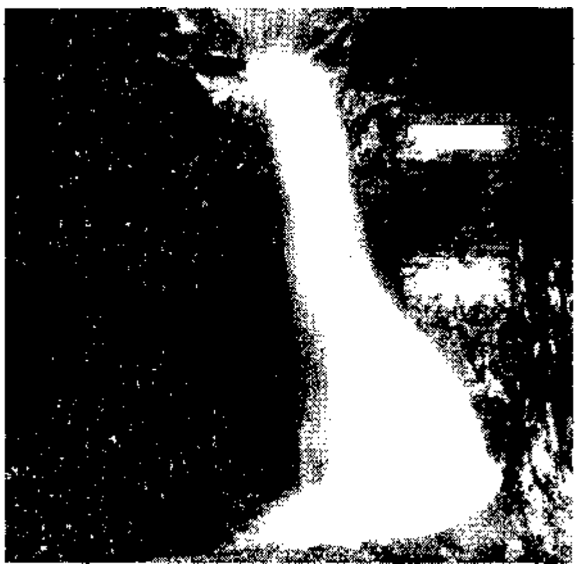
Feasibility Study to Rehabilitate the Fishery Resources of the Arroyo Corte Madera Del Presidio Watershed, Mill Valley California



May 31, 1995

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FEASIBILITY STUDY TO REHABILITATE THE FISHERY RESOURCES OF THE ARROYO CORTE MADERA DEL PRESIDIO WATERSHED, MILL VALLEY, CALIFORNIA

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I. INTRODUCTION

A. PROJECT AREA

The Arroyo Corte Madera del Presidio Watershed drains the east side of Mount Tamalpais and an approximately eight-square mile urbanized area which includes the City of Mill Valley and the unincorporated community of Homestead Valley. The main creek, Arroyo Corte Madera, is fed by tributaries streams, including Old Mill Creek, Reed Creek (flows through Homestead Valley), Widow Reed Creek (flows down East Blithedale Canyon), and Warner Creek. The headwaters of the Arroyo Corte Madera del Presidio Watershed lie in steep "V"-shaped canyons, with gently sloping terrain in the valley regions. The portion of creek which passes through downtown Mill Valley is partially covered over with building construction, roads, etc., and partially open.

B. BACKGROUND

As part of the Mill Valley Watershed Project, initiated in the summer of 1994, *A. A. Rich and Associates* conducted fish habitat and population surveys in the Arroyo Corte Madera del Presidio Watershed. As part of that project, I submitted Progress Reports, summarizing our studies, conclusions, and recommendations. Although, there are many components to a watershed, fishes, particularly trout (both the anadromous steelhead and resident rainbow), hold a special fascination for many people in Mill Valley, as they do elsewhere. In fact, one of the reasons the Mill Valley Watershed Project was formed was that the original financial backer was under the impression that there were no trout in the Mill Valley creeks and wanted to know what had happened to the trout and salmon which used to reside in these creeks and whether or not there was a way to restore these stocks. As there is such an interest in the trout, and, as there has been no previous quantitative fishery resources studies, I decided to write this more comprehensive report. Included in this report is a framework for further studies, public education, and citizen involvement. It is my hope that, with the use of scientific studies, as a basis for identifying cause-and-effect relationships in the restoration process, together with citizen participation, the creeks can be improved for both the fishes and the people of future generations.

I was raised in Mill Valley during the 1950's and 1960's. Although, the town has changed dramatically since that time, I have fond memories of what was, to me, a magical place in which to grow up. I grew up in a house my parents built at 410 Lovell Avenue, in the hills nestled against Mount Tamalpais. It has been a great joy for me to begin to study the creeks in which, as a child, I spent many a day catching unwary crayfish in "The Three Wells", using a string, "baited" with raw bacon, and observing the myriad of organisms, not the least of which were trout.

To begin, I will first discuss the use of this fish, the trout, as an *indicator species* of the health of the watershed.

C. SALMONIDS AS INDICATOR SPECIES OF A WATERSHED'S ECOLOGICAL HEALTH

Salmonids (trout and salmon) are the fish species of primary interest to the citizens of the Mill Valley Watershed. Both anadromous (fish which spawn in freshwater, are reared for a period of time in fresh water, emigrate to sea for several years, and return to their natal streams to spawn), and resident salmonids, inhabit the creeks. The anadromous steelhead and the resident rainbow trout *(Oncorynchus mykiss)* inhabit the creeks of the Mill Valley Watershed. In the past, and, on rare occasion in recent years, coho salmon *(Oncorhynchus kisutch)* have strayed into the watershed, as well; however, the existing habitat is not suitable for coho salmon. If creek conditions improve and coho salmon begin to reappear in significant numbers, then this species will be addressed, as well.

Biologists often use salmonids to assess the ecological well-being of creeks. The reason: salmonids are what are referred to as *indicator species* (McCarthy and Shugart, 1990). Salmonids respond more quickly to environmental perturbations than other fishes. Thus, the condition of salmonids and their habitat provide a good indication of the relative health of a creek. Salmonids are to fisheries biologists what the canary was to miners: *a warning sign.* The salmonid's response to its environment can provide an indication of the health (or lack of it) of the watershed ecosystem, before mankind's actions on the watershed affect mankind directly, just as the condition of the canary (i.e., death!) was used to assess poor air quality conditions in mines. Thus, salmonid health and salmonid habitat are *environmental harbingers* of events to come, if we do not remedy or remove the causative agent (s).

D. IMPORTANCE OF IDENTIFYING HABITAT REQUIREMENTS AND LIMITING FACTORS IN A FISH REHABILITATION PROJECT

Understanding the biological and physical factors which are necessary to sustain the fish populations in the Mill Valley Watershed is *critical* to developing management strategies to improve the habitat and enhance populations. Life history events for any organism must be discussed in concert with key *life requisites. Life requisites* are those features of an organism's environment which are essential to its continued survival and reproductive success. Critical life requisite variables for fishes include:

- *Accessibility to spawning sites;*
- *Adequate stream/lows;*
- *Acceptable water temperatures and water quality;*
- *Appropriate substrate composition; and,*
- *Abundant food.*

When *life requisites* are not met, or are *limited* in some way, the organism's survival and reproductive success can be jeopardized. The factors which *limit* fish populations are called *limiting factors.* One extremely important concept in enhancing fish populations is the following:

If there is no change in the limiting factors (s) for the population (s), no increase in the target population (s) will occur.

Some *limiting factors,* such as not enough woody debris (habitat which salmonids prefer and need), can be influenced by human intervention. Other *limiting factors,* such as the lack of water, often cannot be altered. Thus, at the onset of a fish rehabilitation project, one should identify the following:

- *The requirements of the fishes; and,*
- *Any Limiting Factors which may exist.*

If salmonid populations are limited by factors which are beyond human control, then the best fish management plan would be to keep the creek clean and as cool as possible. If, on the other hand, the *limiting factor(s)* appears to be controllable, or can be influenced positively by human intervention, then it is important to design both a *Rehabilitation Plan* and a *Monitoring Plan.* Such plans enable one to determine whether or not the Rehabilitation Project was successful. As each life stage of each fish species has specific life requirements, it is imperative to understand both the events of each life stage and the factors which affect those events.

The anadromous steelhead trout and coho salmon, and the resident rainbow trout require special conditions for successful spawning, egg development and hatching, growth and survival of juveniles, and smoltification (during which the anadromous fish change from a freshwater to a seawater animal, and emigrate to sea). Although, many general requirements (e.g., good water quality, abundant food, etc.) are the same for the steelhead and rainbow trout, specific factors may *limit production* (i.e., limit the number of fish in the stream). For example, barriers to adult fish immigration may limit the success of spawning for steelhead trout. Thus, it is essential to understand what creeks have to offer for each species and strain of fish, before undertaking any on-site rehabilitation efforts.

II. SCOPE OF WORK AND OBJECTIVES

A stream and its watershed function as a unit. In order for a fishery resources rehabilitation project to be successful, one must consider both the human uses and the biological needs of the area. There is a growing awareness among fisheries biologists that, in order to rehabilitate fish stocks, *watersheds* must be rehabilitated. For example, simply re-stocking damaged areas with hatchery-reared salmonids in areas of poor habitat does not restore runs. In fact, even in rehabilitated areas, continued stocking may lead to a further decline in populations, since biological diversity (i.e., genetic diversity) is reduced. Thus, streams must be rehabilitated in such a way as to improve habitat conditions.

Although the movement to rehabilitate and enhance salmonid (trout and salmon) runs has stimulated the implementation of thousands of projects in California, many conducted by volunteers, under the supervision of trained professionals, most of these projects have not been successful, or their success has been questionable (Rich, 1994; Duff and Wydowski, 1982). The problem: rehabilitation was implemented without pre-project scientific surveys or planning and without adequate post-project monitoring to determine whether or not the rehabilitation endeavor was successful.

In order to be successful, a fish rehabilitation project must include the following:

- Pre-project surveys, to assess existing conditions and identify *limiting factors;*
- A Fish Rehabilitation Plan which can be implemented in conjunction with land use practices;
- Implementation of the Rehabilitation Plan;
- A post-project monitoring effort; and,
- Community interest, education, and involvement.

Before one can rehabilitate a watershed, pre-project surveys must be conducted to collect baseline data and to identify any *limiting factors* which may exist. Without such data as benchmarks for describing existing conditions and identifying *limiting factors,* it is not possible to understand the relative impacts of implementing various rehabilitation plans. And, without such vital information, it is not possible to determine why rehabilitation was not successful. For example, let us suppose that *the factor* which limited trout production in the Mill Valley Watershed was the lack of water. If water were the *limiting factor,* there would not be much point in installing additional spawning gravel; the fish might be able to spawn, but if there were no water for the rearing phase of their life, the fish would not survive. Once *limiting factors* are identified, rehabilitation activities are planned and implemented, often with the help of interested citizens. Finally, to determine the relative success of the rehabilitation efforts, the results must be monitored over time.

Using the above guidelines, the general objective of this project was to address the feasibility of rehabilitating the Mill Valley Watershed, from the perspective of the fishery resources, particularly, trout. More specifically, the objectives of the project were to:

- Provide life stage and habitat information of the fishes;
- Provide a historical perspective of the fishery resources conditions;
- Assess the existing fishery resources conditions;
- Identify *limiting factor (s)* for fishery resources within the watershed; and,
- Identify what needs to be done in the future (i.e., studies, Enhancement projects, public involvement, education), for the continuation of a successful fish rehabilitation project.

By integrating the knowledge of what each fish species requires, with that of historical and existing conditions, we can determine whether or not the habitat requirements have been met in the Mill Valley creeks. From this information, we can identify the relative impact of each of the factors which have been contributing to the changes in the fish populations, and, over time, hopefully, remedy some of the problems.

III. LIFE HISTORY STAGES AND HABITAT REQUIREMENTS OF FISHES IN THE MILL VALLEY WATERSHED

A. SALMONIDS

The anadromous (an anadromous fish is one that begins life in a freshwater stream or river, migrates out to sea to grow and mature, and then returns to its natal stream or river to spawn) steelhead and the resident rainbow trout require special conditions for successful spawning, egg development and hatching, growth and survival of juveniles, and smoltification (during which steelhead trout change from a freshwater to a seawater animal and emigrate to sea). Although, many general requirements (e.g., good water quality, abundant food, etc.) are the same for the steelhead and rainbow trout, specific factors may *limit production* (i.e., limit the number of fish in the stream). For example, barriers to adult fish immigration may limit the success of spawning for steelhead trout. Thus, it is essential to understand what each creek has to offer for each strain of trout, before undertaking any on-site rehabilitation efforts.

1. Steelhead Trout

The steelhead trout *(Oncorhynchus mykiss)* is the anadromous form of the resident rainbow trout. Except for their ocean-going habits and larger spawning size, the steelhead trout is indistinguishable from their non-migratory counterparts, the rainbow trout (Utter et al., 1980; Thorgaard, 1983; Allendorf, 1975; Behnke, 1972; Needham and Card, 1959). Whether or not a particular stream supports an anadromous or resident trout population appears to be the result of local adaptation to geographic location. Steelhead and rainbow trout have well-developed homing abilities, and usually spawn in the same stream and area in which they lived as fry. Thus, local races of trout tend to develop that are adapted to local conditions.

Steelhead trout migrate to sea at various ages, spend varying amounts of time in the ocean (one to four years), and return to their natal stream to spawn. The life history information for the steelhead trout is divided into *five life stage* events, which include (Figures 1 and 2; Table 1):

- *Adult Immigration/Passage;*
- *Spawning;*
- *Egg/Alevin (yolk sac not absorbed) Incubation;*
- *Fry/Juvenile Rearing; and,*
- *Juvenile Smoltification/Emigration.*

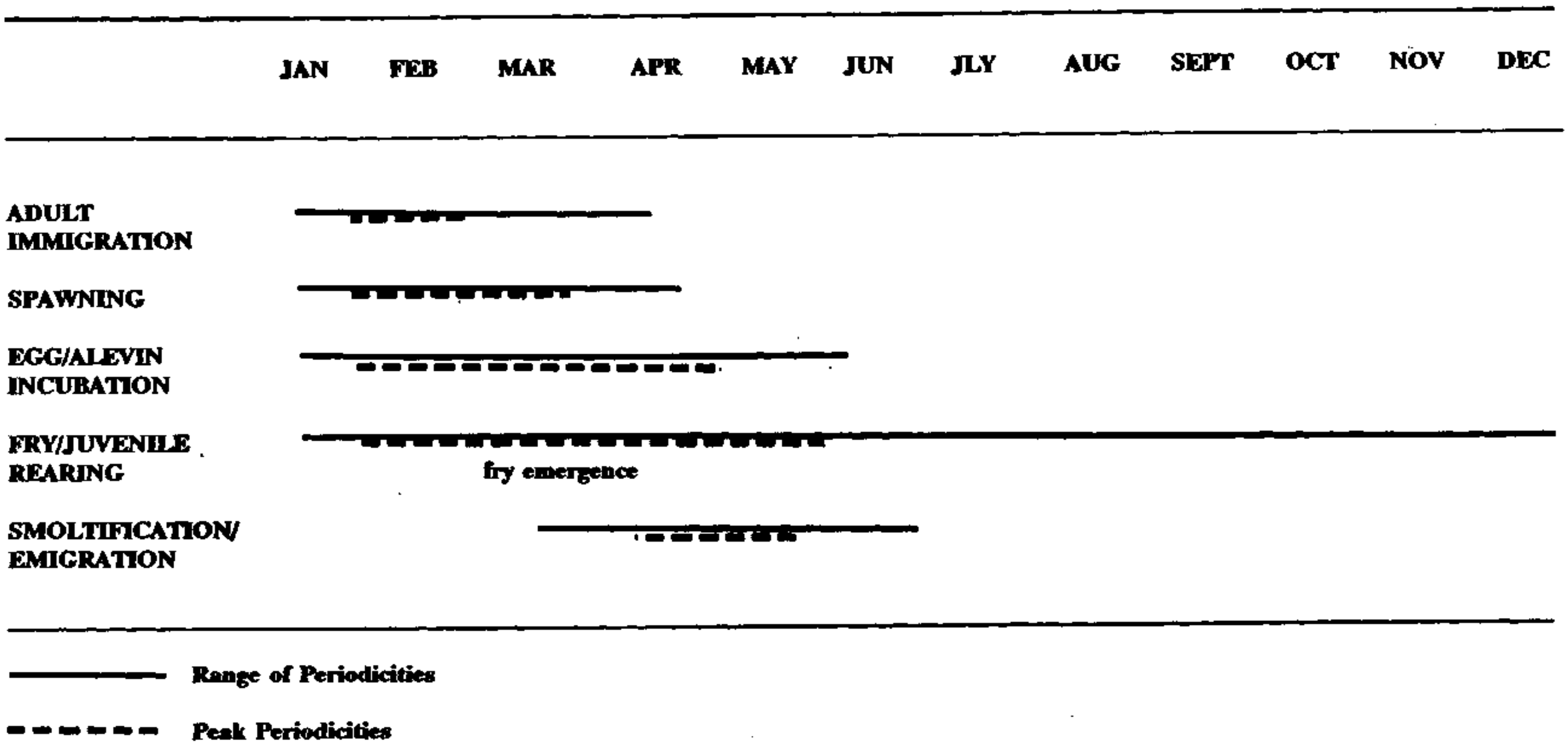

FIGURE 1. STEELHEAD TROUT LIFE STAGE PERIODICITIES

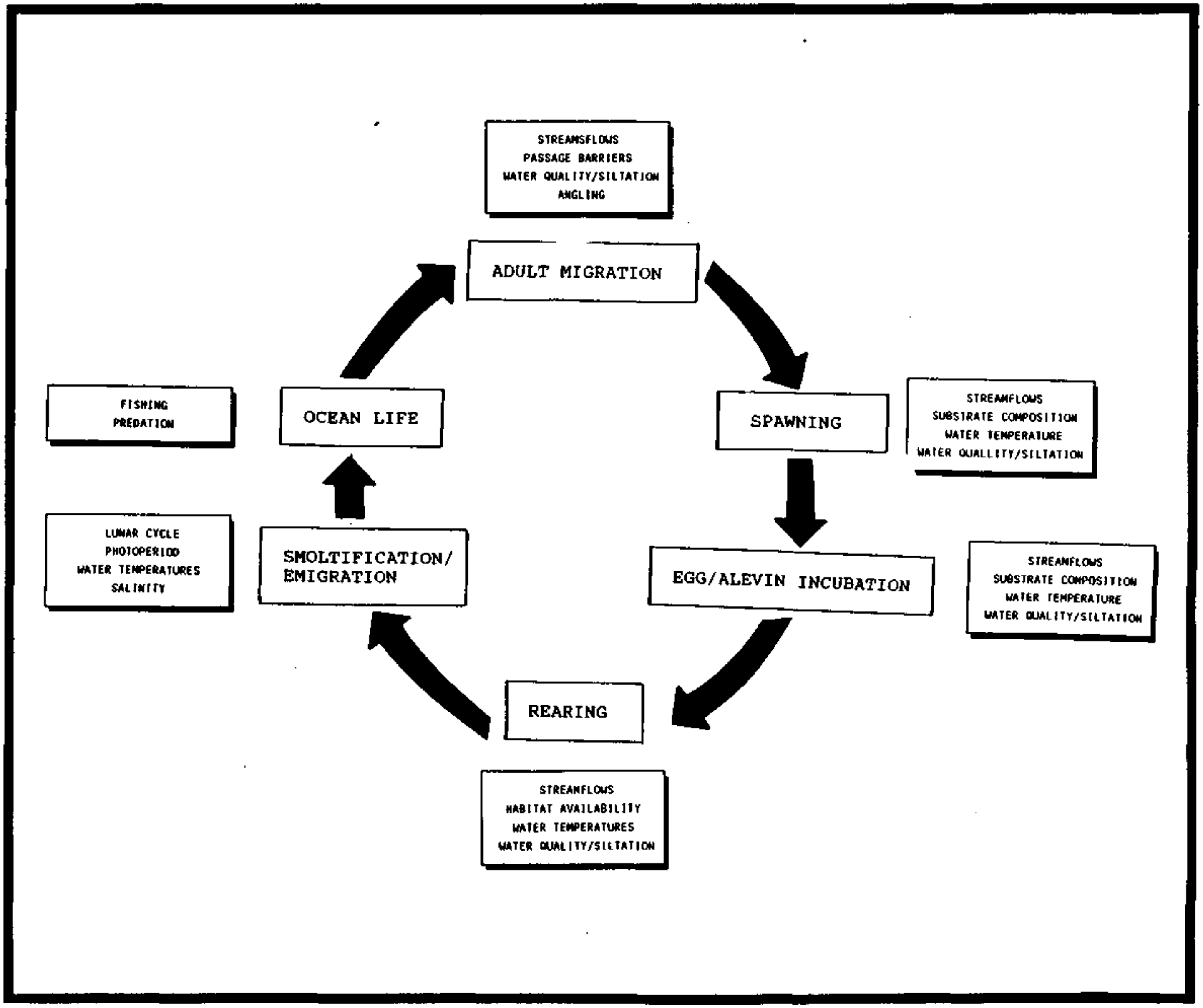

FIGURE 2. LIFE HISTORY STAGES AND FACTORS WHICH AFFECT TROUT

TABLE 1. HABITAT REQUIREMENTS FOR STEELHEAD TROUT

LIFESTAGE	TEMPERATURE PREFERENCE	DISSOLVED OXYGEN (Mg/l)	pH	WATER DEPTH	WATER VELOCITY	SUBSTRATE SIZE
INCUBATION AND PASSAGE	7.8 – 11.2 ºC 46.0-52.0 ºF	≥7 at ≤ 15 ºC ≥ 9 at > 15 ºC	7-8	> 18.3 Cm > 0.6 Ft	< 74.4 Cm/Sec < 2.4 Ft/Sec	N/A
SPAWNING	7.8 -11.2 º C 46.0-52.0 ºF	≥7 at ≤ 15 ºC ≥ 9 at > 15 ºC	7-8	> 24.4 Cm > 0.8 Ft	39.6-91.4 Cm/Sec 1.3 - 3.0 Ft/Sec	1.3 – 10.1 Cm 0.5- 4.0 In
INCUBATION	7.8 - 11.2 ºC 46.0 - 52.0 ºF	≥ 7 at ≤ 15 ºC ≥ 9 at > 15 ºC	7-8	> 3.0 Cm > 0.1 Ft	< 182.9 Cm/Sec < 6.0 Ft/Sec	1-3 - 10.1 Cm 0.5 - 4.0 In
FRY EMERGENCE	8.9 – 11.2 ºC 48.0-52.0 ºF	≥ 7 at ≤ 15 ºC ≥ 9 at > 15 ºC	7-8	> 3.0 Cm > 0.1 Ft	< 182.9 Cm/Sec < 6.0 Ft / Sec	1.3 – 10.1 Cm 0.5- 4.0 In
REARING	12.8 - 15.6 ºC 55.0 - 60.1 ºF	≥ 7 at ≤ 15 ºC ≥ 9 at > 15 ºC	7-8	18.3 - 67.0 Cm 0.6- 2.2 Ft	4.6.24.4 Cm/Sec 0.2-04 FI/Scc	6.4-24.9 Cm 2.5- 9.8 In
SMOLTIFICATION AND EMIGRATION	6.9 – 11.3 ºC 14.4 – 52.3 ºF	≥ 7 at ≤ 15 ºC ≥ 9 at > 15 ºC	7-8	I8.3 - 67.0 Cm 0.6- 2.2 Ft	4.6-24.4 Cm/Sec <U- 03 Fl/Scc	6.4-24.9 Cm 2.5- 9.8 In

Cm = Centimeters
Ft = Feet
C = Centigrade
F = Fahrenheit
In = Inches
Cm/Sec = Centimeters Per Second
Ft/Sec = Feet Per Second
> = More Than
< = Less Than
Sources: Rich, 1987; Hooper, 1973; Dickson and Kramer, 1971; Doudoroff and Shumway, 1970; Orcutt et al., 1968; Frost and Brown, 1967; Thompson, 1972; Smith, 1973; Bovee, 1978; Phillips and Campbell, 1961; Hunter, 1973; Davis et al., 1963.

The life history information which follows is primarily for California coastal streams; very little information is available on Mill Valley creeks.

Adult Immigration and Passage

Of the two general races of steelhead trout which inhabit California streams, the spawning run which enters the Arroyo Corte Madera del Presidio referred to as the "winter-run". These are steelhead trout which enter and spawn during rising stream levels during the winter months (most immigrate in January and February, although the timing is dependent upon streamflow levels in the creek. Often, steelhead trout will migrate into Richardson Bay in the fall, several months before the fish actually spawn. Storm events result in streamflow changes, which cue anadromous fish immigration into Richardson Bay and into Arroyo Corte Madera Creek.

The entry of steelhead trout into coastal streams is not determined entirely by either sexual maturity or age. Although, California steelhead trout typically return to freshwater after one to two years at sea, they have a highly variable life history; some return after three or four years at sea (Shapovalov and Taft, 1954; Briggs, 1953). Steelhead trout which have spent only one year at sea, but have returned to spawn, are termed "grisle"; such males are commonly called "jacks".

Of the factors known to influence a steelhead trout's ascent of coastal systems, streamflow connected with storm events is one of the most import. Other factors include passage barriers, water quality, water temperatures, water depth and velocity, and angling pressure. Sometimes barriers (e.g., shallow riffles, debris jams) in streams will impede or even curtail immigration beyond the barrier. Once the fish immigrate into Arroyo Corte Madera Creek, there has to be enough water for them to "pass over" barriers to spawning gravels. Water quality can be a problem if dissolved oxygen is low, siltation is high, pH is either too low or too high, or pollutants negatively impact the aquatic resources. Water temperatures required for successful immigration have not been studied, per se. However, it is usually assumed that water temperatures needed for spawning are suitable for immigration. From a physiological perspective (i.e., non-stressful), acceptable water temperatures appear to be between 7.7-11.1 °C. Finally, anglers can have a great impact, particularly in creeks with such a small salmonid population. ,

Immigration of steelhead trout occurs in "waves" or pulses, coinciding with storm events resulting in temporary high water flows (freshet conditions). Studies suggest that these freshet conditions are required to initiate both movement into a bay or lagoon (e.g., Richardson Bay) and upstream movement (Shapovolov and Taft, 1954; Briggs, 1953).

Spawning

After the adult steelhead trout move into a stream, they will seek out a pool or glide habitat located near the spawning area; many will "hold" in these areas for two to four weeks while their reproductive products (eggs and milt) ripen. Most steelhead trout spawn from January to the beginning of March in Marin County, although some may spawn as early as November in high water years, and as late as the beginning of April.

During the spawning process, the female steelhead trout will first select a suitable spawning site. Steelhead trout normally chose gravel-based areas, generally at the head of riffles or tail of glides or pools (Shapovolov and Taft, 1954, Kelley and Dettman, 1980). Once a satisfactory site is chosen, the female will begin to dig a nest, also called a *redd,* by turning on her side and rapidly moving her tail. As the tail disturbs the bottom material, the fine sediment is carried away with the water current. This digging process is repeated until a roundish depression is formed. As the female deposits her eggs, the male simultaneously fertilizes them. Then, the female covers up the eggs with her tail and proceeds to dig other pits upstream, until all eggs are deposited. The spawning process for a given female may take a week or more, depending upon the ripeness of the fish and the number of interruptions by intruders (e.g., humans, birds, other fishes).

Most adult steelhead trout die after spawning, but some return to the ocean and then to the stream to spawn again; these fish are called "repeat spawners". Research on coastal streams has shown that the percentage of repeat spawners varies from three to over 50 percent of a run (Shapovolov and Taft, 1954; Briggs, 1953; Bjornn, 1969; Withler, 1966; Fulton, 1970). Although, most steelhead trout return to spawn only once, as many as five times have been recorded, although not in recent years.

Factors which determine whether or not a steelhead trout will chose a particular site to spawn and the spawning success (i.e., fertilization and hatching of eggs) include: streamflows; the quality and depth of spawning substrate; water quality; and, water temperatures. Steelhead trout in California streams rarely chose redds which would later be exposed by receding stream levels (Shapovolov and Taft, 1954). Steelhead, similar to other salmonids, require and seek out clean (silt free) gravel, although they will spawn in embedded substrate, if nothing else is available. The negative impacts of siltation on salmonids are well-documented (Gibbons and Salo, 1973; Bjornn et al., 1977). Non-stressful water temperatures appear to be between 7.7-11.1 °C (Bovee, 1978). In California hatcheries, temperatures below 15.6 °C are considered acceptable (Leitritz and Lewis, 1980).

Egg and Alevin Incubation

Steelhead trout eggs incubate for a variable period of time, depending upon water temperature (Leitritz and Lewis, 1980; Shapovolov and Taft, 1954). In Marin County streams, most incubation occurs from January through mid-April, although the incubation period probably extends into May.

Factors which can affect incubation include water temperatures, streamflows, water quality, water depth, and substrate size. The nature of a salmonid's redd site (head of riffle or tail of glide or pool) insures a good supply of dissolved oxygen (D.O.) and the removal of wastes from the eggs and alevins. No definite minimum level of intragravel D.O. concentration has been established for steelhead trout in the wild, although in hatcheries, 7 parts per million (ppm) is considered preferable (Leitritz and Lewis, 1980). Water temperatures required for successful egg incubation through fry emergence in steelhead trout have not been rigorously tested. Non-stressful temperatures appear to be between 7.7-11.1 °C. In hatcheries, temperatures below 15.6 °C are considered acceptable (Leitritz and Lewis, 1980).

Fry and Juvenile Rearing

The distinction between fry and juvenile is, admittedly, an arbitrary one. "Fry" status is assigned to the fish emerging from the gravel; "juvenile" status is assigned to the fish when it has reached a given length; the length differs from study to study.

Once the yolk sac is absorbed, steelhead trout fry begin to emerge from the gravel. In Marin County streams, most fry emergence is thought to begin in February and continue into May. After emerging from the gravel, the young fish feed and tend to congregate in schools close to shore. As the fish grow, they spread out, eat larger foods, and are thought to inhabit moderately swift portions of creeks (Shapovolov and Taft, 1954). The young steelhead trout spend from one to three years in the stream, before returning to sea (smoltification) where they spend from one to four years, before returning to freshwater to spawn; a very small percentage of fish emigrate out of California creeks during their first year (i.e., less than one year old) (Moyle, 1976; Shapovolov and Taft, 1954; Briggs, 1953; Withler, 1966).

Young steelhead trout, like other salmonids, prefer habitats which are characterized by cool waters, abundant cover, and abundant food resources. Of the myriad of factors which influence salmonid rearing, water temperature, food abundance, streamflows, and water quality are the most important.

Although salmonids are considered temperate (i.e., require cool water temperatures) water animals, the impacts of water temperatures on salmonids are site specific. For example, in Pescadero Lagoon, south of San Francisco, steelhead trout were twice as large in water temperatures which exceeded laboratory optimum by 5-10 °C as those in which temperatures were at or below the upper laboratory optimum(Smith, 1987). However, until site specific physiological data are collected for steelhead trout, non-stressful water temperatures appear to range from 12.8-15.6 °C (Rich, 1987).

Young steelhead trout, like other salmonids, require a large and constantly replenished supply of food, in order to survive and grow. Investigations of food habits of steelhead trout in freshwater streams demonstrated that they feed primarily on aquatic and terrestrial insects (Moyle, 1976).

Smoltification and Emigration

Smoltification, or the *parr-smolt transformation,* consists of behavioral, morphological, and biochemical changes which transform a darkly pigmented, bottom dwelling freshwater salmonid (the *parr)* into a pelagic silvery fish (the *smolt)* (Folmar and Dickhoff, 1980; Wedemeyer et al., 1980). During this process, salmonid emigrate from their natal streams into the sea.

In Marin County streams, Smoltification and emigration probably extends from March through June, with peak emigration occurring in April to mid-May. The percentage of fish which go directly to sea after emigrating down Arroyo Corte Madera Creek is not known, nor is it known what percentage remain in Richardson Bay. In some estuaries in California (e.g., Pescadero Lagoon, San Mateo County) where food is plentiful, many young steelhead remain in the estuary until the following spring (Smith, 1987). Although Richardson Bay is used as a nursery area by many fish species, it is not know to what extent it is used by rearing juvenile salmonids.

A discussion of the dozens of physical and biochemical factors (e.g., lunar cycle, length of day, size of fish, biochemical changes, salinity, etc.) is beyond the scope of this project. However, the many biochemical processes which occur during this life stage are temperature-dependent. In other systems, some of the biochemical processes which occur during the *parr-smolt transformation* in young steelhead trout are inhibited at temperatures which exceed 11.3 °C (Adams et al., 1975; Wagner, 1974; Zaugg and Wagner, 1973; Zaugg et al., 1972). The optimal water temperature range for steelhead trout during *the parr-smolt transformation* is between 6.9-11.3 °C (Rich, 1987).

2. Rainbow Trout

Although, not sea-dwelling, the rest of the life history of the resident rainbow trout is similar to that of the steelhead trout. Most rainbow trout are spring spawners (February to June). They usually mature in their second or third year, although the time of first maturity can vary from the first to the fifth year of life (size at maturity can be 13 centimeters or larger) (Moyle, 1987). Numerous factors which affect steelhead trout also affect the rainbow trout (Figures 3 and 4 and Tables 2 and 3).

B. OTHER SPECIES OF FISH

Non-salmonid fish species which have been sighted in the creeks of the Mill Valley Watershed include the three-spine stickleback, rough sculpin, and California roach (Cully, 1965; Brackett, 1963). Of interest are the stickleback, sculpin, and roach. Although, these species have specific requirements for each of their life stages, they are hardier fishes than salmonids and are able to adapt, establish, and re-establish themselves more easily than salmonids.

1. Three-Spine Stickleback

There are two types of three-spine stickleback: (1) Estuarine anadromous and, (2) Freshwater resident. In all probability, the stickleback collected in the Mill Valley creeks are the estuarine type; they are found primarily in brackish areas. Anadromous populations ascend creeks to spawn in the spring and summer months (Table 4). The breeding cycle lasts two or three months during which an elaborate courtship ritual takes place. At the beginning, the females remain in schools and the males build the nests. After the male builds a nest (out of vegetation and sand, glued together with mucus secretion from the kidney) on the substrate within his territory, gravid females move out of the school into the male territory. The male approaches the passing females, performing a zig-zag courtship dance (Tinbergen, 1953). If a female is ready, she will respond to the dance by following the male to the nest and laying eggs; the male will fertilize the eggs, chase the female away, repair the nest, incubate and guard the nest. Once the eggs hatch (six-eight days at 18-20°C), the fry remain in the nest for a couple of days. Once the fry begin to swim about, the male continues to guard them, grabbing wanderers in its mouth and spitting them back into the main school. Eventually, the fry become more active, the male has more difficulty in guarding them, and begins the spawning cycle again with another female, or joins a school of fish that have finished reproducing. The young fish join schools of similar-sized fish.

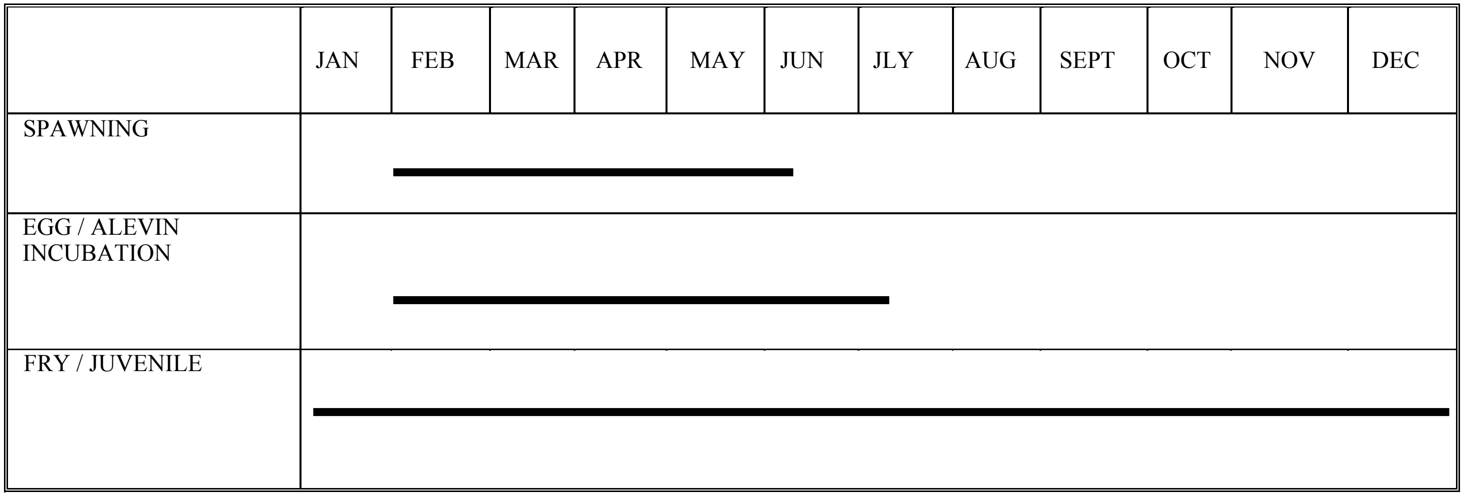

FIGURE 3. RAINBOW TROUT LIFE STAGE PERIODICITIES

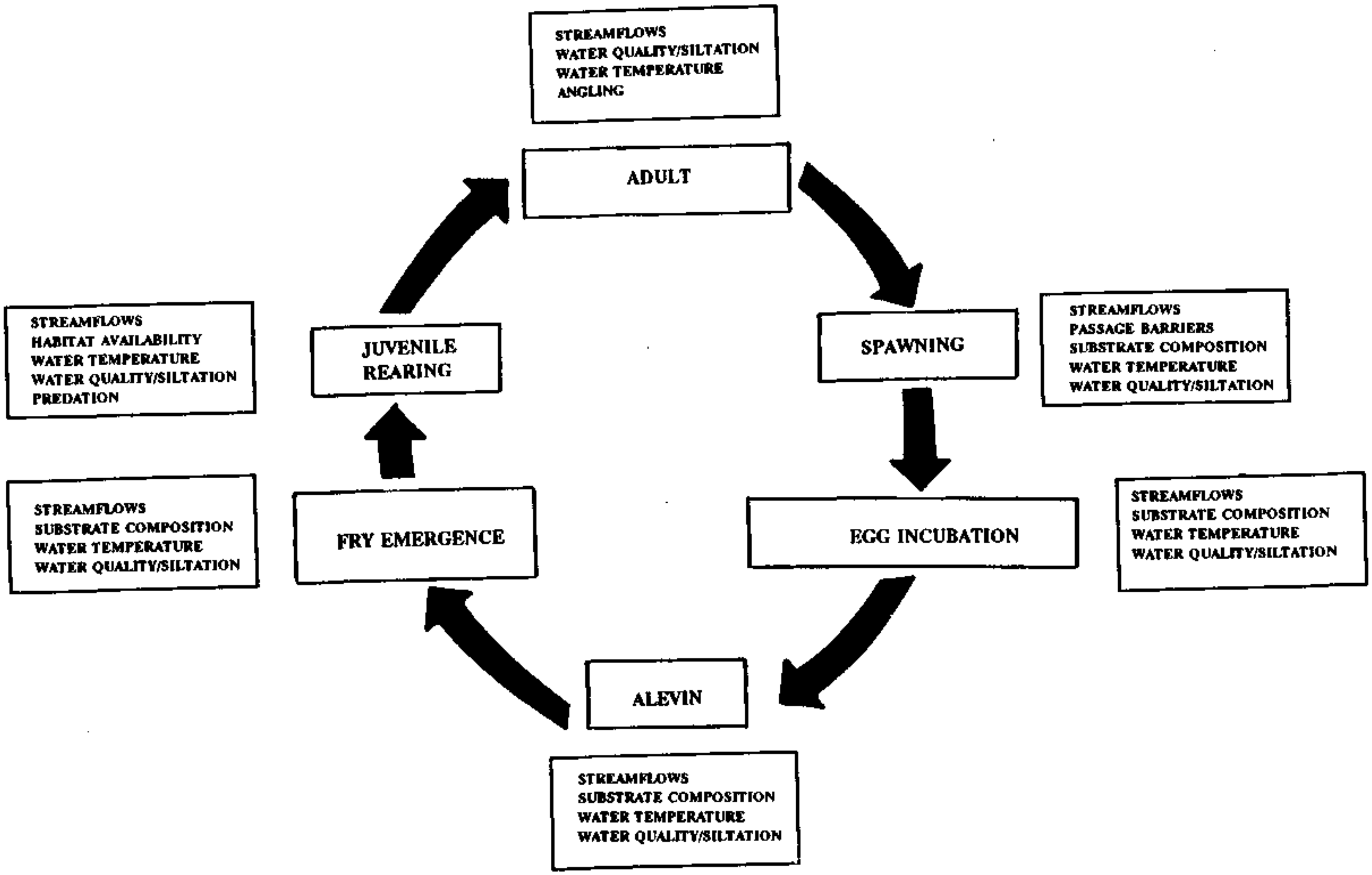

FIGURE 4. LIFE HISTORY STAGES AND FACTORS WHICH AFFECT RAINBOW TROUT

TABLE 2. OPTIMUM SPAWNING CONDITIONS FOR RAINBOW TROUT

GRAVEL SIZE DIAMETER (CM)	REDD SIZE (CM)	WATER DEPTH (CM)	WATER VELOCITY (CM/SEC)	WATER TEMPERATURE (°C)	DISSOLVED OXYGEN
1.5-6.0 for spawners 50 cm long 1.5-10.0 for spawners ≥ cm long	1-6	20-200	30-70	12-18	≥ 7 mg/ 1 at < 15 °C ≥ 9 mg/ 1 at > 15 °C

Sources: Raleigh and Duff, 1980; Reiser and White, 1981; Hooper, 1973; Dickson and Kramer, 1971; Doudoroff and Shumway, 1970; Orcutt et al., 1968; Frost and Brown, 1967.

TABLE 3. OPTIMUM REARING CONDITIONS FOR RAINBOW TROUT

COVER	FOOD	POOL/RIFFLE RATIO	WATER TEMPERATURE (°C)	DISSOLVED OXYGEN
Need abundant cover to protect them from predators, reduce summer water temperatures and provide food resources. Often use turbulence cover as they feed on drifting insects.	Primarily insects, captured as drift organisms	1:1 pool-to-riffle ratio, with areas of slow, deep water	15-20	≥ 7 mg/ 1 at ≤ 15 °C ≥ 9 mg/ 1 at > 15 °C

Sources: Raleigh and Duff, 1980; Reiser and White, 1981; Hooper, 1973; Dickson and Kramer, 1971; Doudoroff and Shumway, 1970; Orcutt et al., 1968; Frost and Brown, 1967

TABLE 4. HABITAT REQUIREMENTS OF THREE-SPINE STICKLEBACK

	ESTUARINE HABITAT		FRESHWATER HABITAT	
	Overwintering	Breeding	Overwintering	Breeding
Period of Occupation	September-April	Hay- August	September - February	March-August
Substrate	Sand	Sand. Mud	Fine gravel	Mud
Vegetation	Variable	Abundant	Sparse	Sparse
Water Depth	More than 1 meter	Less than 1 meter	Less than 1.5 meters	Less than 0.5 meters
Water Current	Strong	Moderate	Moderate	Weak
Water Temperature	10-15 ºC	18-22 ºC	12-17 ºC	18-22 ºC
Salinity	Approximately 30 parts per thousand	0-1 parts per thousand	0 parts per thousand	0 parts per thousand

Source: Snyder and Dingle. 1989.

Stickleback live in weedy pools and backwaters, or among emergent plants at stream edges, over bottoms of sand and mud (Moyle, 1976). They require cool water for long-term survival; it is unusual to find them in water warmer than 23-24 degrees C. It is also unusual to find them in turbid water, since they are visual feeders, as the large eyes suggest. They feed primarily on bottom organisms or organisms living on aquatic plants (Hagen, 1967; Hynes, 1950). Anadromous populations feed more on free-swimming crustaceans, although they may also feed on bottom organisms.

Most stickleback appear to complete their life cycle in one year. Usually, a majority of the stickleback in one area will be uniform size. Freshwater sticklebacks seldom exceed 60 millimeters total length in California, while anadromous sticklebacks commonly reach 80 millimeters. Females are usually larger than males.

Two adaptive features of the stickleback have enabled it to survive, despite its small size. First, the dorsal fin has three spines which the fish can manoeuver into an upright position, thus diminishing its delectability to predators. Second, it is extremely euryhaline; (i.e., it can withstand wide variations in salinity concentrations).

2. Rough Sculpin

The rough sculpin is a small bottom fish with a large flattened head, fan-like pectoral fins and smooth, scaleless, but prickly, body. These features and the absence of the balancing organ, the swim bladder, enable sculpin to remain on the bottom, even in fast-flowing streams. In addition, this species has a darkly mottled coloration, which blends in with the rocky areas they prefer, concealing themselves from both predators and prey.

This species is tolerant of changing salinities, high water temperatures (e.g., 28 °C), prefers substrates of sand, silt and course small gravel, and is often found in pools. Sculpin are voracious eaters, feeding mainly on benthic invertebrates, eggs and even small fishes; the food eaten varies with the size of the fish. Generally, this is a hardy family of fishes, which will adapt to a wide variety of coastal estuarine conditions (Moyle, 1976; McGinnis, 1984).

Most spawning occurs in the spring. The fish migrate downstream, presumably so that the eggs will be laid closer to the estuary where the larvae will live. The male selects the nest site, prepares the nest by digging a small hollow under a large flat rock, and when the female is ready, she move in, is courted by the male, and attaches the eggs to the ceiling of the hollow. The male then chases the female away and guards the eggs until they hatch. The hatched fry are soon ready to swim and, as a result, are swept downstream, where they are planktonic for about a month. After that, they settle on the bottom and start a general upstream movement into their natal stream (Moyle, 1976; McGinnis, 1984).

3. California Roach

California roach are habitat generalists, being found in cold "trout" streams, as well as warm intermittent streams and main channels of rivers (e.g., Russian and Tuolumne Rivers). They are tolerant of relative high temperatures (30-35 °C) and low oxygen levels (1-2 ppm).

Reproduction occurs from March to June, but may be extended through late July. During the spawning season, schools of fish move into shallow areas with moderate flow and gravel/ruffle substrate. Females deposit adhesive eggs in the substrate and the eggs are fertilized by the attendant males. The eggs hatch within 2-3 days and the fry remain in the substrate interstices until they are free-swimming.

Roach are bottom feeders, and feed on filamentous algae, as well as crustaceans and insects. Growth is seasonal, with rapid growth occurring during the summer months.

IV. HISTORICAL PERSPECTIVE OF THE FISHERY RESOURCES

There are few written records of the "how things used to be" before the Europeans arrived, with regard to the fishery resources. But, there is no question that trout were ample enough for the Coast Miwok Indians to rely upon for food. Malcolm Margolin (1978) quoted the nineteenth century ethnologist, Stephen Powers, when describing the California Indians as "almost amphibious." "They are always splashing in water." California had so much water in those early days; freshwater swamps, San Francisco Bay rimmed with vast saltwater marshes, rivers throughout the year, springs out of the hillsides, natural lakes, and enumerable creeks. The clear creeks provided the native Indians with abundant fish and fresh water. The remnants of the Indian trails in the canyons and the traces of their shell mounds in the area of the present Alto-Edna McGuire Schools provide evidence of the early importance of the area, now known as Mill Valley, to their culture and to their survival (Mill Valley Historical Society, 1985).

Old newspapers articles and oral histories of long-tune residents provide a historical perspective of the creeks within the Mill Valley Watershed during the past 125 years, or so. Although, no quantitative surveys were ever conducted, it is evident that, as the years have passed, there have been fewer and fewer salmonids, to the point, where steelhead trout are few, and coho salmon are, virtually, gone. Existing habitat conditions in the creeks are no longer appropriate for coho salmon, who, as juveniles, prefer deep, dark, and dense (i.e., presence of woody debris) pools.

In the last quarter of the nineteeth century, it was a common sight to see coho salmon and steelhead trout swimming up the creek (called Widow Creek, Corte Madera Creek and Arroyo Corte Madera Creek, at different times) flowing through Blithedale Canyon. In those days the creek was a large fishing stream. The creek, in full spate, was considered to be a paradise for fishermen, with salmon in season and trout the year round. In the 1870's, the earth-filled Blithedale Dam was constructed on Widow Creek, equipped with a fish ladder, near the Blithedale Hotel. The resultant reservoir provided swimming and boating. Visitors would see the anadromous salmonids swim up the fish ladder at the side of the dam (Mill Valley Historical Society, 1991, 1987).

In a large auction of lots on May 30, 1890, most of the lots purchased were along the Corte Madera and Old Mill creeks. It was believed at the time that Mill Valley would never be more than a summer resort town. Those lots along the creeks were shady and cool and afforded fishing and swimming. At that tune, no water was being taken for domestic use and the streams had a large flow of water in them. It was not until some five years after this large auction that people began to realize that Mill Valley was destined to become a year-round residence community (Mill Valley Record, 1949a, b; Quinn, 1981).

The large amount of flowing water (so needed by salmonids) in Old Mill Creek a hundred years ago is in sharp contrast to the low and, in some places, non-existent flows of today. Just before the turn of the century, Old Mill Creek (then called Cascade Creek) was dammed at the junction of Cornwall to form a lake for swimming and boating. The remains of the dam are still visible, as are those of other summer dams along the creek (Mill Valley Historical Society, 1993). And, the method of transporting the newly cut timber from the mill to Richardson's Bay was by floating the lumber down the stream towards a knoll near Richardson's Bay.

Rapid settlement of Mill Valley for summer cottages prior to the turn of the century determined development patterns which, in turn, changed the Mill Valley creeks forever, and not for the better. The white settlers brought with them a new set of values for the exploitation of the resources of the watershed. For example, at the mouth of the Arroyo Corte Madera, there was reclamation and elimination of wetlands. A logging mill was constructed on Old Mill Creek around 1834 by John Thomas Reed, one of the recipients of a land grant from the Mexican government. The felling of the virgin timber resulted in denuding the hillsides, which, in turn, created erosion problems along the creek banks. The erosion resulted in the "silting in" of the creeks which, ultimately, lead to a reduction in salmonid populations. The numerous small swimming dams on the creeks, as well as Cascade Reservoir (no longer in existence) altered creek flows and created barriers to anadromous fish migrations (Mill Valley Historical Society, 1984, 1985, 1992).

As children, friends of mine used to catch (1950's and early 1960's) small trout (up to eight inches) near the Old Mill. While these were not as numerous and, perhaps, not as large as those caught at the turn of the century, they were more numerous and larger than any seen today (Foster, 1995).

During the summers of 1963 and 1965, the CFG conducted qualitative one-day habitat surveys of the Arroyo Corte Madera del Presidio drainage. The biologists concluded that: (1) Spawning gravel was heavility silted; (2) Old Mill and Cascade creeks were important as spawning and nursery areas; (3) Relatively high water temperatures (20 °C) in Old Mill Creek was due to the presence of Cascade Reservoir; (4) Pools in the higher gradient areas of Old Mill Creek (i.e., above the confluence with Cascade Creek) provided rearing habitat, but Arroyo Corte Madera creek, downstream of downtown Mill Valley, was composed of relatively sluggish pools, with little riffle area; (5) Natural obstructions, such as gradient conditions were the only limiting factors to upstream migration (with the exception of Cascade Dam on Old Mill Creek); (6) Mayfly larvae were abundant as a food source; (7) Juvenile salmonids, stickleback, and California roach were observed; (8) Salmonid survival appeared to be low, as a result of the lack of good spawning gravel; (9) The stream as it flowed through downtown Mill Valley had been converted at some points; and, (10) The creeks should be maintained for steelhead trout (Cully, 1965; Brackett, 1963).

The damage and loss of fish habitat in the Arroyo Corte Madera Creek Watershed which have lead to decreased salmonid stocks did not happen overnight, nor did it occur only within the past ten or twenty years. Rather, it has occurred as a cumulative process, beginning with the first white inhabitants of this valley. Summer dams, water diversions, reservoirs, reduction of the wetlands, channelization of the creeks, paving of the valley floor, together with a history of alternate drought and flood conditions, have all contributed to the decline in the fish habitat, and hence, to the marked reduction in salmonid populations. In addition, as with so many other creeks throughout the world, some people still treat the creeks in Mill Valley as garbage dumps and sewers. Before the fish can return, their habitat has to be improved. And, because there are so many more watershed users now then there were a hundred or more years ago, it is all the more important that all the watershed users become active in rehabilitating these creeks.

V. METHODOLOGY

A. GENERAL APPROACH

In order to meet the Project Objectives, the following Tasks were performed:

- Reviewed historical documents, oral histories, and newspaper clippings from the Historical Society in the basement of the Mill Valley Library, as well as spoke with friends and relatives who had lived in Mill Valley for many years;
- Conducted a Summer Fish Habitat Survey; and,
- Conducted a Summer fish population survey.

B. EXISTING FISH HABITAT CONDITIONS

Identification of the components of fish habitat is essential to accurately describe the existing fishery resources conditions in the creeks. To describe the stream habitat conditions, *Habitat Typing* (Bisson et al., 1982, modified for California coastal streams by Dr. Alice Rich) and general descriptive measurements were used (Appendix A). Habitat Typing consists of measuring the individual habitat units or types within a selected stream. This information is then compared with the habitat needs of the fishes collected from the stream.

The habitat surveys of the main stem and two major tributaries of the Arroyo Corte Madera del Presidio Watershed were surveyed from October 27 to November 4 , 1994. Following summarizes the creeks which were surveyed and the level of detail of each survey:

- Old Mill Creek and its tributary (Cascade Creek)

  detailed habitat mapping

- Arroyo Corte Madera del Presidio-Richardson Bay up to Center of Town

  "spot checked", using habitat mapping (ran out of tune, due to the rains in November)

- Arroyo Corte Madera del Presidio-Center of Town up to headwaters

  ran out of time, due to the rains in November

- Reed Creek

  very brief, as surveying this creek was not in the proposal/budget; but I did spend a little time on it, although the November rains curtailed most of this

- Warner Creek

  very brief, as surveying this creek was not in the proposal/budget; but I did spend a little time on it, although the November rains curtailed most of this

As fishery biologists proceed upstream from the mouth of creeks, when conducting habitat surveys, the description of the fish habitat is addressed accordingly. For example, the habitat description of Old Mill Creek begins with the confluence of Old Mill Creek with that of the main channel and proceeds upstream to the old Cascade Reservoir site.

C. EXISTING FISH POPULATION ESTIMATES

To assess fish population conditions within three of the primary creeks of the Arroyo Corte Madera del Presidio Watershed, electrofishing surveys were conducted from October 26-November 4. Electrofishing is commonly used by fisheries biologists for collecting fish. However, in order to minimize the capture stress on the fishes, this method must be used with caution and only by trained personnel. When used quickly, efficiently, and knowledgeably, this method is less stressful than that of beach seining and/or other collection techniques.

To accurately sample the number and species of fishes in the creeks, it was necessary to electrofish *representative samples* of each habitat type observed in the creek. Ideally, one needs to identify first the number *of habitat types* and then sample (randomly) as many sites as necessary to provide a statistically-sound study. However, as the survey was intended to provide an *initial overview* of existing fish habitat and population conditions, during low flow conditions, the sample sites chosen were not statistically-based. However, at least one of each habitat type for each creek was chosen for the fish sampling. Due to the onset of rainy weather, we were unable to sample the uppermost fish sampling sites in Blithedale Canyon.

A total of 29 sampling sites were chosen, as follows: seven sites in Arroyo Corte Madera del Presidio Creek along Miller Avenue; six sites in Arroyo Corte Madera del Presidio Creek in Blithedale Canyon; 15 sites in Old Mill Creek; and one site in Cascade Creek (Figure 5; Appendix B).

The electrofishing proceeeded as follows. To prevent the fish from escaping during the sampling procedure, block nets were placed at the lower and upper ends of the sampling site. To sample the site, an electrofisher (Smith-Root Type 12 backpack) was used. The fish sampling crew consisted of one "electrofisher", who operated the electrofishing unit, and two netters. Starting at the downstream block net, the electrofisher waded upstream through the sampling station, operating the electrofisher. Stunned fish were netted and placed in water-filled buckets. Three or more passes were completed at each station in order to estimate fish population sizes by the maximum-likelihood method (Van Deventer and Platts, 1983, 1986) (Appendix A).

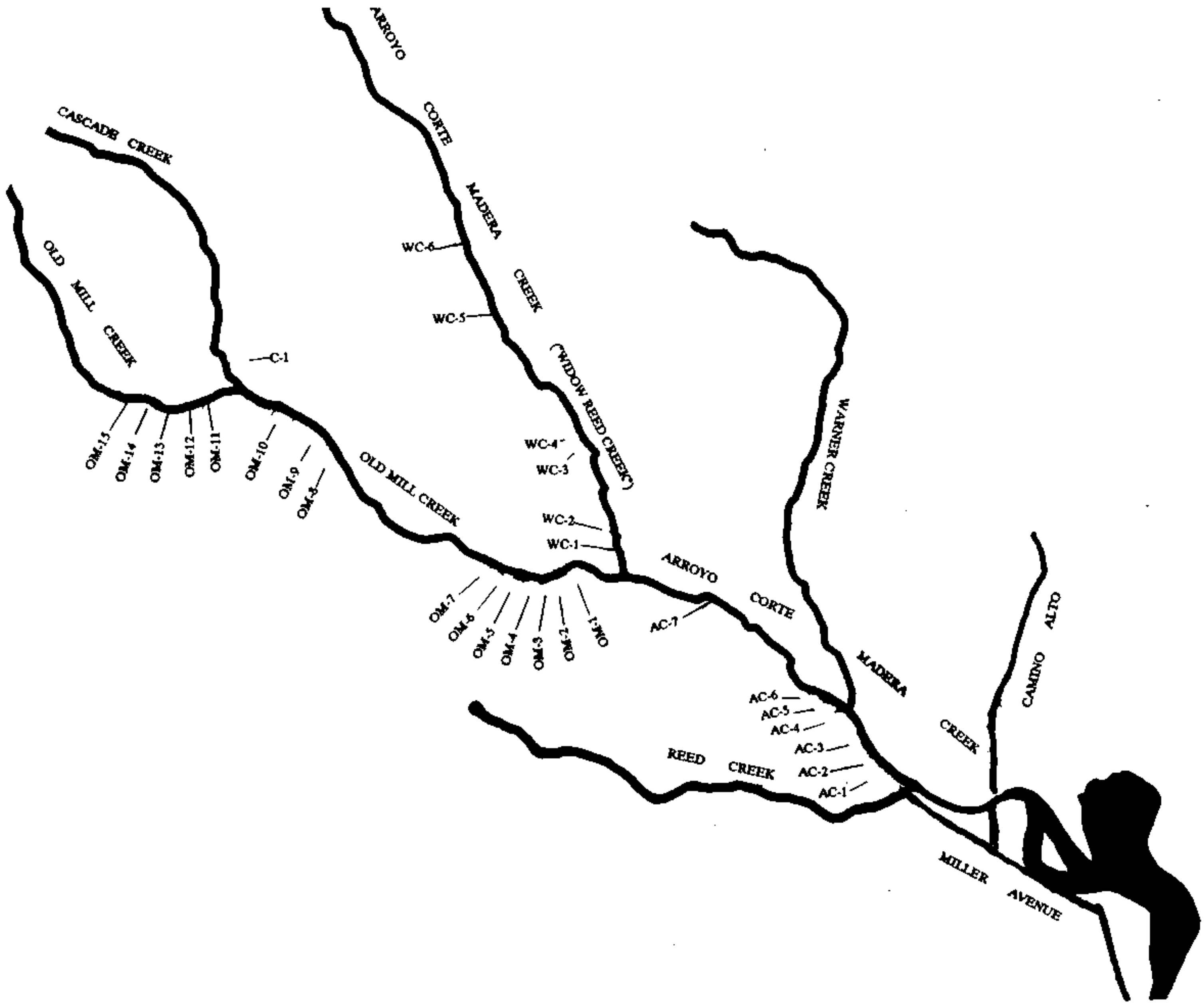

FIGURE 5. ELECTROFISHING SITES.

To reduce the stress of capture on the fishes (particularly the sensitive trout), the fish were placed in a buffered (sodium bicarbonate to pH 7.0, 75 parts per million) anaesthetic (methane trisulphonate, 50 parts per million); previous studies (Rich, 1979, 1983) demonstrated that salmonids exhibit little stress response when such a mixture is used. In addition, a battery-operated pump aerated the water in which the fish were residing.

After each pass, fish were identified to species and enumerated. For each fish, the following items were recorded: species name, fork length, and weight. After the electrofishing was completed, the fishes were returned to the sampling station from which they were collected. After the electrofishing was completed at each station, the physical dimensions of the habitat (e.g., length, depth, width) were recorded. The dimensions were used to calculate the number of fish (by species) per square meter of stream.

Following is a summary of the extent of surveys conducted, thus far (Figure 5):

- Old Mill Creek

  Fairly good representation of types and numbers of fish species in representative habitats

- Arroyo Corte Madera del Presidio (downstream of town center)

  Fairly good representation of types and numbers of fish species in representative habitats

- Arroyo Corte Madera del Presidio (upstream of town center)

  Fairly good representation of types and numbers of fish species in lower reach (Marguerite Avenue), but rain curtailed the completion of the population surveys

- No sampling in Warner or Reed creeks (not in the proposal/budget and also we would not have had time last year (due to the November rains), even if there had been the funds

D. DATA ENTRY AND ANALYSIS

The data were entered into RBASE for DOS, a computer data management program. Population (maximum-likelihood method), length, weight and total biomass (i.e., total weight of the fish) estimates were calculated on the computer, using Microfish (Van Deventer and Platts, 1983).

No statistical analysis has been performed on the data, to date. Due to the budget restrictions, this initial "Phase" of the project was intended to provide an overview of fish habitat and population conditions. However, the habitat and population data collected could used to assist with planning a statistically-based study to identify, quantitatively, existing conditions, and, thus, impacts of future rehabilitation efforts. The results of any future surveys could be integrated with those of this 1994 study at that time.

VI. EXISTING FISH HABITAT CONDITIONS

In order for salmonids to thrive, there must be appropriate habitat conditions, including the following: accessibility to spawning sites; adequate streamflows; acceptable water temperatures and water quality; appropriate substrate composition; and, abundant food. The habitat of of the Arroyo Corte Madera del Presidio Watershed is described below. It is divided into the following creeks:

(1) Arroyo Corte Madera del Presidio (confluence with Richardson Bay upstream to downtown Mill Valley);

(2) Arroyo Corte Madera del Presidio (downtown Mill Valley upstream through Blithedale Park);

(3) Old Mill Creek (downtown upstream to where Cascade Reservoir used to be);

(4) Cascade Creek (confluence with Old Mill Creek upstream to Cascade Falls);

(5) Warner Creek (no detailed field surveys); and,

(6) Reed Creek (no detailed field surveys).

A. SUMMARY DESCRIPTION OF THE CREEKS

The topography of the Arroyo Corte Madera del Presidio Watershed is moderately steep in the headwaters and gently sloping in the valley regions (i.e., Mill Valley). The headwaters lie in steep "V"-shaped canyons which have the abundant vegetation typical of a redwood forest. From the lower end of the headwaters to the beginning of the town of Mill Valley, the stream is located in a rather narrow steep valley. The portion of the creeks within Mill Valley are partially covered with buildings, culverts, and roads.

Of the four creeks surveyed (i.e., Arroyo Corte Madera del Presidio Creek along Miller Avenue; Arroyo Corte Madera del Presidio Creek up Blithedale Canyon; Old Mill Creek; and, Cascade Creek), Old Mill Creek offered the most promise, from a salmonid rehabilitation perspective. However, there are a number of watershed-based rehabilitation projects which could enhance fish populations of all of the creeks in the watershed, once the necessary scientific studies (i.e., fishery resources and sediment/geomorphology-related studies) have been completed.

B. EXISTING FISH HABITAT CONDITIONS

1. *Overview*

The habitat of some of the principal creeks within the Arroyo Corte Madera del Presidio Watershed is described below:

(1) Arroyo Corte Madera del Presidio (mouth upstream to the center of Mill Valley)

Mostly channelized, limited habitat for salmonids, other than as a migration upstream (adults) and downstream (during the parr-smolt tranformation)

(2) Arroyo Corte Madera del Presidio (upstream of the center of Mill Valley through Blithedale Canyon)

More natural appearing than downstream, but there are remains of old summer dams, as well as large culverts

(3) Old Mill Creek

The most natural of the creeks surveyed, from the standpoint of fish habitat

(4) Warner Creek

Highly impacted by the presence of houses (downstream sections flow under concrete and asphalt, or through a cement channel, throughout much of its course; upstream, the Mill Valley Golf Course has had, and continues to have, a negative impact on the creek

(5) Reed Creek

Extremely narrow, channelized creek, with limited fish value at the present time

2. Arroyo Corte Madera Creek (mouth upstream to downtown Mill Valley)

a. From the Mouth Upstream to Reed Creek

The lowermost reach serves as a migration (both upstream for the adults, and downstream, for the juveniles) route for steelhead trout, but is unsuitable for rearing; the substrate is composed of sand and silt and there is little protective cover. However, at the tune of the survey (late October-early November), this reach provided habitat for euryhaline fish species (species which can adapt to fluctuating saltwater concentrations), such as the threespine stickleback *(Gasterosteus aculeatus).*

This creek, which flows into Richardson Bay near the Methodist Church on Camino Alto, was characterized by a tidally-influenced long (approximately 1,500 meters), fairly wide (10-12 meters) channel (i.e., a "lateral scour pool associated with bankcut"). The depth of the lower end of the channel was greater (more than 1 meter depth) than that of the upper section (6-20 cm deep) in the vicinity of Reed Creek, a tributary which flows into the mainstem at Circle Valley. The creek up to this tributary is a typical slough, with common weeds and marsh plants and scarce vegetative cover.

b. Confluence with Reed Creek (Circle Valley) Upstream to Evergreen Avenue

Beginning in this stream reach, there appeared to be some juvenile salmonid rearing habitat, albeit slight. However, no salmonids were collected and, it is expected that this reach is used, primarily, as a migration route by salmonids.

Characteristics of the 3-4 meter wide channel within this reach included: 100% overhead canopy cover; substrate composed of spawning-sized gravel; very shallow (less than 10 centimeters deep) lateral scour pools associated with bankcut; shallow (less than 8 centimeters) low gradient riffles. The low water levels throughout this area during the summer months limits its usefulness for salmonids. Whether or not this area is used at all for spawning will need to be determined; from the electrofishing surveys, it was apparent that the area was used, primarily, by juvenile threespine stickleback.

c. Evergreen Avenue to La Goma Street

Based on fish habitat needs and the results of the electrofishing survey, the channel within this reach is used primarily by stickleback; steelhead trout would use the reach as a migration route on their way upstream (as adults) or downstream (during the parr-smolt transformation).

Characteristics of this reach included: narrowing of the channel (downstream: 3-4 meter wet width of channel; upstream less than one meter wet width); channel choked with aquatic vegetation; shallow (couple of centimeters deep) conditions; and, in the upstream section, negligible velocity.

d. La Goma Street to Locust Avenue

Although channelized, the reach was characterized by a diversity of fish species not previously observed, although no salmonids were collected. Numerous threespine stickleback, rough sculpin, and California roach were collected within this reach. The habitat changed from the choked channel of the preceeding reach to a more open free-flowing channel, although it was unsuitable for rearing steelhead trout at the time of the survey.

This reach was characterized by a 0.3-1.5 meter wide channel composed, primarily, of a shallow (few centimeters deep) lateral scour pool associated with bankcut, salmonid spawning-sized gravel substrate, and about 50 percent canopy cover (i.e., protection for fishes). Other habitat types included extremely shallow rootwad pools and low gradient riffles.

e. Locust Avenue to Willow Avenue

This reach provided borderline habitat for salmonids (more water, with deeper lateral scour pools than observed downstream), as well as habitat for stickleback, sculpin, and roach. However, similar to the previous reaches, the stream in this area is probably used as a migration corridor by salmonids.

The reach between Locust Avenue to Willow Avenue was characterized by a wider (2.0-3.5 meters), deeper (10-60 centimeters) channel than that of the previous reach. In addition, the substrate was composed of gravel and there was from 50-100% canopy cover. However, the reach was highly channelized and the remains of a cement dam lay just upstream of the Locust Avenue bridge; this cement dam would impede streamflow, during low flow conditions. During a later (February 3, 1995) site visit, after weeks of rain, the entire stream reach had become a fast-flowing low gradient riffle.

f. Willow Avenue to Miller Avenue Church (Fern Avenue)

The stream reach between Willow Avenue and the Miller Avenue Church was marginally suitable for salmonid rearing, but again probably serves as a migratory corridor, primarily.

Most of the channel was composed of a long narrow (1.5-2 meter wide) low gradient riffle, with a little pool habitat along the right bank (as one faces upstream).

g. Miller Avenue Church (Fern Avnue) Upstream to the Confluence with the Other Two Streams in Downtown Mill Valley.

Beginning in this stream reach, there is more evidence of urbanization of the creek. Although steelhead trout juveniles were present, the habitat consists of silt-laden lateral scour pools. As the creek reached the Mill Valley Lumber Yard and Vogue Cleaner (77 Miller Avenue), it had become a cement channel in places, and, in others, the silt-laden scour pools were not suitable for salmonid rearing. This type of habitat worsened throughout the Town Center, as the Old Mill Creek and Arroyo Corte Madera (formerly called Widow Reed Creek) flowed into the mainstem under the asphalt lying over the center of town.

2. Arroyo Corte Madera (downtown up East Blithedale Canyon) (Previously called Widow Reed Creek)

a. Center of Mill Valley (Downtown)

As one proceeds upstream through downtown, from the confuence with the mainstem near Vogue Cleaners, the fish habitat, particularly that of salmonids, was of extremely poor quality. Although, there were numerous rainbow/steelhead juveniles in the lower two electrofishing sites within this creek, the habitat can best be described as that of a "trout ghetto".

The creek was characterized by a highly channelized cement and asphalt channel, with low flow conditions, and pools which "stranded", or trapped, salmonids and other fishes both above surface and subsurface (i.e., under the asphalt of City Center); much of the creek flowed underground through part of the City Center, and reappeared upstream of Sunnyside Avenue, next to what was the old bus depot area. The creek then flowed under Throckmorton Avenue, and reappeared upstream of Throckmorton Avenue, behind the Mill Valley Market and up to Gardner Street.

b. Gardner Avenue to Miller Grove Park

Proceeding upstream past Gardner Avenue to Miller Grove Park, the creek was channelized, as it passed alongside and under several houses. The habitat in this reach was poor, much of the channel being composed of cement walls. There was limited suitable habitat for salmonids and if any trout existed in this reach, they had become stranded, due to the low-flow conditions of the creek at the time of the survey.

c. Miller Grove Park

Although, streamflows were minimal and depth shallow (1-24 centimeters deep) throughout Miller Park, there was some pool "structure", so needed by rearing salmonids, as well as some pools associated with overhanging boulders, bedrock, and bankcut. The structure consisted of small woody debris (i.e., sticks) and redwood roots, extending into the pools from the base of several redwood trees. There appeared to be abundant food (i.e., terrestrial insects, primarily) for rearing salmonids in the few pools (size: 2-4 meters wide by 3-4 meters long by 10-25 centimeters deep) which existed. Numerous rainbow/steelhead trout and stickleback were collected in this reach, but only in the pool habitat. Due to the rather poor habitat in this reach, other than the pool areas, as well as the poor salmonid habitat upstream of Miller Grove Park, it was expected that the rainbow/steelhead trout would seek out areas such as the rootwad pools of Miller Grove Park. However, due to the dearth of water, and hence, riffles, the substrate within the pools was embedded with silt and the pools were few in number. Hence, the pool habitat was not of particularly good quality, from a salmonid rearing perspective, but it was better than that observed alongside and under the houses upstream of Miller Grove Park.

d. Upstream Boundary of Miller Grove Park to Blithedale Park

Proceeding upstream past Miller Grove Park between and under the many houses along the creek, the creek was channelized once again (cement walls throughout most of its length, up to Marguerite Avenue). Understandably, although there was abundant shade, and, hence, cool water temperatures, the channelized cement habitat is not beneficial to fishes, in general, and rearing salmonids, specifically.

e. Blithedale Park (Marguerite Avenue to Lee Street)

Salmonid habitat in the Blithedale Park reach appeared better than that observed downstream. The reach was characterized by a series of cascades, with bedrock pools and clean water. The habitat of some of the pools appeared to be suitable for larger salmonids. Unfortunately, this was the last electrofishing site last year; the electrofishing effort was curtailed when the storms began. It will be useful to determine how much, if any, of this area is being used by salmonids.

3. Old Mill Creek (Tributary to Arroyo Corte Madera del Presidio Creek)

With the exception of the "Downtown" section, Old Mill Creek provided the best salmonid habitat of the creeks surveyed. Old Mill Creek appeared more natural, having been channelized less, with fewer remnants of old cement swimming holes and existing cement and asphalt reinforcement. The existence of Old Mill Park and The Three Wells Park contributed to the more naturally-appearing condition of this creek.

a. Downtown (Vogue Cleaners Upstream to Mill Creek Apartments (19IB Throckmorton Avenue)

Proceeding upstream from the confluence with the mainstem near Vogue Cleaners, fish habitat, particularly that of salmonids, was of the similar poor quality as that of the Arroyo Corte Madera flowing through downtown Mill Valley. After flowing under the asphalt road (Miller Avenue) and parking lot (behind Dowd's Barn), Old Mill Creek reappeared twice in the parking lot behind Throckmorton Avenue. Within this reach, the creek flowed through large cement culverts, under a large parking lot, and was channelized (cement).

Although, there were numerous rainbow/steelhead juveniles in the electrofishing sites within Old Mill Creek in the Downtown area, the habitat can best be described as that of a "trout ghetto". Due to the many near dry portions of the creek in the Downtown area, fishes were essentially trapped in the habitats in which they were collected, until winter rains arrived.

b. Downtown (Mill Creek Apartments-19IB Throckmorton) Upstream to Ethel Avenue

Due to extremely low flow and some siltation, the stream reach between the Mill Creek Apartments and Ethel Avenue, was of marginal quality, from a salmonid habitat perspective, although numerous rainbow/steelhead trout were collected during the electrofishing survey. Due to the limited amount of water, the fish resided in the deeper portions of the creek, but were stranded during these low flow conditions.

The reach was characterized by long (30-50 meter) shallow (3-10 centimeters deep) low gradient riffles, interspersed with various types of shallow (3-20 centimeters deep) lateral scour pools (associated with bankcut and boulders, primarily). Throughout the reach, flow was so low that fishes were stranded in the shallow pools. Behind the Mill Creek Apartments cement had been used to reinforce the bank; some of this cement formed the substrate for portions of the creek, hardly a lovely site to see. In addition, at the Ethel Avenue bridge, there was a very small plunge pool, created by the drop (a few centimeters) from the cement culvert down into the creek pool, artificially created with cement. Abundant cover (e.g., canopy, overhanging vegetation, fallen leaves), gravel and cobble substrate, and cool (less than 15 °) water temperatures also characterized this stream reach.

c. Ethel Avenue to Old Mill Park (Olive Avenue)

Although, the reach from Ethel Avenue upstream to the lower boundary of Old Mill Park was not particularly suitable for salmonids, there were "pockets" of marginal salmonid habitat, interspersed with stretches of creek where there was practically no water at all. The "pockets" of marginal habitat consisted of several lateral scour pools in the vicinity of 297 Throckmorton. One of these pools was associated with a large log, another with a bankcut, and the third, with a series of large boulders directly behind 297 Throckmorton. The owner of the property, Maria Alex, someone I have known all my life, told me that several years ago (in the early winter or late fall) she saw an adult steelhead trout in the lateral scour pool associated with the log near the downstream border of her property. She said that the fish was "flopping around" noisily and appeared to be attempting to make its way upstream. However, the fish was stranded in the pool, due to the low flow conditions of the creek at the time.

We collected many rainbow/steelhead trout, probably of at least two, and maybe three age classes (i.e., young-of-the-year; one-year old; two-year old fish). In the future, from the analysis of the rainbow/steelhead scales, we will be able to identify the various age groups for this species of fish. Aging the fish is an important part of this project because multiple age classes of rainbow/steelhead trout implies habitat diversity, and hence, a higher probability that there will be more fish in successive years.

Most of the reach was characterized by long (30-100 meters) shallow (1-10 centimeters deep) low gradient riffles (which, with a bit more water, would probably be lateral scour pools), interspersed with shallow (3-20 centimeters deep) lateral scour pools (associated with bankcut). Most of these pools were too shallow to provide much habitat for fish. Other characteristics of the reach included abundant cover (e.g., canopy, overhanging vegetation, fallen leaves), gravel and cobble substrate, and cool (less than 15 °C) water temperatures.

One of the problems noted in the creek within this reach was the presence of several garden hoses, as well as a pump immediately upstream of the Ethel Avenue bridge. The hoses originated from the first house upstream of the Ethel Avenue bridge; they were probably used during higher flows. People need to understand that diversion of any water from a small creek can have a significant negative impact on salmonids, a highly sensitive group of fishes. Also, in the creek just upstream of the Ethel Avenue bridge was what appeared to be a storm drain which emptied into the creek.

Another problem noted in the creek was the presence of numerous pieces of both asphalt and cement, strewn about the creekbed, hardly suitable habitat for fishes.

Finally, the left bank immediately downstream of the lower boundary of Old Mill Park was eroding into the creek. This was one of the pools in which there were many stranded salmonids of various ages, some of which had skin lesions. The bank (left, as one faces upstream) which is eroding should be repaired,.

d. Old Mill Park (Olive Avenue up to Laurel Avenue)

Due to the absence of water throughout most of the creek in this reach downstream of the Cascade Way culvert, the creek was unsuitable for fishes, particularly salmonids. The only habitat in which fishes were collected was a shallow (1-8 centimeters deep) pool at the downstream end of the park and a shallow (1-7 centimeters deep) lateral scour pool associated with the cement wall, adjacent to the Old Mill; few fish (all salmonids) were collected at either site. In both of these pools, the salmonids were stranded, unable to leave the habitat, due to the absence of water both upstream and downstream.

There was a problem with bank erosion on the left bank (as one faces upstream) across from the Old Mill. Children (myself included, many years ago) customarily take a shortcut from Molino Avenue to the Park and Old Mill School, by scampering down this bank, thereby causing bank erosion. The area needs to be "shored" up.

Evidence of a number of "manmade" structures are evident within the creek in Old Mill Park. As one proceeds up through Old Mill Park, there is evidence of the old lumber mill pool (adjacent to the Old Mill). The banks of much of this reach have been riprapped. A better, more aesthetic method of stabilizing banks is with the use of "Armorloc", or some other related product. Armorloc consists of large concrete blocks, usually square-shaped, with a hole in the middle. One can plant shrubs or trees within this hole and, within a short period of time, the cement blocks disappear, as the shrubs cover them. A successful project using an armorloc type of product can be found in Novato on the banks of the Novato River. At the Novato site, the area which was riprapped looks like riprap; but, on the banks where the armorloc was placed, there is no visible sign of the armorloc, but rather grasses and shrubs, instead.

Upstream of the culvert under Cascade Way, the creek meanders through redwoods and up to the Laurel Avenue bridge. The creek was characterized by shallow (several centimeters deep) lateral scour pools associated with bankcut, followed by shallow low gradient riffles. Substrate within the pools and riffles was composed of silt and gravel, respectively. Although, the area upstream of the Cascade Way culvert was not electrofished, numerous juvenile salmonids were observed in the pools. Again, though, the fish were stranded, as there was not enough streamflow between habitats to allow the fish to leave the areas they were residing in.

e. Laurel Avenue up to Three Wells Park (Cascade Drive downstream of Throckmorton Avenue)

Throughout this reach, similar to the areas downstream, fishes were located in deeper lateral scour pools. The creek flowed through numerous residential properties and was characterized by alternating low gradient riffles and lateral scour pools associated with cement retaining walls and bankcuts; there were also a few lateral scour pools associated with rootwads. Little flow was apparent, both the pools and riffles were narrow (1-2 meters wide) and shallow (1-30 centimeters deep). With more streamflow, the riffle areas would become lateral scour pools. With the exception of the areas with the retaining walls, there was an abundance of cover in the form of both canopy and overhanging vegetation, and the water was cool (about 15 °C).

f. Three Wells Park

The "Three Wells" Park Area was characterized by two distinct reaches. The downstream reach was characterized by shallow (3-15 centimeters deep) low gradient riffles (3 meters long) and lateral scour pools associated with bankcut and bedrock (6-8 meters long). The upper reach was characterized by a series of wonderful bedrock pools, with water cascading down through each of the pools. There was abundant cover in the form of canopy, rocks, woody debris, and turbulence. Gravel and cobble substrate predominated in the lower reach; gravel substrate predominated in the upper reach. Few fish (salmonids only) were collected in the lower reach; many fish (salmonids) were in the lowermost "Three Well" pool; some crayfish were observed in some of the "Three Wells". Again, however, the fish were stranded within their habitat, until the winter rains appeared.

g. Three Wells Park (Upstream Boundary) to Cascade Creek (Tributary)

This area was composed of a series of shallow (3-10 centimeters deep) cascade-pools with a natural bedrock-based substrate and was not really suitable for salmonid rearing; some crayfish were observed.

Under the first residential bridge upstream of the Three Wells, there was a lot of cement in the creek; upstream of the bridge, the left bank (as face upstream) was eroding into the creek.

h. Cascade Creek Tributary to Unamed Tributary (Left Side, as Proceed Upstream)

Although as shallow as in the previous reach, the substrate of the creek in this reach was composed of gravel, cobble, and boulders. At about 460 Cascade Drive, there was evidence of the old summer dam which, near the turn of the century, the original owner constructed for use as a swimming hole each year. Although salmonids were collected in sections of this reach, the lack of water strands the the fish. At the end of this stream reach, the slope of the creek had increased significantly and, due to the lack of water, there was no fish habitat available.

i. Unamed Tributary to Old Cascade Reservoir Site

Due to the lack of water and steepness of the gradient, this reach did not contain any suitable fish habitat.

4. Cascade Creek (Tributary to Old Mill Creek)

Although there was one rainbow/steelhead trout collected in the pool above the culvert at the entrance to the trail to Cascade Falls, the lack of water and steep gradient provided little, if any, fish habitat at the time of the survey.

5. Warner Creek (Tributary to Arroyo Corte Madera del Presidio Creek)

As Warner Creek was not within the Scope of Work for this first field evaluation and analysis of the creeks, I am drawing primarily upon my own memory of the creek and on a recent conversation I had with Eric Larsen, who lives along the creek, downstream of East Blithedale. Warner Creek flows down past the Mill Valley Golf Course, alongside Boyle Park, and proceeds downstream through a channelized course into Arroyo Corte Madera del Presidio Creek near Locust Avenue. Although the creek appeared more "natural" in the upper reaches (i.e., Boyle Park upstream), it had extremely low flow during the summer months and the species of fish which utilized the creek were probably, primarily, stickleback, sculpin, and roach. Steelhead trout have been seen migrating up this creek through the residential area, downstream of East Blithedale. As, as recently as five-six years ago, Eric fed snails to five-six adult steelhead in the pool behind his house. However, at the time of our survey, there were no rearing pools and the low streamflows resulted in another "trout ghetto", from the standpoint of salmonid fish habitat.

6. Reed Creek (Tributary to Arroyo Corte Madera del Presidio Creek)

As Reed Creek was not within the Scope of Work for this preliminary field evaluation and analysis of the creeks, following is an extremely brief summary, based on my own recollection of Reed Creek and a cursory "drive by" evaluation of the creek. Reed Creek is a highly channelized, narrow creek which flows out of Homestead Valley into Arroyo Corte Madera del Presidio Creek at Valley Circle. The creek consists of a cement-walled and, at times, cement bag-lined channel, as it flows downstream, adjacent to Reed Avenue. Although there was fairly clean gravel, suitable for salmonid spawning throughout the lower reach, there were no rearing pools. Hence, although salmonids have been sighted, this creek is another "trout ghetto", from the standpoint of salmonid fish habitat.

VII. EXISTING FISH POPULATION CONDITIONS

A. OVERVIEW

The four fish species collected in the Arroyo Corte Madera del Presidio Watershed included the rainbow/steelhead trout, threespine stickleback, rough sculpin, and California roach (Figures 6-9). Although, the highest salmonid populations were in Arroyo Corte Madera along Miller Avenue, the high density was as a result of stranding of the fish. The *limiting factor* controlling both fish abundance and diversity at the time of the survey was the lack of water. The poor habitat conditions resulting from the lack of water was exacerbated by many cement-lined channel pools, particularly from downtown Mill Valley downstream to Richardson Bay.

Based on the size distribution, most of the rainbow/steelhead trout were young-of-the year and one-year olds, although there were also probably two and three year olds, as well, in Old Mill Creek.

Based on the size distribution, most of the stickleback were young-of-the-year fish, although there were some larger-sized fish in Blithedale Canyon.

Based on the size distribution, the sculpin and roach were represented by one through four age classes.

B. INDIVIDUAL CREEKS

1. Arroyo Corte Madera del Presidio Creek (along Miller Avenue)

Of the four fish species (rainbow/steelhead trout, stickleback, rough sculpin, and California roach) collected in this creek, stickleback were the most numerous (Figure 10). This was not surprising as stickleback are opportunistic, with regard to habitat. The habitat was not suitable for rainbow/steelhead trout, other than as a passageway for steelhead to and from Richardson Bay; the pools in which the rainbow/steelhead were collected were reinforced with cement and asphalt. Sculpin and California roach commonly inhabit sloughs such as this creek.

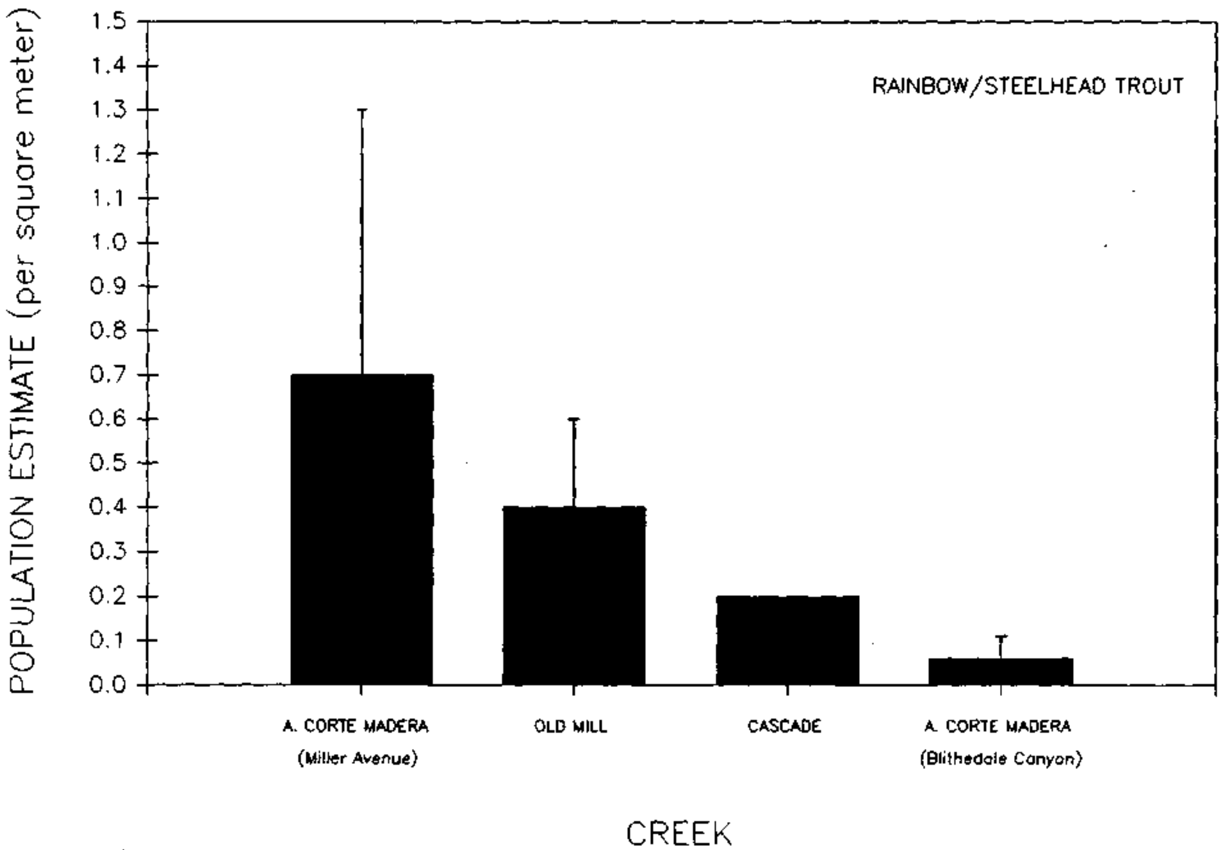

FIGURE 6. RELATIVE RAINBOW/STEELHEAD TROUT POPULATIONS IN THE CREEKS (mean ± s.e.m.)

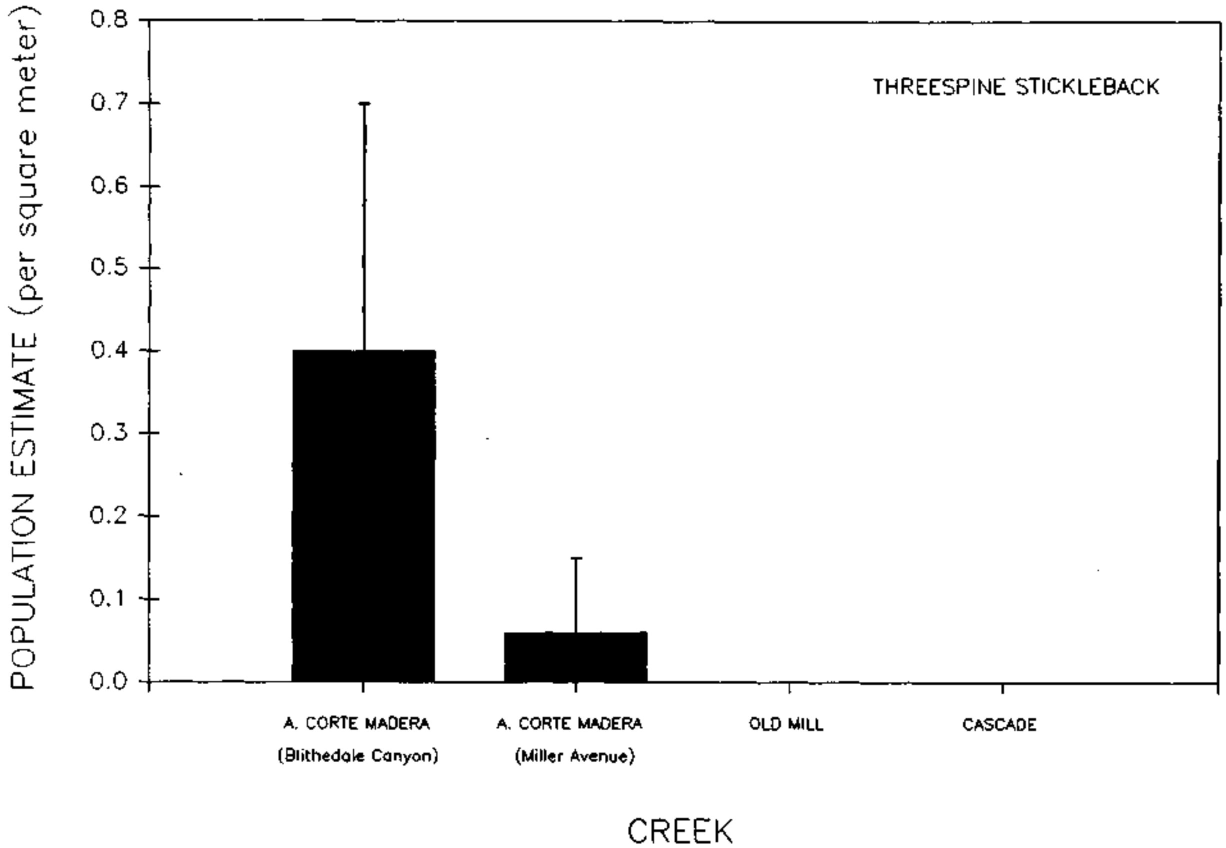

FIGURE 7. RELATIVE THREESPINE STICKLEBACK POPULATIONS IN THE CREEKS (mean ± s.e.m.)

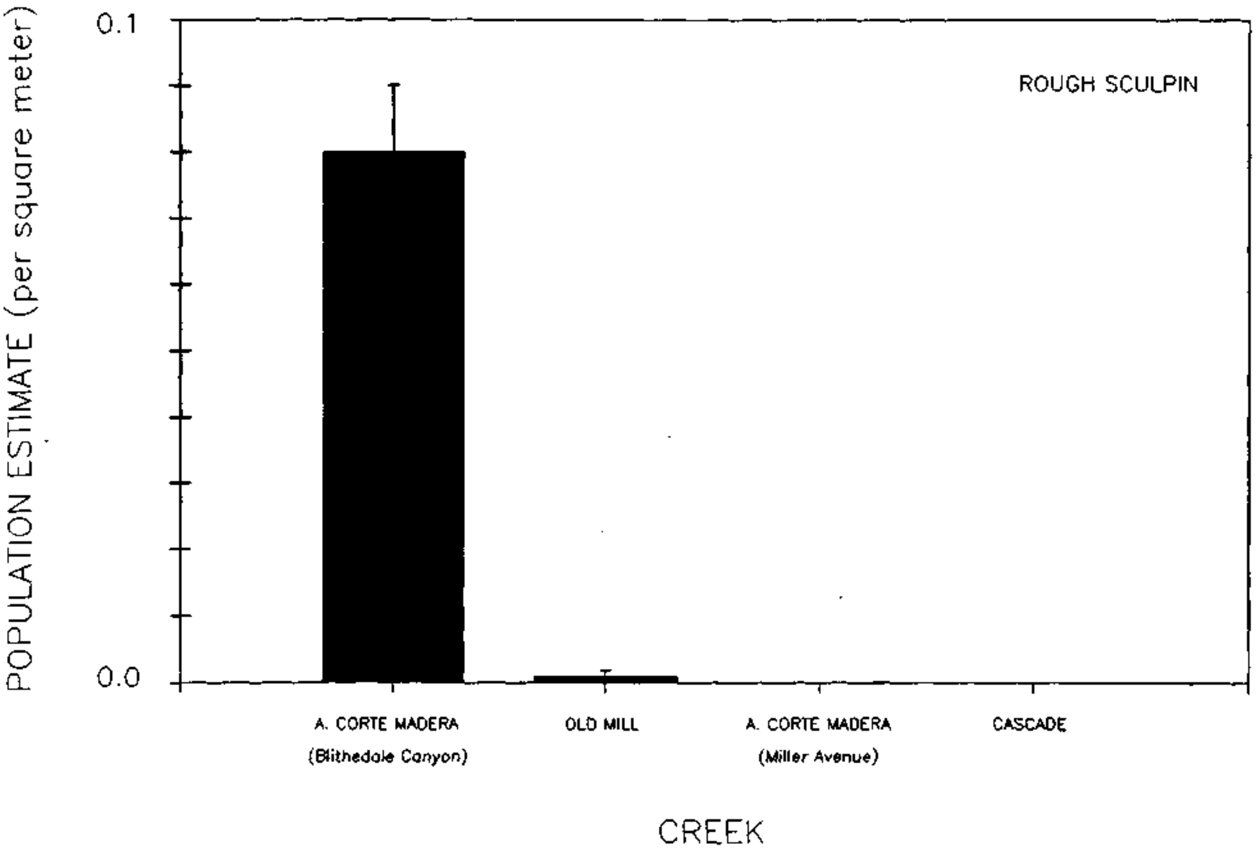

FIGURE 8. RELATIVE ROUGH SCULPIN POPULATIONS IN THE CREEKS (mean ± s.e.m.)

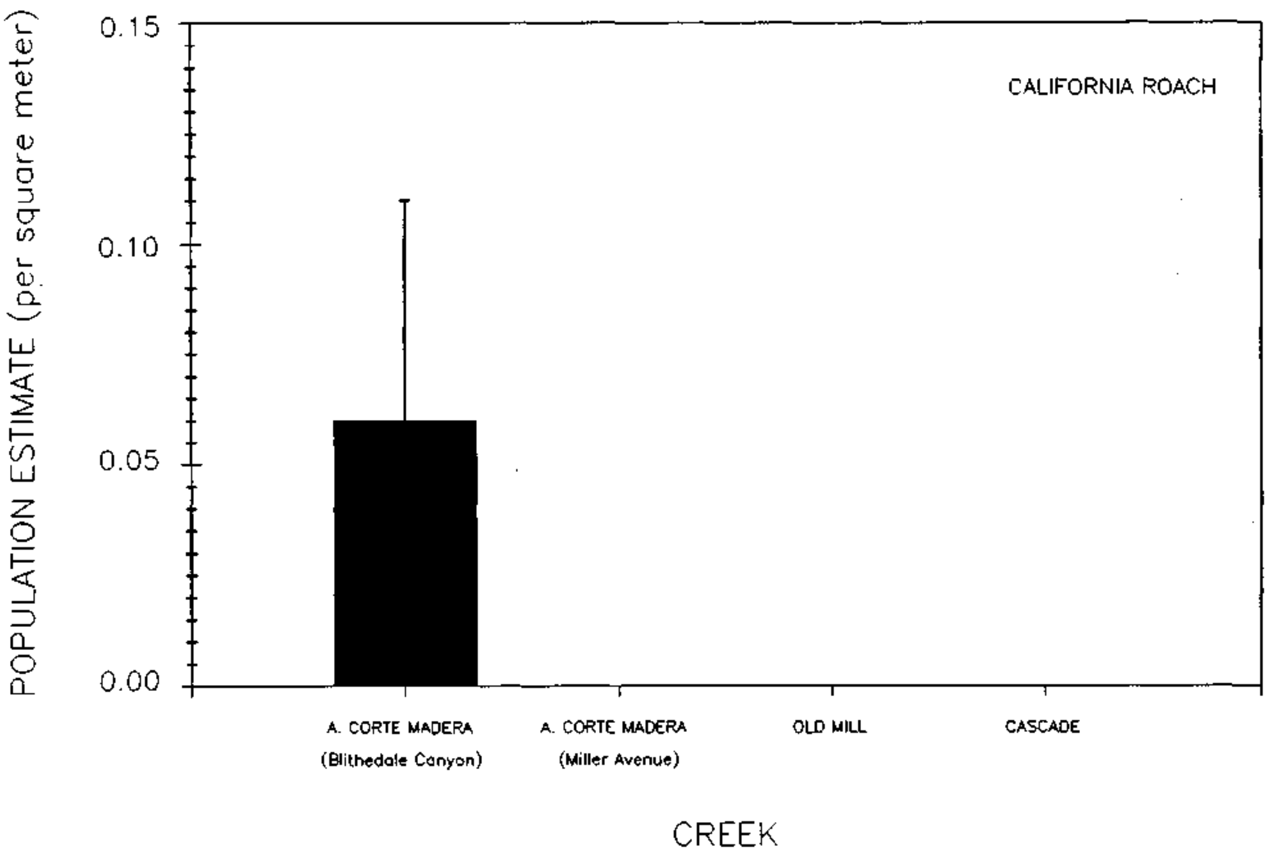

FIGURE 9. RELATIVE CALIFORNIA ROACH POPULATIONS IN THE CREEKS (mean ± s.e.m.)

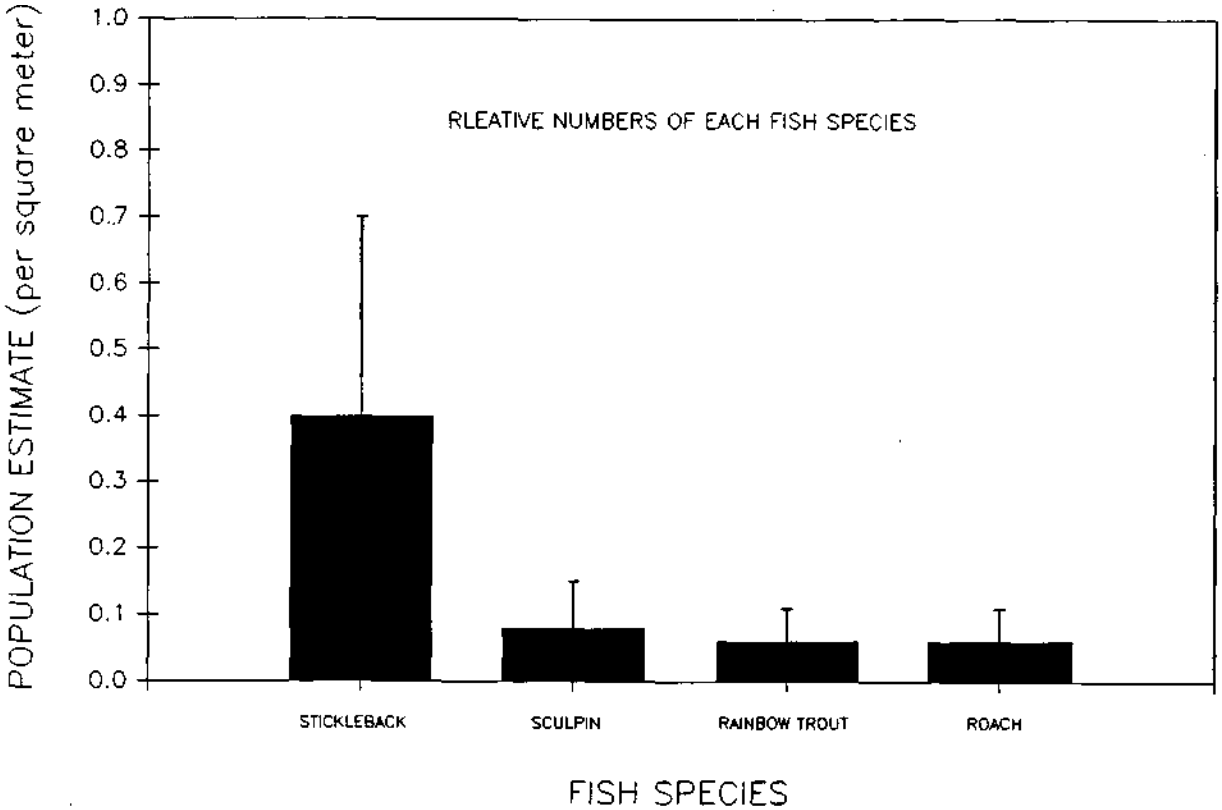

FIGURE 10. RELATIVE POPULATIONS OF FISHES IN ARROYO CORTE MADERA CREEK (mean ± s.e.m.)

2. ***Arroyo Corte*** *Madera del Presidio Creek (up Blithedale Canyon)*

Of the two fish species (rainbow/steelhead trout and stickleback) collected in this creek, rainbow/steelhead trout were more numerous (Figure 11). Most of the trout were collected in the deeper pools, associated with roots, logs, bedrock, and, in one case, a cement-walled pool at King Street. This last habitat was not suitable for the trout, but, due to the low flows, the fish were stranded.

3. Old Mill Creek

Rainbow/steelhead trout were collected at all sites in Old Mill Creek, except for two low shallow gradient riffles (Figure 12). As with the other creeks, the fish were stranded, due to the low streamflows. The best habitat consisted of the pools with structure (e.g., rootwad, boulders, logs) in them.

4. Cascade Creek

Only one juvenile rainbow/steelhead trout was collected in a small pool in Cascade Creek, on the upstream side of the culvert under Cascade Drive (Figure (13). Due to the steep gradient and low flow conditions, Cascade Creek was not suitable for juvenile trout rearing at the time of the survey.

C. AGE OF FISH SPECIES COLLECTED

1. Rainbow/Steelhead Trout

Based on the size distribution (Figure 14-16), the juvenile rainbow/steelhead trout were probably from three to four different age classes. Most of the fish were young-of-the-year fish (i.e., hatched last spring), but there were some older fish in both Old Mill and Arroyo Corte Madera del Presidio (Blithedale Canyon) creeks. The diversity of age classes of trout demonstrated that these creeks offered better habitat conditions than that of the mainstem along Miller Avenue. The habitat conditions in these creeks provided more opportunity for growth and survival (hence, more age classes) than the other creeks.

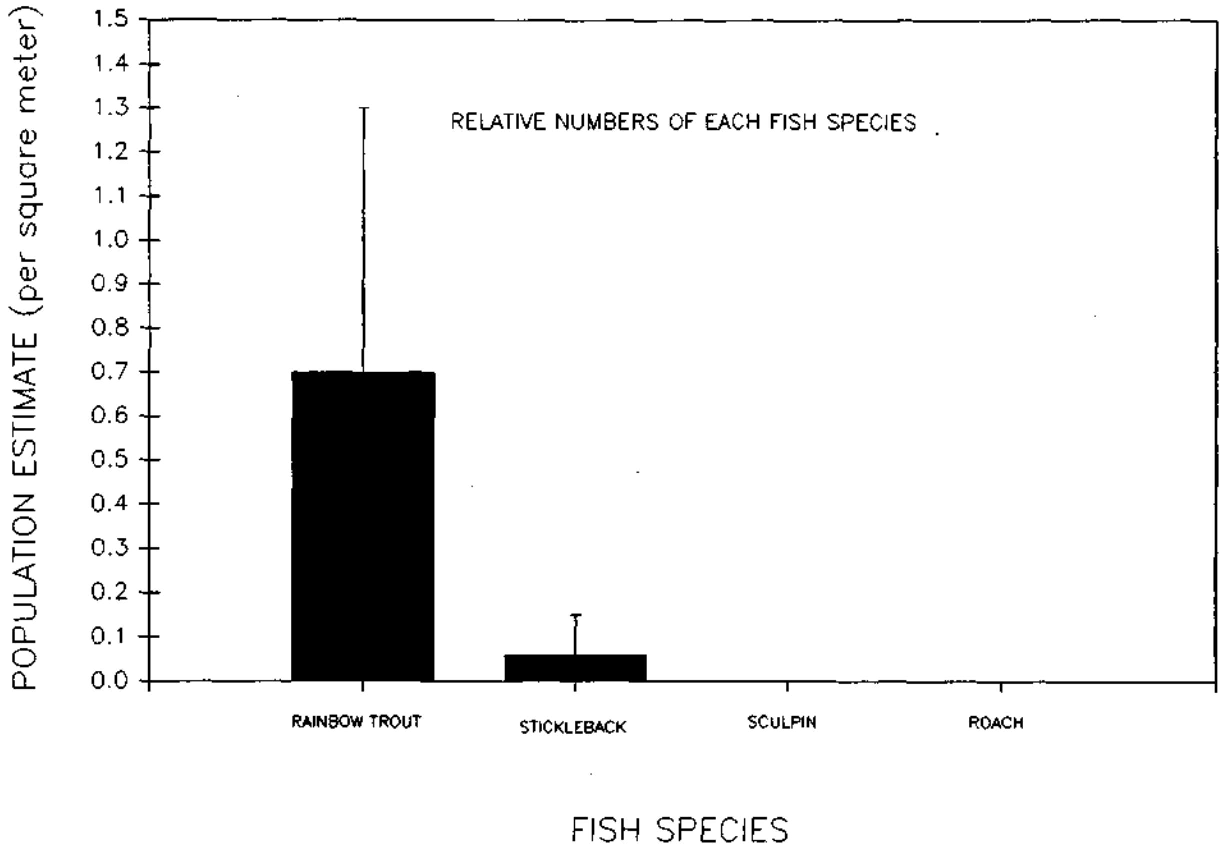

FIGURE 11. RELATIVE POPULATIONS OF FISHES IN "WIDOW REED" CREEK (mean ± s.e.m.)

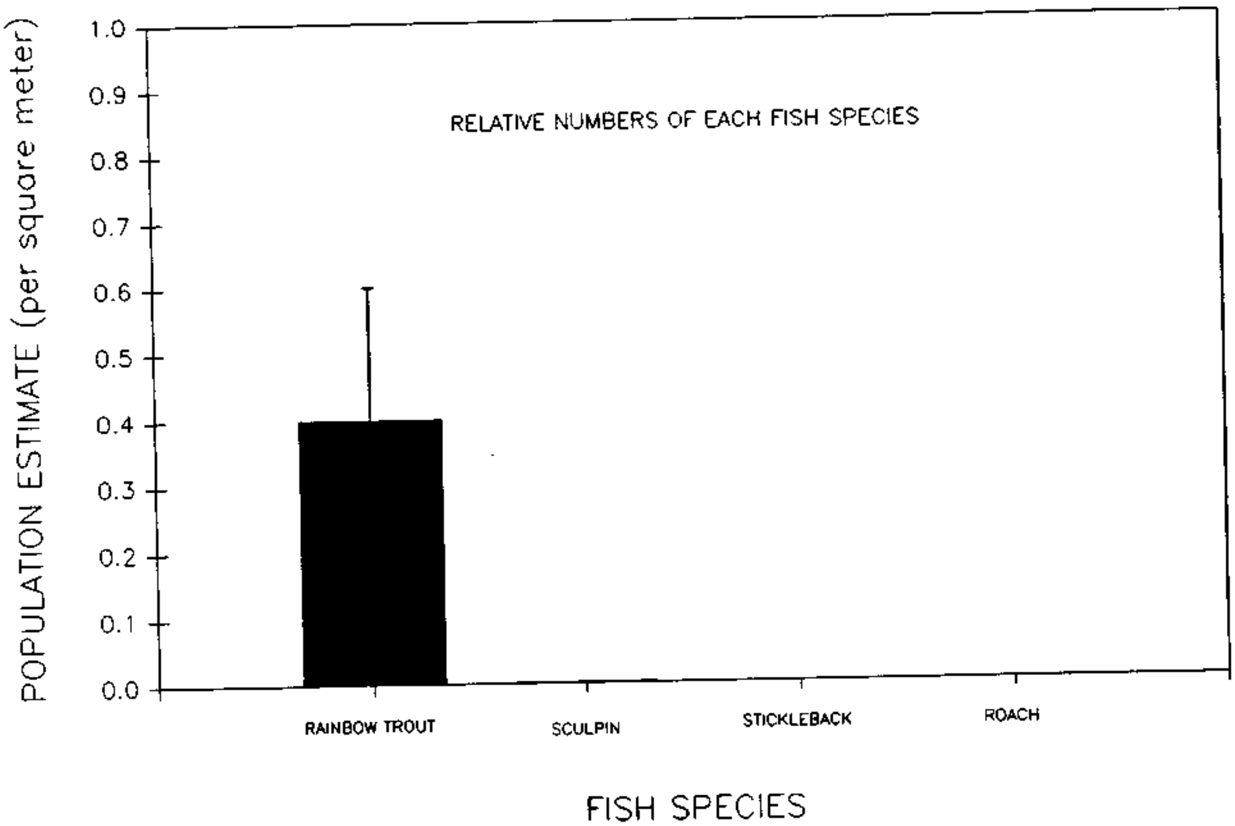

FIGURE 12. RELATIVE POPULATIONS OF FISHES IN OLD MILL CREEK (mean ± s.e.m.)

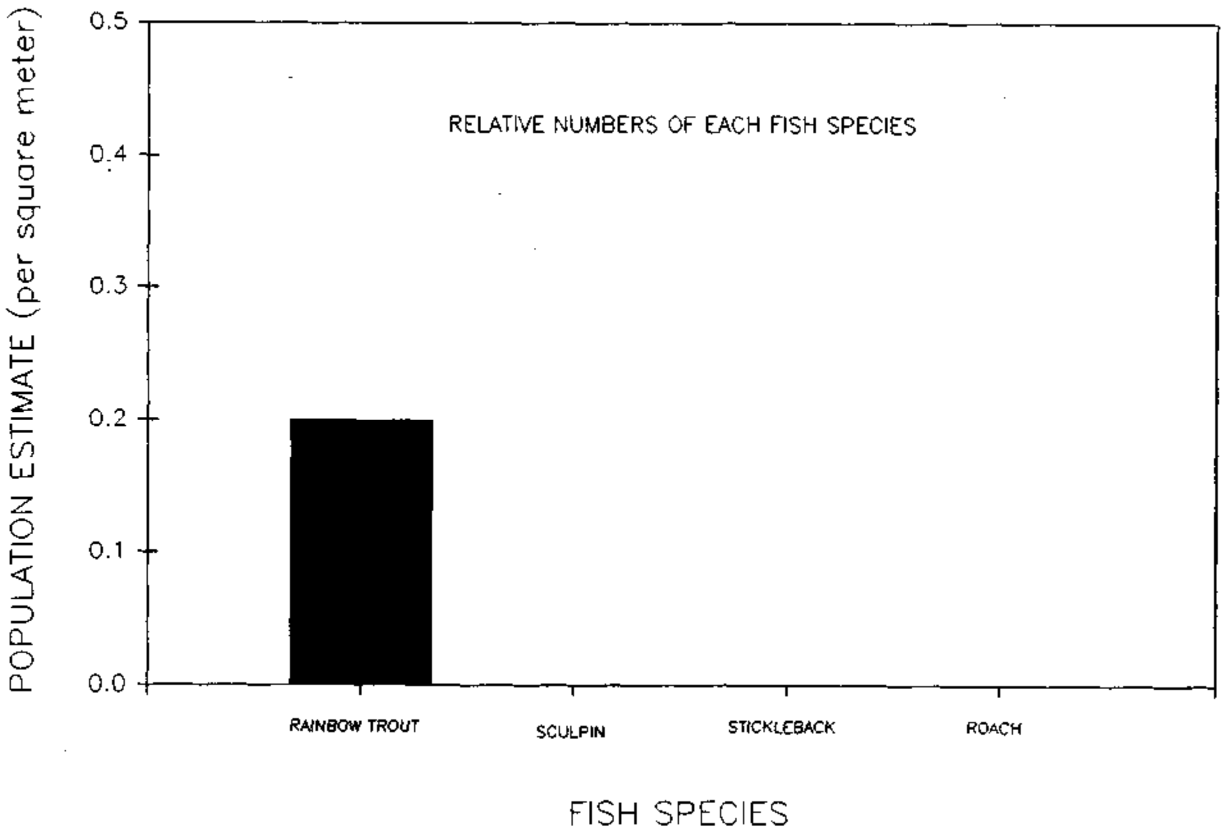

FIGURE 13. RELATIVE POPULATIONS OF FISHES IN CASCADE CREEK (mean ± s.e.m.)

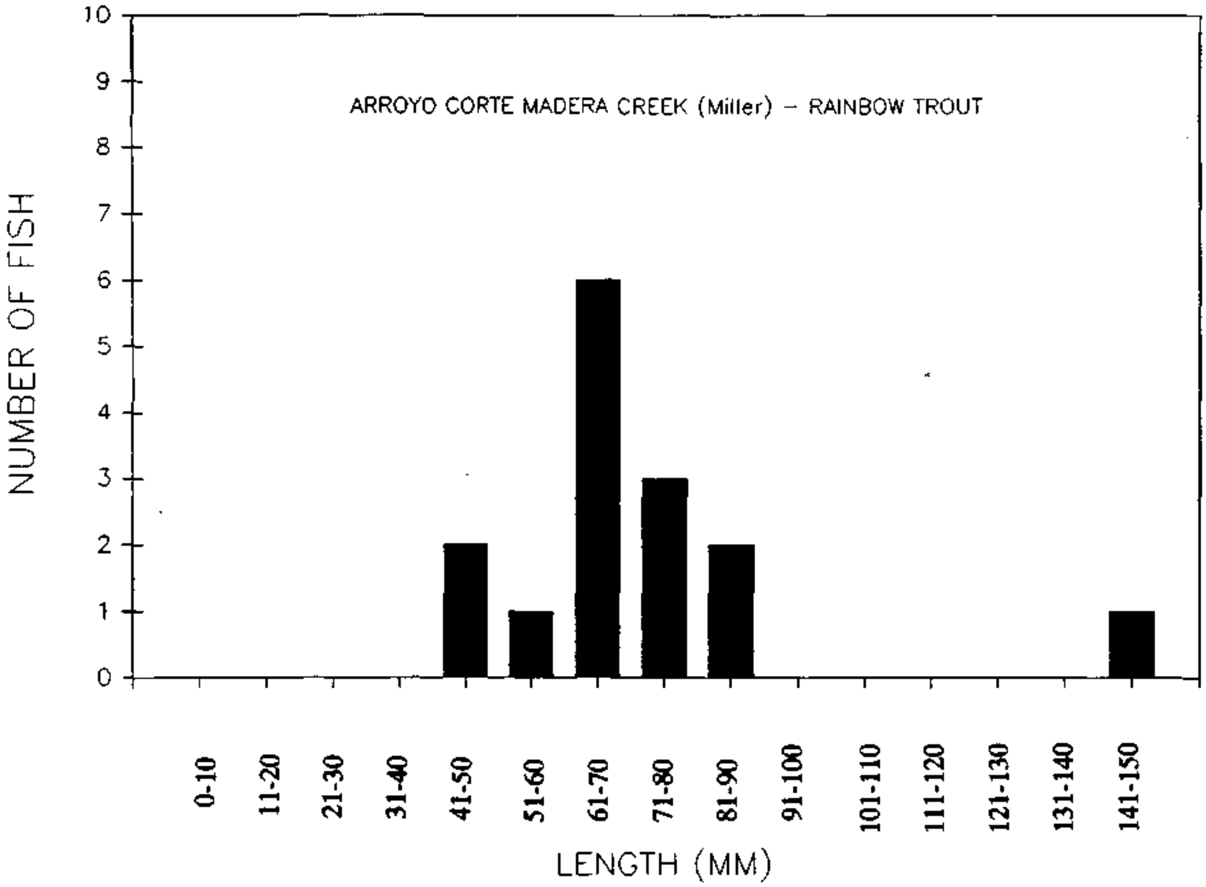

FIGURE 14. RELATIVE LENGTHS OF RAINBOW/STEELHEAD TROUT IN ARROYO CORTE MADERA CREEK (mean ± s.e.m.)

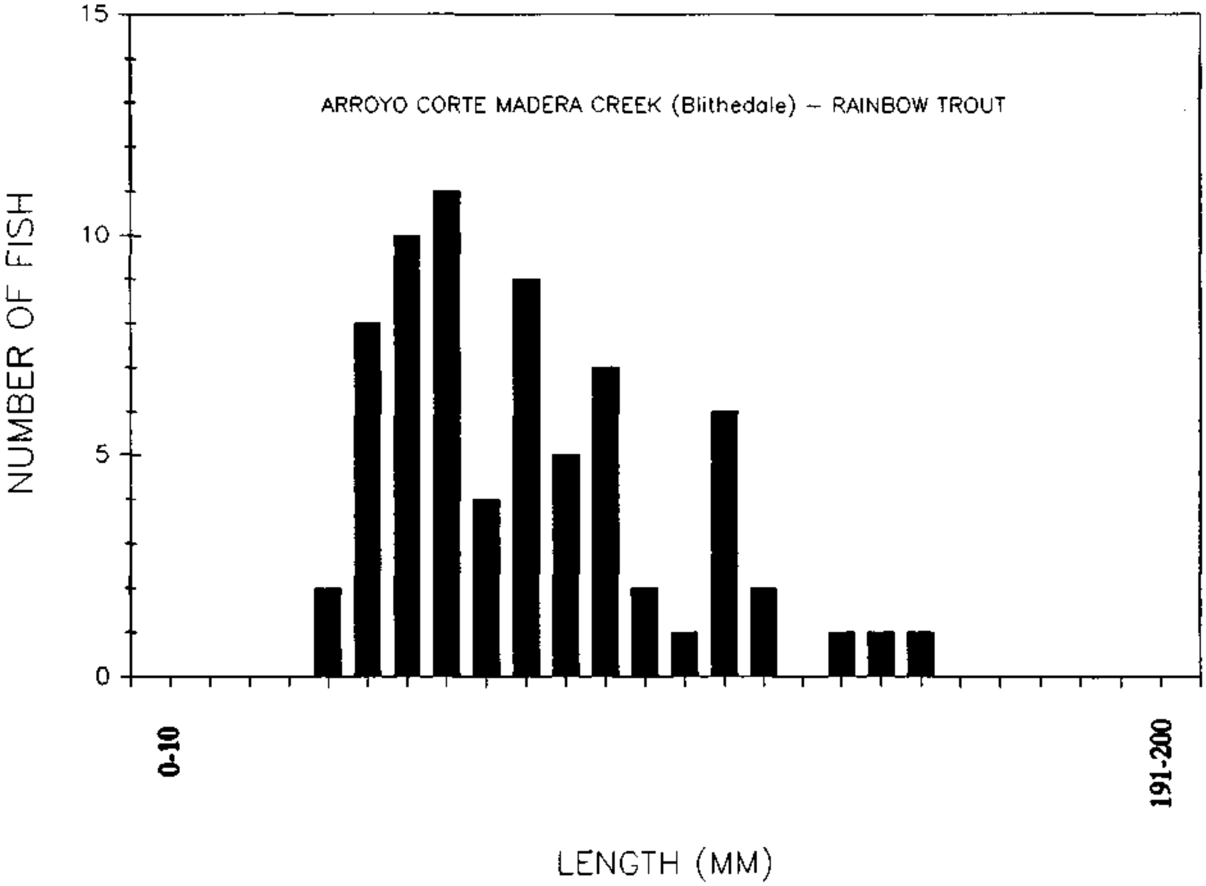

FIGURE 15. RELATIVE LENGTHS OF RAINBOW/STEELHEAD TROUT IN "WIDOW REED" CREEK (mean ± s.e.m.)

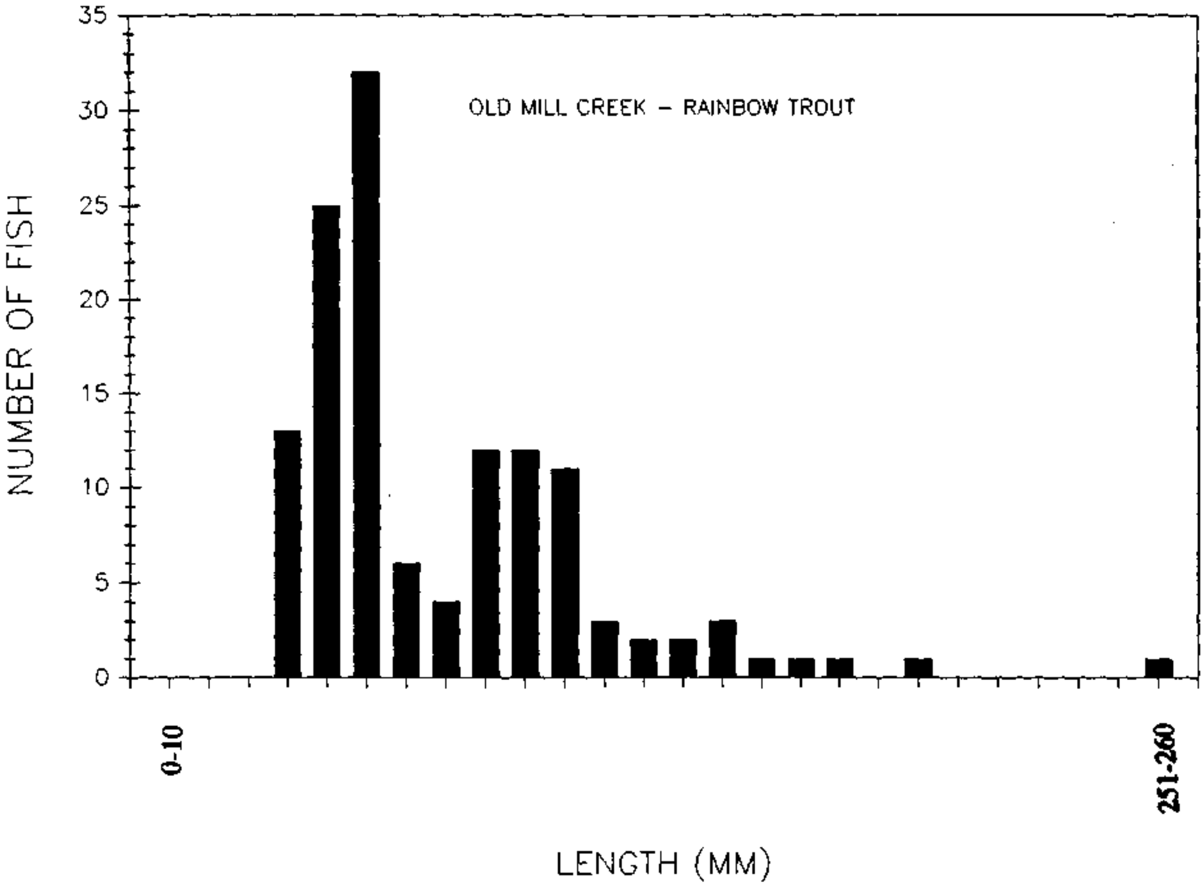

FIGURE 16. RELATIVE LENGTHS OF RAINBOW/STEELHEAD TROUT IN OLD MILL CREEK (mean ± s.e.m.)

2. Threespine Stickleback

Based on the length data, the stickleback collected were mostly young-of-the-year, although some larger speciments (probably one-two year olds) were collected in Blithedale Canyon (Figure 17-18).

3. Rough Sculpin and California Roach

Based on the length data, the age of the sculpin and roach collected probably ranged from one to four years (Figures 19 and 20).

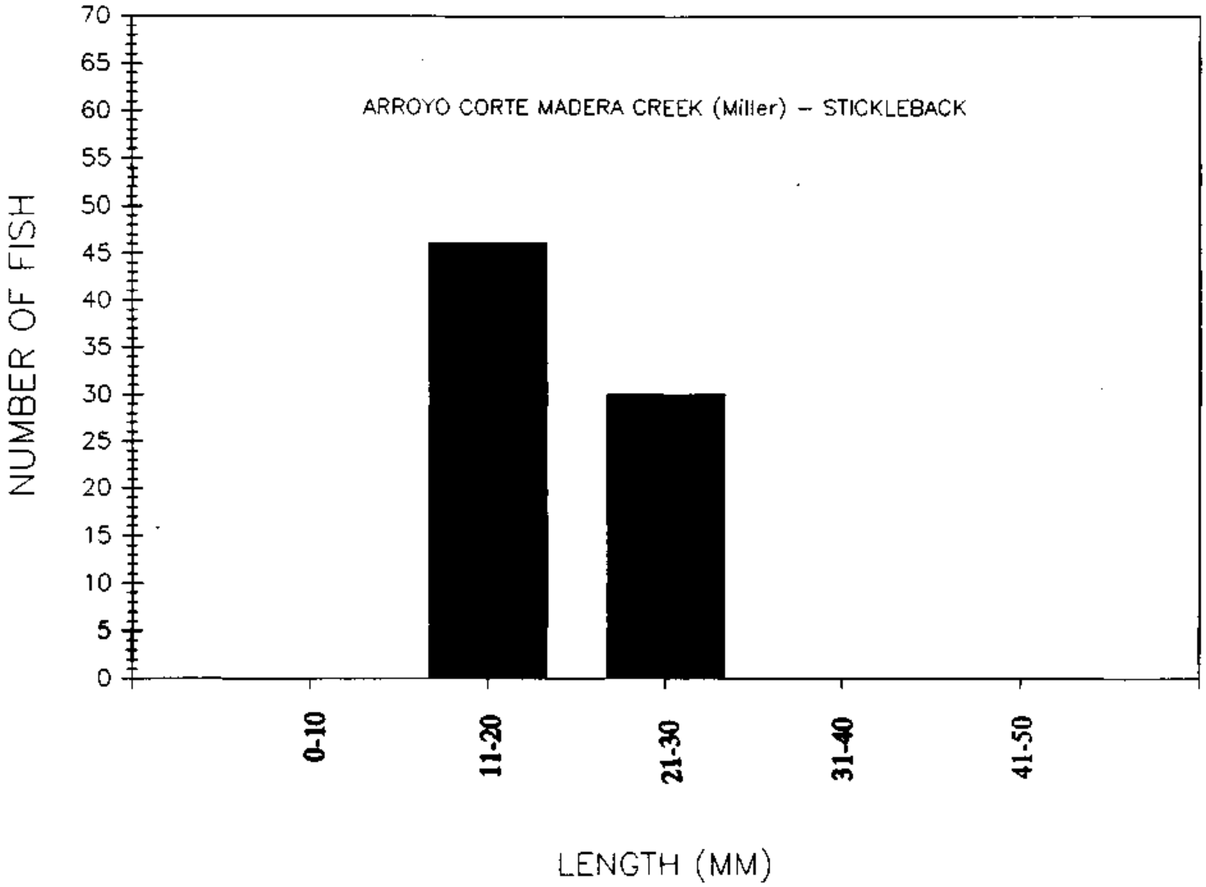

FIGURE 17. RELATIVE LENGTHS OF STICKLEBACK IN ARROYO CORTE MADERA CREEK (mean ± s.e.m.)

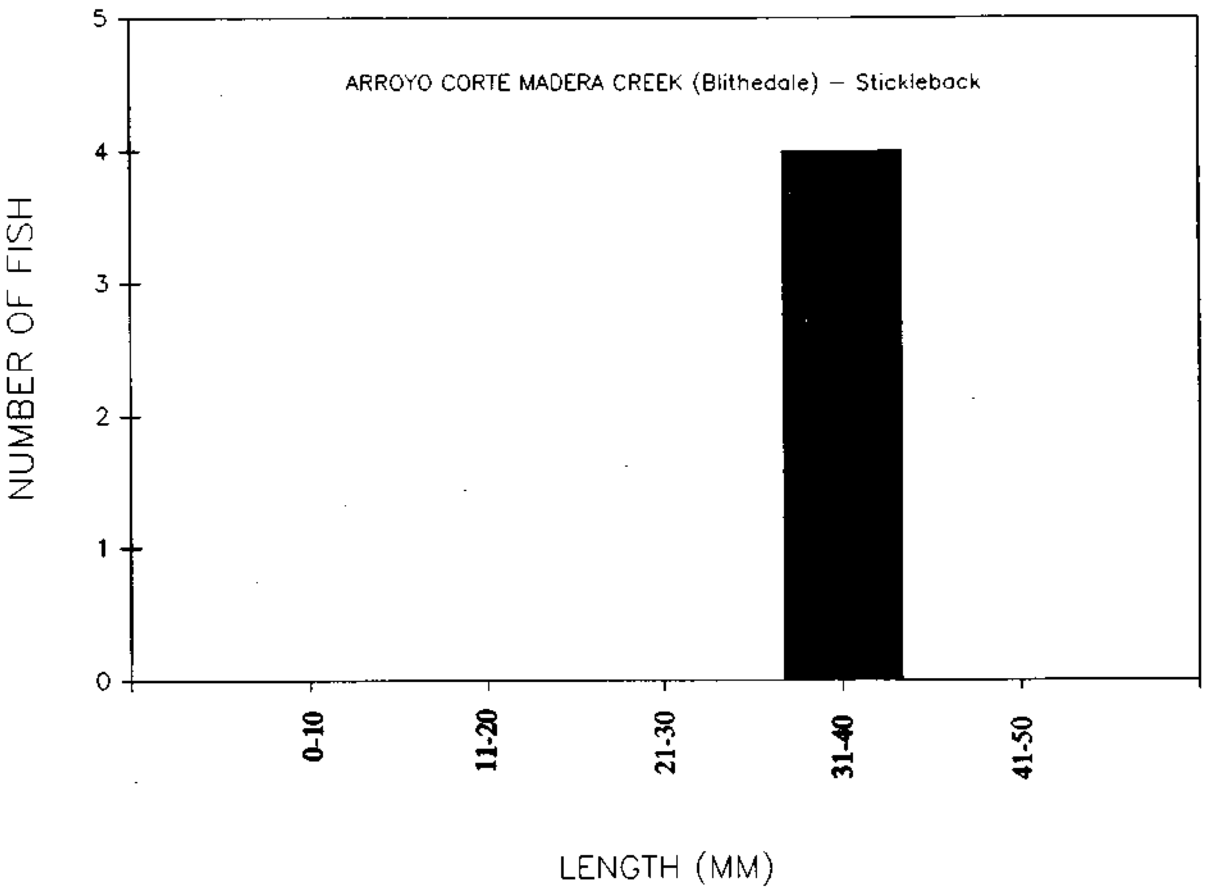

FIGURE 18. RELATIVE LENGTHS OF STICKLEBACK IN "WIDOW REED" CREEK (mean ± s.e.m.)

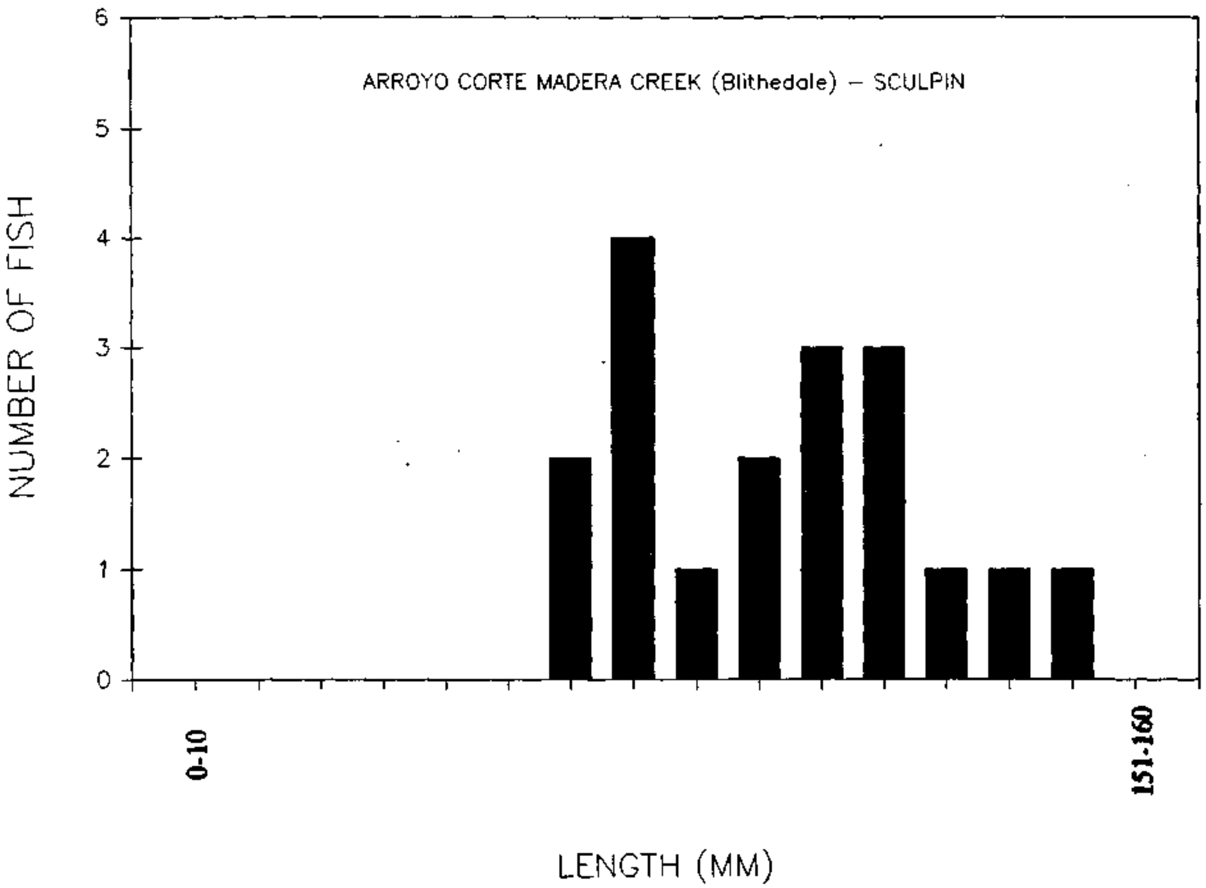

FIGURE 19. RELATIVE LENGTHS OF SCULPIN IN ARROYO CORTE MADERA CREEK (mean ± s.e.m.)

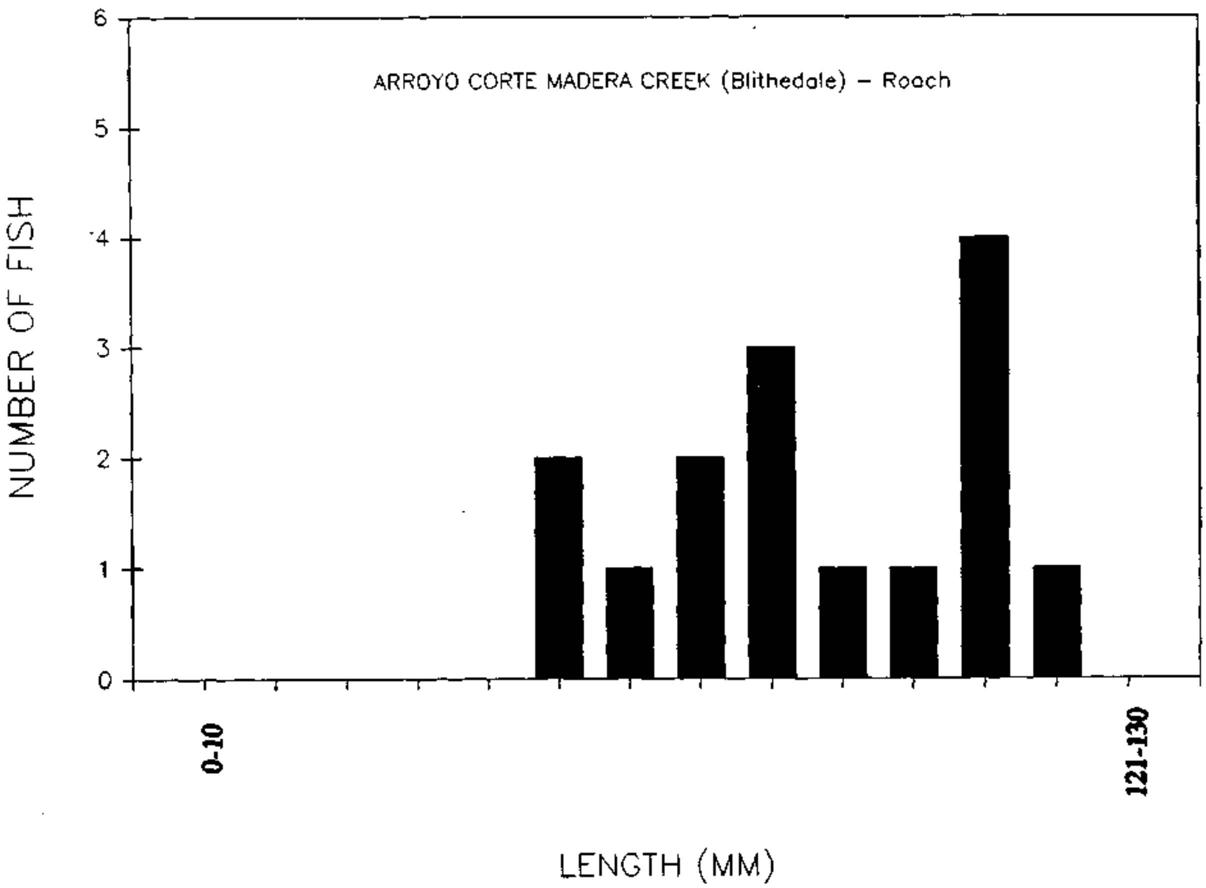

FIGURE 20. RELATIVE LENGTHS OF ROACH IN ARROYO CORTE MADERA CREEK (mean ± s.e.m.)

VIII. CONCLUSIONS

(1) Arroyo Corte Madera del Presidio (mouth upstream to the center of Mill Valley) consisted of mostly channelized habitat and is probably used primarily as a migration corridor for salmonids.

(2) Arroyo Corte Madera del Presidio (upstream of the center of Mill Valley through Blithedale Canyon) was more natural appearing than downstream, but there are remains of old summer dams, as well as large culverts.

(3) Old Mill Creek was the most natural of the creeks surveyed, from the standpoint of fish habitat.

(4) Warner Creek was highly impacted by the presence of houses (downstream sections flow under concrete and asphalt, or through a cement channel, throughout much of its course); upstream, the Mill Valley Golf Course has had, and continues to have, a negative impact on the creek.

(5) Reed Creek was an extremely narrow, channelized creek, with limited fish value at the present time.

(6) The four fish species collected in the Arroyo Corte Madera del Presidio Watershed included the rainbow/steelhead trout, threespine stickleback, rough sculpin, and California roach.

(7) Although, the highest salmonid populations were in Arroyo Corte Madera along Miller Avenue, the high density was as a result of stranding of the fish.

(8) The *limiting factor* controlling both fish abundance and diversity at the time of the survey was the lack of water.

(9) The poor habitat conditions resulting from the lack of water was exacerbated by many cement-lined channel pools, particularly from downtown Mill Valley downstream to Richardson Bay.

(10) Based on the size distribution, most of the rainbow/steelhead trout were young-of-the year and one-year olds, although there were also probably two and three year olds, as well, in Old Mill Creek.

(11) Based on the size distribution, most of the stickleback were young-of-the-year fish, although there were some larger-sized fish in Blithedale Canyon.

(12) Based on the size distribution, the sculpin and roach were represented by one through four age classes.

(13) Based on this preliminary survey, it appears feasible to improve habitat conditions in the creeks of the Arroyo Corte Madera Creek Watershed, although it will take both a great deal of citizen involvement and some more scientific studies.

IX. RECOMMENDATIONS FOR FUTURE STUDIES AND BEGINNING THE PROCESS OF PUBLIC INVOLVEMENT IN THE REHABILITATION OF THE SALMONID RESOURCES OF THE ARROYO CORTE MADERA DEL PRESIDIO WATERSHED

A. A PHASED APPROACH

One way of viewing a fish rehabilitation project which integrates science and public involvement to achieve watershed rehabilitation is to divide the project into the following phases:

- **PHASE I: Pre-Project Analysis/Fish Rehabilitation Plan**
    - Pre-project surveys to identify existing conditions (to compare with those of future conditions, once rehabilitation efforts have proceeded)
    - Management and Monitoring Plans
    - Recommendations for involving both adults and children in the project (set up a preliminary list of possibilities for review by other team members first, then the Advisory Board, and finally by the townspeople)
- **PHASE II: Implementation of Trout Rehabilitation Measures**
- **PHASE III: Monitoring results of success of project**

Clearly, this study falls within the preliminary surveys of Phase I. Although, a great deal more is needed, there are many rehabilitation measures which can begin. Possibilities include regular stream clean-ups, education of the public on how to create and maintain a healthy watershed, from the perspective of fishery resources, and, general prevention of bank erosion.

B. SOME RECOMMENDATIONS

- *Plan a Series of Field Trips for the Public, Focusing on the Fish Requirements and Rehabilitation*

  For example, it would be particularly educational to take small groups out and teach them about the fishes in their creeks. Such field trips could include comparisons of good versus bad trout habitat, what not to do, if one wants to preserve, protect, and, hopefully, enhance fishery resources.

- *Continuation of Resources Assessment*

  - *Identification of Spawning Redd Sites*

    This could be conducted with the particiption of interested citizens. However, to protect the fish, it would be necessary that such surveys be supervised by professional biologists. It is extremely easy to walk on redds and, thereby, kill the eggs and alevins. The best time to conduct these surveys is in good weather, and clear stream conditions.

  - *Determination of Quality of Salmonid Spawning Gravel*

    Determination of the quality of spawning gravel could be conducted, using McNeil Samplers. This could be done, with the assistance of volunteers, under the direction of trained fisheries biologists.

- *Smolt Trapping*

  This should never be conducted by volunteers, without assistance from trained fisheries biologists. The reason: salmonids undergoing smoltification are under stress and unnecessary handling can ultimately kill the fish or induce chronic long-term stress which, long-term, can have a negative impact on the fish.

  To identify whether or not the juvenile salmonids observed were steelhead, it would be necessary to trap the emigrating fish; it would also be determined whether or not any coho salmon were present. Such a study would provide data on the productivity of the watershed, of paramount concern for a trout-based (i.e., using salmonids as an *indicator species* of watershed health) watershed study.

  This year we could set up a pilot project, involving the community, including school children. Smolt trapping is labor intensive (daily checking of the traps from mid-March to or through June). Such a project could be conducted with the assistance of the public. Again, however, it would need to be supervised by trained fisheries biologists. One of the very real problems with trapping studies is vandalism. Hence, the logistics of where to place traps would have to be worked out prior to trapping.

- *Continue with the Summer Habitat and Population Surveys*

  Although this past summer's surveys were helpful in identifying general habitat types, species diversity, and relative numbers, the surveys were rather cursory and should be continued this next summer.

  The public (including students) could assist, under direction of trained fisheries biologists. One person could accompany the "habitat typer". One or two people could assist with recording data and setting up equipment during the electrofishing surveys.

- *Sediment/Geomorphology/Hydrology Studies Need to be Conducted*

  One of the necessary components to a fish rehabilitation project is information on the sediment load, geomorphology of the creeks, and hydrology of the creeks. This information needs to be conducted by professional scientists, if one wants to effectively rehabilitat a creek for salmonid use.

- *Set up a Stream Clean-Up this Summer, Removing Garbage and Debris*

- *Education of the Public Regarding About the Problems of Diversions from the Creeks, with regard to Trout*

- *Adopt-A-Watershed Program for Different Grade Levels*

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APPENDIX A: SAMPLE DATA SHEETS

HABITAT INVENTORY

Stream_______________ Date /__/__ T _ R___S __Reach # __ Time ___ Flow ____(cfs) Crew

SRU					
Habitat Type					
Length (m)					
Width (m)					
Depth (m)					
Cover (%): 1,2,3,4 in quarters)					
Aquatic Vegetation					
Bedrock					
Canopy					
Depth (>0.5m)					
Overhanging Vegetation					
Rocks					
Rootwads					
Turbulence					
Undercut Banks					
Woody Debris, Large (> 12")					
Woody Debris, Small (< 12")					
Other					
Substrate(2 dom.)/% Embed:(l,2,3,4)					
Silt/clay					
Sand (< 0.08")					
Gravel (0.08-2.5")					
Small Cobble (2.5-5")					
Large Cobble (5-10")					
Boulder (> 10")					
Bedrock					
Bank, Left, Dominant Composition					
Bank, Left, % Vegetation					
Bank, Right, Dominant Composition					
Bank, Right, % Vegetated					
Temperature (ºC)-Air					
Temperature (ºC)-Surface					
Temperature (ºC)-Bottom					
Photo. (Roll, Number)					

ELECTROFISHING SURVEYS

STREAM:____ SRU: _____________ DATE: ________

SHOCKERS: _________________ RECORDER: _______ WEATHER: ______________________

PAGE __ OF ___

HABITAT: ____ TIME: ______________

LENGTH, TOTAL (M) ________________________

WIDTH, MEAN (M) __________________________

DEPTH, MEAN (M)__________________________

TEMP, Air (C): _______ TEMP, H20-BOTTOM (C):_______ TEMP, H20-SURFACE (C): ______

FREQ ____ VOLTS ____ SHOCKTIME _____ SHOCKING EFFICIENCY: _________________

PHOTOS: ____ROLL – FRAME ____

____________ ____

____________ ____

____________ ____

COMMENTS: ____

PASS NO.	SPECIES	LENGTH, FORK (MM)	BIOMASS (G)	PASS NO.	SPECIES	LENGTH, FORK (MM)	BIOMASS (G)

APPENDIX B: ELECTROFISHING SITES

TABLE B-l. ELECTROFISHING SITES IN ARROYO CORTE MADERA DEL PRESIDIO CREEK (ALONG MILLER AVENUE)

SITE NUMBER	SITE LOCATION	TYPE OF HABITAT
AC-1	Across from Evergreen Avenue: downstream side of bridge	Low Gradient Riffle
AC-2	Across from Evergreen Avenue: downstream side of bridge	Lateral Scour Pool (extremely shallow) Associated with Cement Wall
AC-3	La Goma Avenue: downstream side of bridge	Pool Associated with Aquatic Vegetation (i.e., choked channel)
AC-4	Locust Avenue: downstream side of bridge	Lateral Scour Pool Associated with Redwood Roots
AC-5	Locust Avenue: upstream side of bridge	Lateral Scour Pool Associated with Cement Wall
AC-6	Willow Avenue: upstream side of foot bridge	Low Gradient Riffle
AC-7	Millwood Avenue: downstream of road	Lateral Scour Pool Associated with Cement Wall

s.e.m. = Standard Error of the Mean
( ) = Estimated Number of Fish

TABLE B-2. ELECTROFISHEMG SITES IN ARROYO CORTE MADERA DEL PRESIDIO CREEK (UP BLITHEDALE CANYON)

SITE NUMBER	SITE LOCATION	TYPE OF HABITAT
WC-1	Downstream of Sunnyside Avenue	Low Gradient Riffle
WC-2	Downstream of Sunnyside Avenue	Lateral Scour Pool Associated with Asphalt Bank
WC-3	Miller Grove Park	Lateral Scour Pool Associated with Redwood Roots
WC-4	Miller Grove Park	Mid- Water Pool (extremely shallow) Associated with Boulders
WC-5	King Street: downstream of bridge	Mid- Water Pool Associated with Cement Walls and Channel
WC-6	Marguerita Avenue: upstream of bridge	Mid- Water Pool Associated with Cement Walls and Channel

TABLE B-3. ELECTROFISHING SITES IN OLD MILL CREEK

SITE NUMBER	SITE LOCATION	TYPE OF HABITAT
OM-1	Behind Dowd's Barn	Lateral Scour Pool Associated with Cement Wall
OM-2	Behind Mill Creek Apartments (191B Throckmorton Avenue)	Lateral Scour Pool Associated with Bankcut (left bank) and Boulders (right bank)
OM-3	In Old Mill Creek at about 167 Throckmorton Avenue)	Lateral Scour Pool Associated with Bankcut (right bank) and Boulders (left bank)
OM-4	In Old Mill Creek at 297 Throckmorton Avenue	Lateral Scour Pool Associated with Boulders
OM-5	Old Mill Park at Lower Boundary	Lateral Scour Pool Associated with Rootwad (Redwood tree)
OM-6	Old Mill Park about 10 meters upstream of Lower Boundary	Mid-Channel "Pool'/Low Gradient Riffle
OM-7	Old Mill Park at Old Mill site, downstream from old dam	Mid-Channel Pool Associated with Cement Dam
OM-8	At entrance to trail to the Three Wells	Lateral Scour Pool Associated with Bedrock
OM-9	About 20 meters upstream of entrance to Three Wells	Low Gradient Riffle
OM-10	Lowermost pool at the Three Wells	Mid-Channel Pool Associated with Bedrock
OM-11	Just above culvert upstream of confluence with Cascade Creek in vicinity of 422 Cascade Drive	Cascade Associated with Bedrock (shallow)
OM-12	About 110 meters upstream of Site OM-11	Lateral Scour Pool Associated with Roots (left bank) and Boulders (right bank)
OM-13	About 15 meters upstream of Site OM-12 (just downstream of 460 Cascade Drive bridge)	Trench Pool Associated with Bedrock (shallow)
OM-14	About 200 meters upstream of Site OM-13	Pool Associated with Bankcut
OM-15	About 30 meters upstream of Site OM-14	Cascade Associated with Bedrock (shallow)

Note: Due to budget and time constraints, after three days of extensive surveys, I had to change the method of data recording for habitat typing for the rest of the surveys; as it was, we were in the field for two working weeks, and the winter was fast approaching. Habitat Data Sheets for the rest of Old Mill Creek, Cascade Creek, "Widow Creek", Reed Creek, and Arroyo Corte Madera Creek are in the form of extensive field notes, with periodic field measurements, together with photographs of each habitat type, as I proceeded up the creeks.