FACTORS INFLUENCING THE SURVIVAL OF JUVENILE STEELHEAD RAINBOW TROUT *(Salmo gairdneri gairdneri)* IN THE VENTURA RIVER, CALIFORNIA

by Mark R. Moore

June, 1980

Cover photograph: Ventura River steelhead lying in quiet water several hundred yards above the Main Street Bridge, March 29, 1947 (courtesy California Department of Fish and Game, Region 5).

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by

Mark R. Moore

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ABSTRACT

Selected portions of the Ventura River, California were examined during three consecutive summer-fall base flow periods to determine the factors influencing the survival of juvenile steelhead rainbow trout (Salmo gairdneri gairdneri).

Because of the relatively small, heterogeneous salmonid population in the Casitas Springs study area, 40,000 juvenile steelhead were marked and planted during the study to help determine factors influencing the survival of juvenile steelhead: 11,000 in June, 1976; 9,000 in June, 1977; and 20,000 in June, 1978. Survival estimates and growth rates were obtained between June and October, 1976, 1977, and 1978. Changes in the quantity and quality of juvenile steelhead rearing habitat were also recorded during the course of the study.

Although limited by man-made alterations, juvenile steelhead rearing habitat in the Ventura River was found to be productive, allowing rapid growth under summer-fall base flow conditions. The quantity and quality of juvenile steelhead rearing habitat examined remained relatively constant during the summer-fall periods of 1976 and 1977 (drought years), but underwent significant changes following heavy flooding during the winter of 1978.

Survival of planted juvenile steelhead between June and October averaged 20 percent. Survival of acclimated planted juvenile steelhead between June and October averaged 32 percent. Survival of wild steelhead and resident rainbow trout between June and October averaged 28 percent.

Growth rates of planted juvenile steelhead ranged from 1.66 cm per month to 2.8 cm per month, with the largest gains occurring during July and August, and the smallest during the fall. Planted juvenile steelhead growth was greater during the summer-fall period of 1978 (a flood year) than during the same periods of 1976 and 1977 (drought years), though the number of fish observed during the spring period of 1978 was less than the two previous years. Wild steelhead and resident rainbow trout grew at a slower rate, averaging .95 cm per month.

Survival and growth rates were influenced during the study by extreme drought and flood conditions that were exacerbated by groundwater extractions which further lowered summer-fall surface flow, and emergency flood control activities which radically altered natural channel morphology.

Management recommendations for the maintenance and rehabilitation of the steelhead population in the Ventura River include the establishment of minimum flows through the control of surface diversions and groundwater extractions, employment of less disruptive flood control measures, improvement of water quality in the lower river through the control of waste discharges to meet or exceed state and federal waste discharge requirements, and the development of a smolt rearing facility to mitigate the loss of the historic spawning and rearing areas rendered inaccessible by the construction of dams and diversions.

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I would like to express my appreciation to Mark Capelli and Edgar Henke whose work on behalf of the protection and restoration of the Ventura River and its tributaries has served as an inspiration throughout this study.

To my wife, Susy, and many close friends I am also indebted for the many long hours which were spent assisting in the collection of data.

The Ventura River study was made possible through the generous funding of the California Fisheries Restoration Foundation, California Trout, Inc., the Friends of the Ventura River, the U.S. Water and Power Resources Service (formerly the U.S. Bureau of Reclamation), and the Ventura County Fish and Game Commission. The California Department of Fish and Game and the Humboldt State University Fish Hatchery supplied juvenile steelhead, transportation, equipment, and personnel needed to complete the study.

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INTRODUCTION

The historical spawning range of steelhead rainbow trout (*Salmo gairdneri gairdneri*) included suitable coastal streams along the Pacific Coast from Alaska to the California-Mexico border, and possibly extended into Baja California (Hubbs, 1946; Shapovalov and Taft, 1954). Boydstun (1973) reported that the Ventura River is probably the southernmost stream currently supporting a steelhead run in most years. There are also scattered reports of contemporary steelhead runs in streams further south when winter and spring run-off is sufficient to allow upstream migration. Cooper (1976) and Swift (1975a) have reported adult steelhead in the Santa Clara River and Malibu Creek (8 and 64 kilometers south of the Ventura River). The Santa Margarita River, which discharges to the ocean 30 kilometers north of the California-Mexico border, has also been reported to support a contemporary run of steelhead (Swift, 1975b).

Except for occasional stream checks by the California Department of Fish and Game, there have been no systematic studies of the contemporary steelhead runs in southern California coastal streams. Consequently, little is known about their origin, composition, size, frequency, or timing.

Prior to 1948, the Ventura River was reported to be a highly productive trout and steelhead stream, with perennial surface flow occurring along most of its length except during drought years. Although early data are lacking, it is believed that a native resident rainbow trout population historically existed in the Ventura River along with a population of migratory steelhead. Fry (1938) described the Ventura River as one of the few streams in southern California where trout could be taken as far down as the ocean, and included the river in an angler's list of "consistently good streams in southern California". Other early commentators (Chase, 1913; Chittenden, c. 1885) have reported an abundance of catchable-sized rainbow trout throughout the year.

Accounts of large and consistent runs of steelhead have also been related by early observers (Combs, 1971; Fry, 1973; Henke, 1970; Hubbs, 1946; Kreider, 1948). Clanton and Jarvis (1946) estimated that a minimum average run of between 2,000 and 2,500 adult steelhead annually entered Matilija Creek, a tributary which they believed received 50 percent of the adult steelhead entering the Ventura River system. Since 1948, the trout and steelhead habitat of the main stem of the Ventura River has been significantly degraded and the river's major spawning tributaries have been rendered inaccessible to migrating adult steelhead as a result of the contruction of dams, increased groundwater extraction, streambed alterations, and pollution. The resident rainbow trout population in the main stem of the river is confined during most years to a few short reaches with adequate perennial surface flow; the number of steelhead entering the river to spawn is estimated to be no more than one or two hundred adults per year.

Despite man-made modifications in the Ventura River basin, anglers still report taking resident rainbow trout and juvenile steelhead during the summer and fall, as well as a few adult steelhead during the winter and spring steelhead angling season. In recent years, considerable interest has been expressed in the protection of the existing fishery of the Ventura River and the rehabilitation of the steelhead fishery (California Department of Water Resources, 1979; U.S. Water and Power Resources Service, 1980; Ventura County Fish and Game Commission, 1973).

The objective of this investigation was to identify the factors influencing the survival of juvenile steelhead in the spawning and rearing habitat remaining accessible to adults migrating in the Ventura River system. Particular attention was focused on the rearing habitat conditions prevailing during the critical summer-fall base flow periods in order to determine:

1. the quantity and quality of the remaining juvenile steelhead rearing habitat;
2. the percentage of young of-the-year steelhead which may be expected to survive the critical summer-fall base flow periods;
3. the growth rate of juvenile steelhead during the summer-fall base flow periods.

In addition, significant environmental changes occurring throughout the year were evaluated to determine their influence on the survival and growth of rearing juvenile steelhead.

Accurate information about these factors should aid in the management of the existing steelhead population of the Ventura River and provide information useful for developing the full potential of the remaining steelhead rearing habitat in the Ventura River system.

The Ventura River study began in June, 1976 and concluded in December, 1978, encompassing three complete summer-fall cycles.

DESCRIPTION OF VENTURA RIVER SYSTEM

Ventura River and Tributaries

The Ventura River is the northernmost major coastal stream in southern California (Lantis, et al., 1970). It discharges to the Pacific Ocean near the west end of the City of San Buenaventura, approximately 97 kilometers north of Los Angeles and 48 kilometers south of Santa Barbara. The Ventura River drainage is fanshaped, and covers approximately 586 square kilometers. Upland portions of the watershed consist of steep narrow canyons, while the main stem of the river lies in a relatively broad valley. The main stem of the Ventura River orginates at the junction of Matilija Creek and the North Fork of the Ventura River and is approximately 25 kilometers long. It flows in a southerly direction, terminating in a small estuary which is subject to tidal activity when not closed by a sand bar. The sand bar at the mouth of the estuary is regularly breached during the summer and fall as river flows back up behind the bar. During the winter months the sand bar remains open continuously as the result of increased river flow. When full, the estuary covers approximately 1.5 surface hectares and has a depth ranging from .6 to 2.4 meters.

The principal tributaries of the Ventura River include the North Fork of the Ventura River, Matilija Creek, San Antonio Creek and Coyote Creek (U.S. Army Corps of Engineers, 1971, 1973). Figure 1 shows the Ventura River basin with the major tributaries of the Ventura River system.

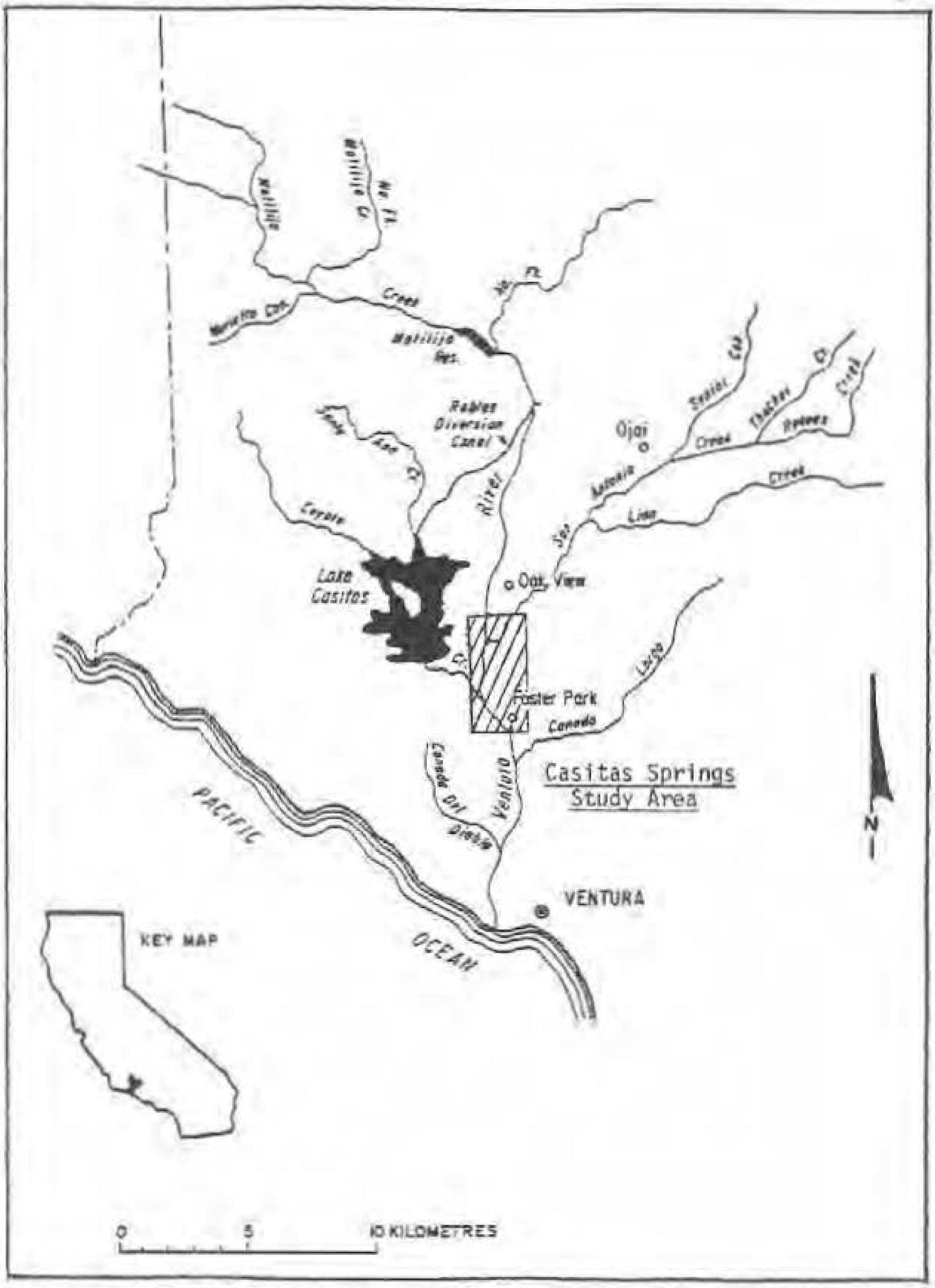

Figure 1. Ventura River Basin

The North Fork of the Ventura River originates in the headwaters of the basin and has a steep mountainous drainage which covers 41 square kilometers. The average gradient of the North Fork of the Ventura River is approximately 87 meters per kilometer. The longest course of flow is 8 kilometers. The North Fork of the Ventura River joins Matilija Creek to form the main stem of the Ventura River approximately 26 kilometers upstream from the river's mouth.

Matilija Creek originates in the northwest quadrant of the basin and drains approximately 145 square kilometers with an average gradient of 38 meters per kilometer. Matilija Creek is fed by two major tributaries, the North Fork of Matilija Creek and Murietta Creek. The longest course of flow through this area is 25 kilometers. As noted above, Matilija Creek joins the North Fork of the Ventura River to form the main stem of the Ventura River.

San Antonio Creek originates in Senior Canyon on the southerly slopes of the Topa Topa Mountains in the northeast quadrant of the basin; it has a drainage of 135 square kilometers and an average gradient of approximately 11 meters per kilometer. Major tributaries to San Antonio Creek include Gridley, Thacher, Reeves, and Lion Creeks. The longest course of flow through this area is 18.4 kilometers. San Antonio Creek joins the Ventura River 13 kilometers upstream from the river's mouth in an area known as Casitas Springs.

Coyote Creek orginates on the southern slopes of the Santa Ynez Mountains in the southwest quadrant of the basin; it has a drainage of 106 square kilometers and an average gradient of 49 meters per kilometer. Santa Ana Creek is the principal tributary to Coyote Creek. The longest course of flow through this area is 21 kilometers. Coyote Creek (now dry below the Casitas Dam except for short periods following heavy local run-off or spillage from the Casitas reservoir) joins the Ventura River 9.7 kilometers upstream from the river's mouth in an area known as Foster Park.

Prior to the development of extensive water diversion and storage facilities, the major tributaries of the Ventura River were accessible to migrating steelhead and served as the principal spawning and rearing habitat in the river system. Today, only the middle reach of the main stem of the Ventura River and San Antonio Creek are accessible to steelhead and provide suitable spawning and rearing habitat.

Climate and Rainfall

The climate of the Ventura River basin is characterized by two distinct seasons; a cool, wet winter from November through April, and a dry, warm summer from May through October (Bailey, 1966). The majority of the precipitation falls as rain and occurs from December through March in most years with the annual amount of precipitation varying widely from year to year. The average annual rainfall for the basin also varies considerably, ranging from 40 centimeters near the river's mouth at the Pacific Ocean to approximately 102 centimeters in the mountainous areas of the basin. The average annual rainfall for the entire basin is approximately 56 centimeters. Snow is common during the winter months in the higher elevations, but does not normally contribute significantly to the annual stream run-off (U.S. Army Corps of Engineers, 1971). Figure 2 shows annual rainfall totals for the years of the study and long term annual averages for three locations in the Ventura River basin (Ventura County Flood Control District, 1978).

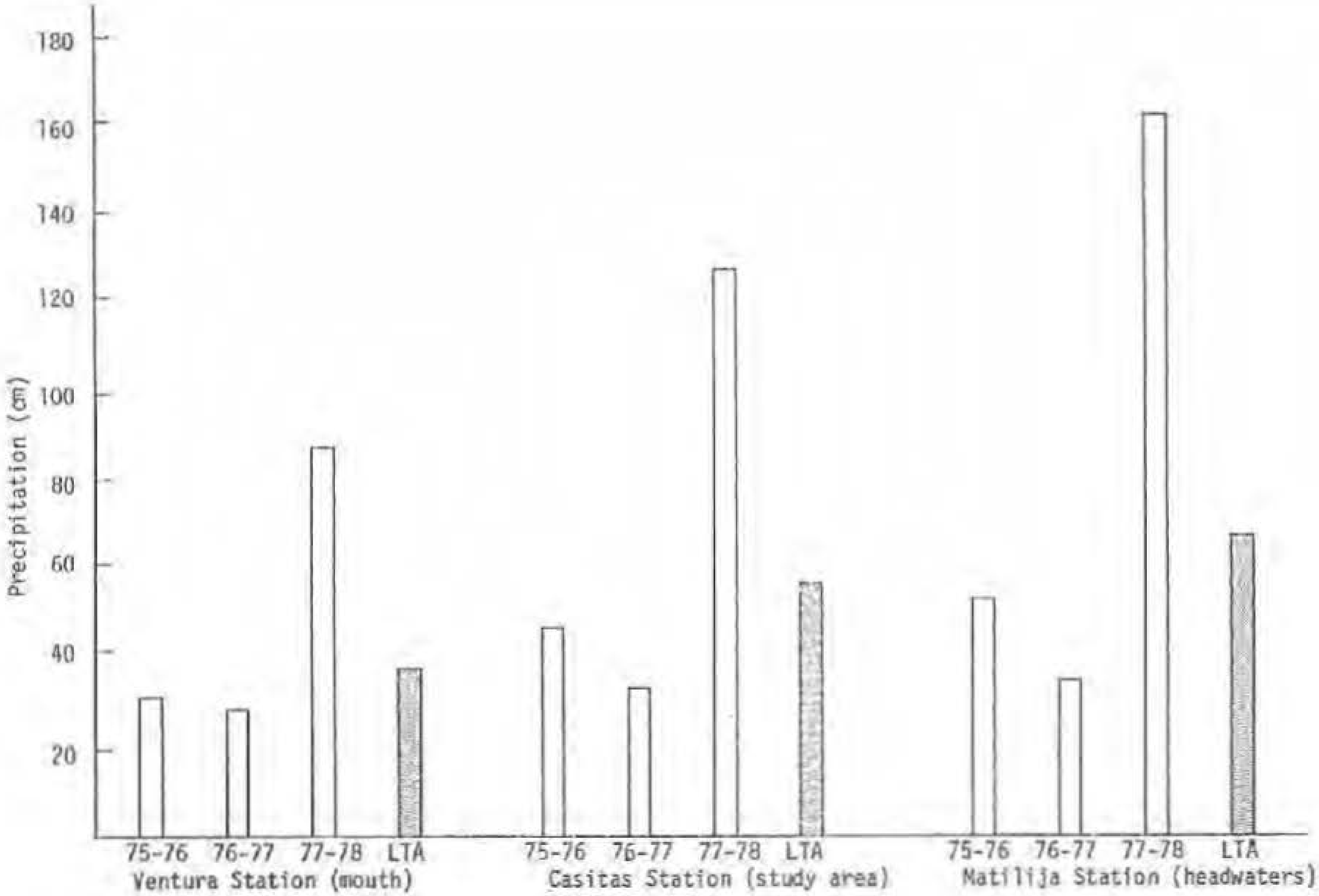

Figure 2. Annual Rainfall Totals for 1976-1978 and Long Term Averages at Three Locations in the Ventura River Basin.

Geology and Hydrology

The Ventura River basin forms part of the Transverse range of southern California (Putnam, 1942) and is characterized by steep coastal mountains and narrow canyons which converge to form a comparatively broad, level central valley. The ratio of mountainous and foothill area to valley area is greater than six to one. The crest of the mountains along the boundary of the watershed commonly rises to over 1,524 meters, and in a few areas rises to a height of 1,828 meters. Much of the river basin lies within the Los Padres National Forest.

Approximately 85 percent of the area within the Ventura River basin is composed of relatively impervious deposits (Turner, 1971; U.S. Army Corps of Engineers, 1940). The exposed rock material is sedimentary in origin and generally easily erodible. The primary geologic formations include well cemented and interbedded sandstones, shales, and conglomerates which produce little water except along joints and fractures. The streambed of the lower two-thirds of the Ventura River widens to a relatively broad plain composed of pervious materials which are subject to high percolation. These materials consist of alluvial deposits of silt, sand, gravel, cobbles, and boulders common to southern California coastal streams.

The main stem of the Ventura River is classified as an interrupted stream, made up of perennial reaches with intervening intermittent reaches. Under present conditions, the Ventura River maintains a perennial surface flow from its headwaters to the Robles Diversion Dam, a distance of approximately 10 kilometers. The next 12.8 kilometers, from the Robles Diversion Dam to the confluence of San Antonio Creek is intermittent, carrying a surface flow only for short periods during and followmajor rain storms. The 3.2 kilometers from the confluence of San Antonio Creek to Foster Park maintains a perennial surface flow, with some desiccation occurring in the Foster Park area during drought years as a result of municipal groundwater extraction. Surface flow in this reach of the river is made up of flows from San Antonio Creek, Live Oak Acres Creek, several small springs, and rising groundwater. Of special significance is a geologic discontinuity or natural obstruction in the Ventura River alluvium in the vicinity of Casitas Springs. This feature obstructs the sub-surface flow in the Ventura River above the confluence of San Antonio Creek causing groundwater to rise and flow as a surface stream. This rising groundwater contributes to the perennial surface flow below the confluence of San Antonio Creek (Casitas Municipal Water District and City of San Buenaventura, 1978). The lower 9.6 kilometers of the river from Foster Park to the Pacific Ocean also normally maintains a perennial surface flow (made up of the same sources as the Casitas Springs reach), but is augmented by the discharge from the Oak View Sanitary District's sewage treatment plant.

Vegetation

Chaparral is the dominant plant community of the mountainous portions of the Ventura River basin. At the highest elevations which form the hydrographic boundary of the basin, the chaparral community is bordered by a coniferous forest. The plant communities found at lower elevations in the basin include southern oak woodland, riparian woodland, coastal sage scrub, coastal strand, and coastal fresh and saltwater marsh. The composition of the riparian plant community varies with the stream altitude and gradient. Large tree species, such as Black cottonwood (Populus trichocarpa), California sycamore (Platanus racemosa), and White alder (<u>Alnus rhombifolia</u>) predominate in the higher stream elevations, while shrub-like species such as Willow (<u>Salix spp.</u>) are dominant at the lower elevations where periodic flooding inhibits the establishment of mature tree species. There is also an extensive littoral and lotic plant community in the lower reaches of the Ventura River from the confluence of San Antonio Creek to the Pacific Ocean.

Man-Made Features

The Ventura River bisects several unincorporated communities as well as the City of San Buenaventura. These areas have experienced rapid expansion since 1946 (Bjelland, 1951; Le Resche, 1951; Reith, 1962). The establishment and growth of these communities has resulted in significant modification of the Ventura River (Browne, 1974; Thomas Stetson Civil and Consulting Engineers, Inc., 1964).

The development of water supply systems in the Ventura River basin have had the most significant impacts on the fishery resources of the Ventura system. Principal water development facilities include Matilija Dam on Matilija Creek (completed in 1948); Robles Diversion Dam on the main stem of the Ventura River (completed in 1958); Casitas Dam on Coyote Creek (completed in 1958); and the Foster Park Diversion on the lower main stem of the Ventura River (completed in 1906). In addition to these facilities, there are a number of private and municipal wells which draw on the Ventura River aquifer. These facilities have had an impact on fishery resources in the Ventura River system by: a) reducing the magnitude and duration of peak discharges; b) reducing the duration and magnitude of between-storm-flows; c) increasing the extent and duration of desiccation of stream sections; and d) blocking or inhibiting the

the passage of adult steelhead to historically important spawning and rearing habitat in the river's major tributaries.

The construction of a municipal sewage treatment plant, along with individual industrial discharges and the installation of domestic septic systems below Foster Park have also contributed to the degradation of water quality in the lower main stem of the Ventura River. Agricultural developments and urbanization have also constituted significant non-point sources of pollution in the lower river system (Winters, 1971).

Urbanization in the Ventura River basin has also led to the construction of flood control facilities and periodic channel modifications after major floods to protect private property and public facilities. Urban encroachment into the flood plain and the subsequent development of flood control facilities and maintenance procedures has resulted in the continued disruption of the natural river morphology and associated plant communities which constitute critical elements of the fish habitat in the Ventura River basin.

DESCRIPTION OF CASITAS SPRINGS STUDY AREA

A section of the Ventura River below the confluence of San Antonio Creek near the community of Casitas Springs was selected for study because it retains perennial surface flow of high quality and is believed to provide the principal spawning and rearing habitat remaining accessible to steelhead in the Ventura River system. Studies were conducted in this area to determine survival, growth rates, and population densities. Figure 3 shows the channel configuration of the Casitas Springs study area.

Perennial surface flow in the Casitas Springs reach of the Ventura River persists even in drought years as a result of a natural obstruction in the river's alluvium near the confluence of San Antonio Creek. This hydrologic discontinuity causes groundwater to rise, thereby augmenting surface flow in years of average or above average run-off and ensuring base flow during years of below average run-off. The upper end of the study area was delimited by this rising groudwater; the lower end of the study area was delimited by the City of San Buenaventura's surface diversion at Foster Park. The length of the study area varied during the course of the study in response to rainfall and run-off as discussed below.

Base flows immediately above and below the City of San Buenaventura's Foster Park diversion are substantially reduced during most years as a result of surface water diversions and the operation of the municipal wells immediately upstream of the surface diversion by the City of San Buenaventura. A small sub-surface flow usually passes around the eastern

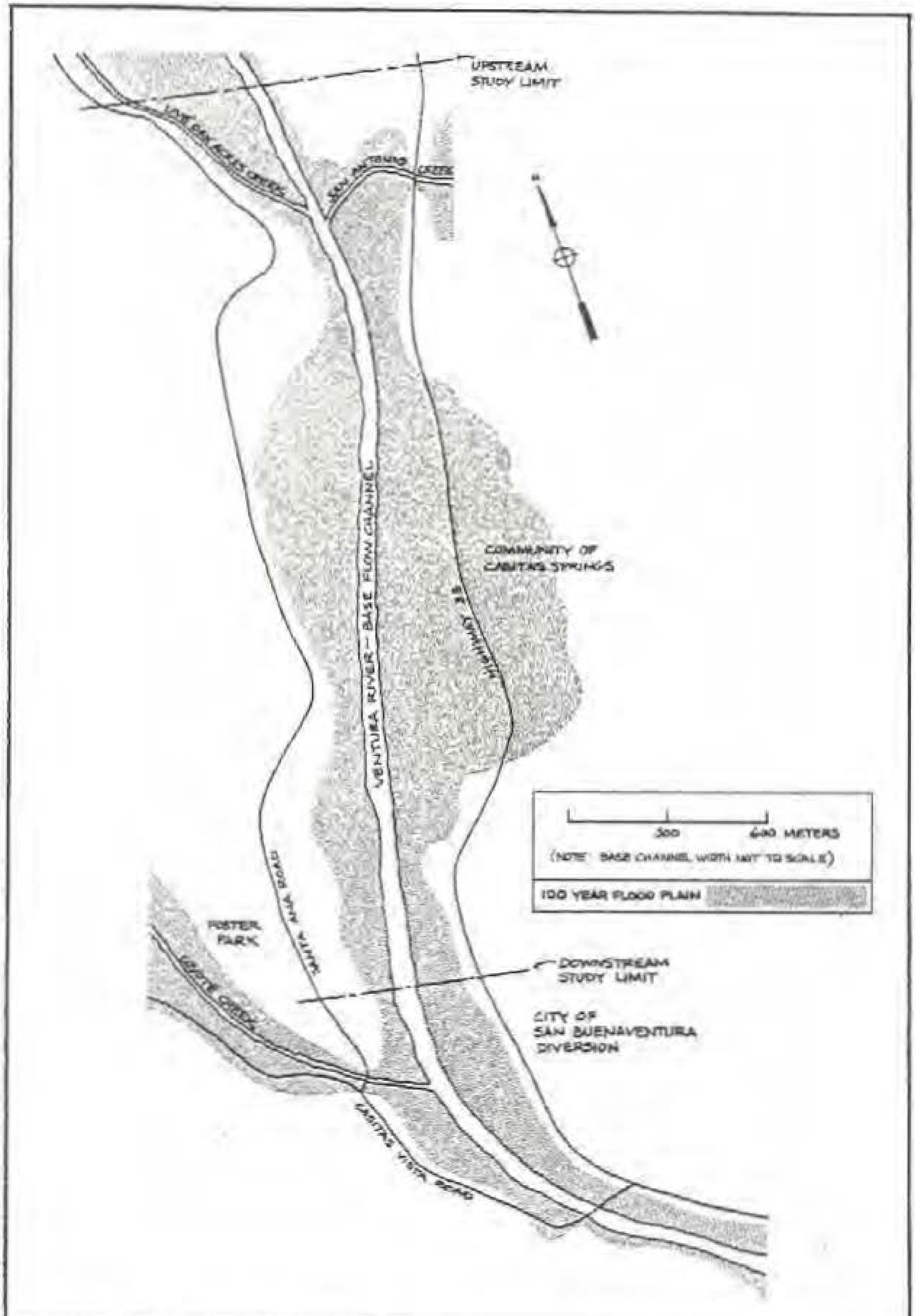

Figure 3. Casitas Springs Study Area

end of the City of San Buenaventura's submerged diversion dam, even during drought years, and re-surfaces several hundred meters downstream where it is augmented by the discharge from the Oak View Sanitary District's sewage treatment plant.

The stream channel through the study area is set in a relatively wide alluvium filled flood plain which is subject to rapid channel modification as a result of periodic flooding. Following high flows, the base surface flow occupies one or more channels and is characterized by a typical pool riffle continuum found in low gradient streams. The stream substrate is composed predominantly of cobbles and rocks intermixed with lesser amounts of sand and gravel materials.

The riparian vegetation in the study area is made up primarily of a variety of willows and shrub-like species. There is also a significant stand of mature cottonwood and sycamore trees at the northern end of the study area near the confluence of San Antonio Creek. The littoral and lotic vegetation in the study area is typical of spring fed streams, with Watercress (Rorippa nasturtium-aquaticum) and Water veronica (Veronica anagallis-aquatica) accounting for the majority of cover in this reach of the river. Table 1 presents a list of the dominant summer riparian and lotic vegetation associated with the Ventura River in the study area.

The physical, hydrological, and botantical characteristics of this reach of the Ventura River combine to form one of the few areas in the lower river which still provides suitable juvenile steelhead habitat throughout the year.

Table 1. Dominant Summer Riparian and Lotic Plant Species at Casitas Springs Study Area.

Scientific Name	Common Name
Veronica anagallis-aquatica	Water Veronica
Cicuta douglasii	Water Hemlock
Rorippa nasturtium-aquaticum	Watercress
Artemisia douglasiana	Mugwort
Urtica holosericea	Stinging Nettle
Cyperus eragrostis	Umbrella Sedge
Phragmites australis	Common Reed
Xanthium strumarium canadense	Cocklebur
Heterotheca gradiflora	Telegraph Weed
Plantago lanceolata	English Plantian
Foeniculum vulgare	Sweet Fennel
Salix lasiandra	Pacific Willow
Populus trichocarpa	Black Cottonwood
Plantanus racemosa	California Sycamore
Alnus rhombifolia	White Alder
Typha latifolia	Cattail

Dominant Genera of Algae	
Enteromorpha spp.	*Zygnema spp.*
Chara spp.	
Cladophora spp.	
Rhizoclonium spp.	

METHODS

Initially, a general reconnaissance of the main stem of the Ventura River was made to identify areas where channel morphology, flow levels, and stream cover appeared adequate to provide suitable habitat for juvenile steelhead. Sections of the Ventura River were then selected for further investigation.

Habitat Characteristics

The physical, hydrological, and botanical characteristics of the Casitas Springs study area were examined in June and October of 1976, 1977, and 1978. The study area was surveyed to determine the amount and quality of living space available to juvenile steelhead from late spring through the following fall of each year.

Physical features examined included length of the rearing area, number of pools and riffles, flow level, and the amount and type of plant cover. Water quality characteristics examined included temperature range, dissolved oxygen, pH, chloride, orthophosphate, nitrate nitrogen, ammonia nitrogen, nitrate, total dissolved solids, and total hardness.*

Periodic inspections were made of the upper river above the study area, San Antonio Creek, and the lower river and estuary to assess the physical conditions of these areas during the course of the study. A special assessment of impacts of the 1978 floods and related flood control activities on the study area was also made.

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*All water quality tests were made using standard methods (American Public Health Association, 1971).

Bioassays

To determine the relative water quality of two sections of the Ventura River, three 96-hour bioassays were conducted in the Casitas Springs study area and in the lower river below the Oak View Sanitary District's sewage treatment plant during the fall of 1977. These tests coincided with the lowest flow observed in the river during the study. Stream flow in the study area was reduced to .006 cms in December, 1977, immediately before the onset of the winter rains. During the summer and fall periods of 1977, the discharge from the Oak View Sanitary District's sewage treatment plant constituted the primary source of base flow in the lower river between the plant and the ocean, a distance of 7.2 kilometers. Sewage treatment at the Oak View Sanitary District's facility consists of barminution, primary sedimentation, biofiltration, activated sludge, secondary clarification, and chlorination/dechlorination. The discharge from the Oak View Sanitary Distirct's sewage treatment plant averaged .0452 cms during this period (California Regional Water Quality Control Board, Los Angeles Region, 1979).

Juvenile resident rainbow trout with a mean length of 8 cms were used as test organisms in the bioassys. Fifty fish were provided for each bioassy by the California Department of Fish and Game from the State Hatchery at Fillmore, California. Ten trout were placed in one gallon perforated translucent plastic live cages. The live cages were anchored in well oxygenated riffle water and sheltered from the main current. A total of four stations were established: one in the Casitas Springs study area, and three in the lower river, 7.2, 4.8, and .4 kilometers upstream the river's mouth at the Pacific Ocean.

Water quality characteristics examined during the bioassys included temperature, pH, dissolved oxygen, total residual chlorine, chloride, orthophosphate, nitrate nitrogen, ammonia nitrogen, nitrate, and chromate. Hach and La Motte field test kits were used for all analyses except dissolved oxygen which was analyzed using the Winkler method with the azide modification.

Steelhead Planting

The Ventura River below the Robles Diversion Dam supports a heterogeneous salmonid population consisting of migratory steelhead and resident rainbow trout (Tippets, 1979). The population of wild juvenile steelhead was not determined prior to the initiation of the study but was believed to be relatively small. To facilitate the assessment of mortality and growth rates of juvenile steelhead, the existing salmonid population was augmented by planting a total of 40,000 juvenile steelhead in the Casitas Springs study area: 11,000 in 1976; 9,000 in 1977; and 20,000 in 1978.

The majority of the planted steelhead were obtained from the Mad River Hatchery. However, due to a late adult run at the Mad River Hatchery in 1977, eggs were transported in the eyed stage from the Mad River facility to the fish hatchery at Humboldt State University where slightly warmer incubating temperatures shortened the hatching time, producing fish of nearly the same length at the time of the planting as the fish planted in 1976 and 1977. An additional 2,000 juvenile steelhead were provided by the Humboldt State University Fish Hatchery in 1977.

All steelhead were planted during the last week of June in each year. At the time of planting, the fish averaged 5.0, 4.5, and 4.7 cm fork length for 1976, 1977, and 1978 respectively. Each steelhead was marked for later identification with a complete dorsal fin clip. The steelhead were anethetized with tricaine methane sulfonate for ease of handling. An attempt was made initially to remove the adipose fin, but because of the small fin size and the potential for rapid fin regeneration, this procedure was abandoned. Fish were allowed to acclimate for one week following the marking before being transported to the Ventura River.

The steelhead were flown from Humboldt County to Ventura County by the California Department of Fish and Game and transported by truck to the rearing area in aerated containers by personnel from the State Fish Hatchery at Fillmore. The juvenile steelhead were evenly distributed throughout the study area. Observed planting mortality was insignificant in 1976 and 1977, but an unusually warm day and above normal water temperature resulted in the loss of approximately 1,000 of the 20,000 juvenile steelhead in 1978.

At no time during the study were there any falls or other obstacles which inhibited the free movement of juvenile steelhead to any section of the study area. However, in 1976 and 1977 fish movement beyond the study area was impossible during the summer and fall periods due to the absence of surface flow immediately above and below the study area. During the summer and fall periods of 1978 fish movement was unrestricted below the study area, but restricted above the study area due to the loss of adequate late summer surface flow. Movement, however, was possible into lower San Antonio Creek during the summer and fall periods, though it was probably minimal because of the lack of favorable pool and riffle depths and suitable cover.

Population Surveys

Juvenile salmonids were collected in December, 1976 and throughout the summer and fall periods of 1977 and 1978 in the Casitas Springs study area by electrofishing, using a Smith-Root Type III model and a Coffelt gasoline powered model QEG 300. Block nets were placed at the upper and lower ends of the stream section being sampled to prohibit escapement. The two pass removal method described by Seber and Le Cren (1967) was used to estimate populations. Fish were collected, counted, measured, and periodically weighed for standing crop estimates.

Wild steelhead and resident rainbow trout were assumed to occupy a territory comparable in size to that occupied by the planted steelhead of similar length. Because of the heterogeneity of the wild salmonid population and the difficulty in distinguishing between migratory steelhead and resident rainbow trout, only fish collected with a clipped dorsal fin were counted as steelhead for the purpose of this study. Population estimates, however, included a combination of planted steelhead and wild steelhead and resident rainbow trout.

RESULTS

Surface Flows

Extreme drought conditions existed throughout California during 1976 and 1977 (California Department of Water Resources, 1976; Office of the Governor, 1977). Rainfall totals in the Ventura River basin during these years were between 13 and 48 percent below long term averages, thus providing an opportunity to assess the suitability of the Casitas Springs study area and other sections of the Ventura River as rearing habitat for juvenile steelhead under extreme low flow conditions.

Surface flow within the study area between June and October of 1976 and 1977 was made up entirely of rising groundwater. Flow was gradually reduced during the summer and fall months in the lower reaches of the study area through the operation of municipal wells.

In 1976, base flow in the study area was reduced from .147 cms in June to .099 cms in October, a 33 percent reduction. In 1977, the second consecutive drought year, base flow in the study area dropped more radically from .116 cms in June to .059 in October, a 49 percent reduction. Surface flow measurements in December, 1977, immediately prior to the onset of winter rains showed a base flow of .006 cms in the study area, the lowest flow observed during the study. Under these conditions, riffles in the study area nearly disappeared. All major pools, however, remained except those at the lower end of the study area which were influenced by well pumping. Following the abnormally high winter flow in 1978, base flow in the study area ranged from 2.547 cms in June to .425 cms in October, an 83 percent reduction.

Size of Study Area

The length of surface flow in the Casitas Springs study area in 1976 was reduced from 2.75 kilometers in June to 2.11 kilometers in October, a reduction of 23 percent. In 1977, the length of surface flow was reduced from 2.79 kilometers in June to 1.98 kilometers in October, a 29 percent reduction.

In 1978, as a result of significantly higher winter flow and a divided stream channel, the length of surface flow in June increased to 4.59 kilometers, a 40 percent increase over the length of surface flow in June of 1976 and 1977. Because the upper groundwater basin remained full through the summer and fall of 1978, the river maintained a continuous surface flow from the confluence of San Antonio Creek to the ocean for the remainder of the year. Figures 4 and 5 show the base flow channel configuration of the Casitas Springs study area before and after the 1978 floods.

The length of surface flow in the study area between June and October of 1978 remained constant. By comparison, the length of surface flow in October, 1976 and 1977 was 54 and 57 percent less than in October, 1978.

Pool and Riffle Changes

Due to the lack of high winter flows, pool/riffle ratios and areas remained relatively constant from June to October of 1976 and 1977. Pool/riffle ratios differed slightly between these years as the continuation of the drought caused desiccation of surface flows to extend further upstream into the study area in 1977. A total of 19 pools and 23 riffles and 17 pools and 21 riffles remained in October of 1976 and 1977 respectively.

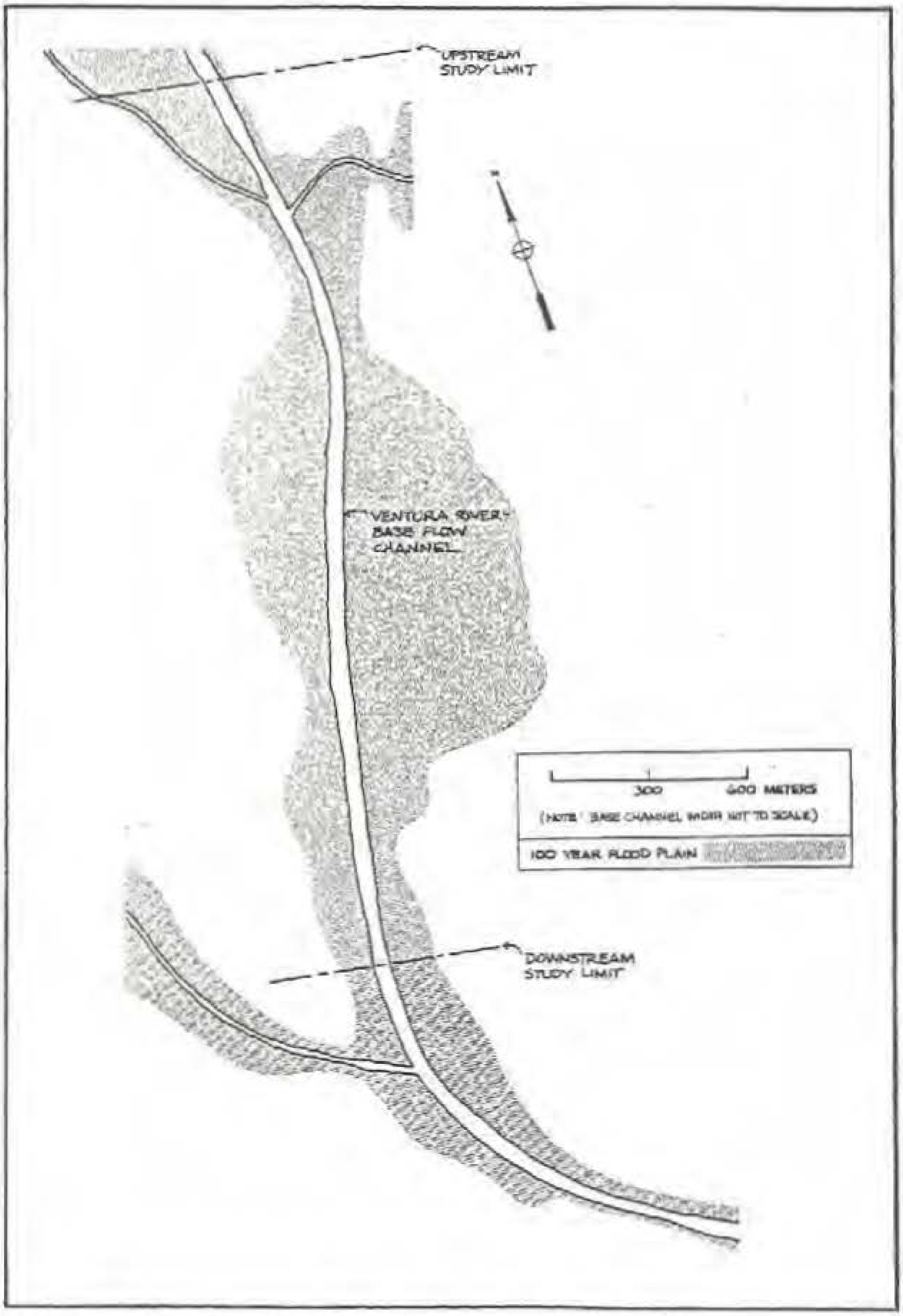

Figure 4. Casitas Springs Study Area Channel Configuration Before Floods of 1978.

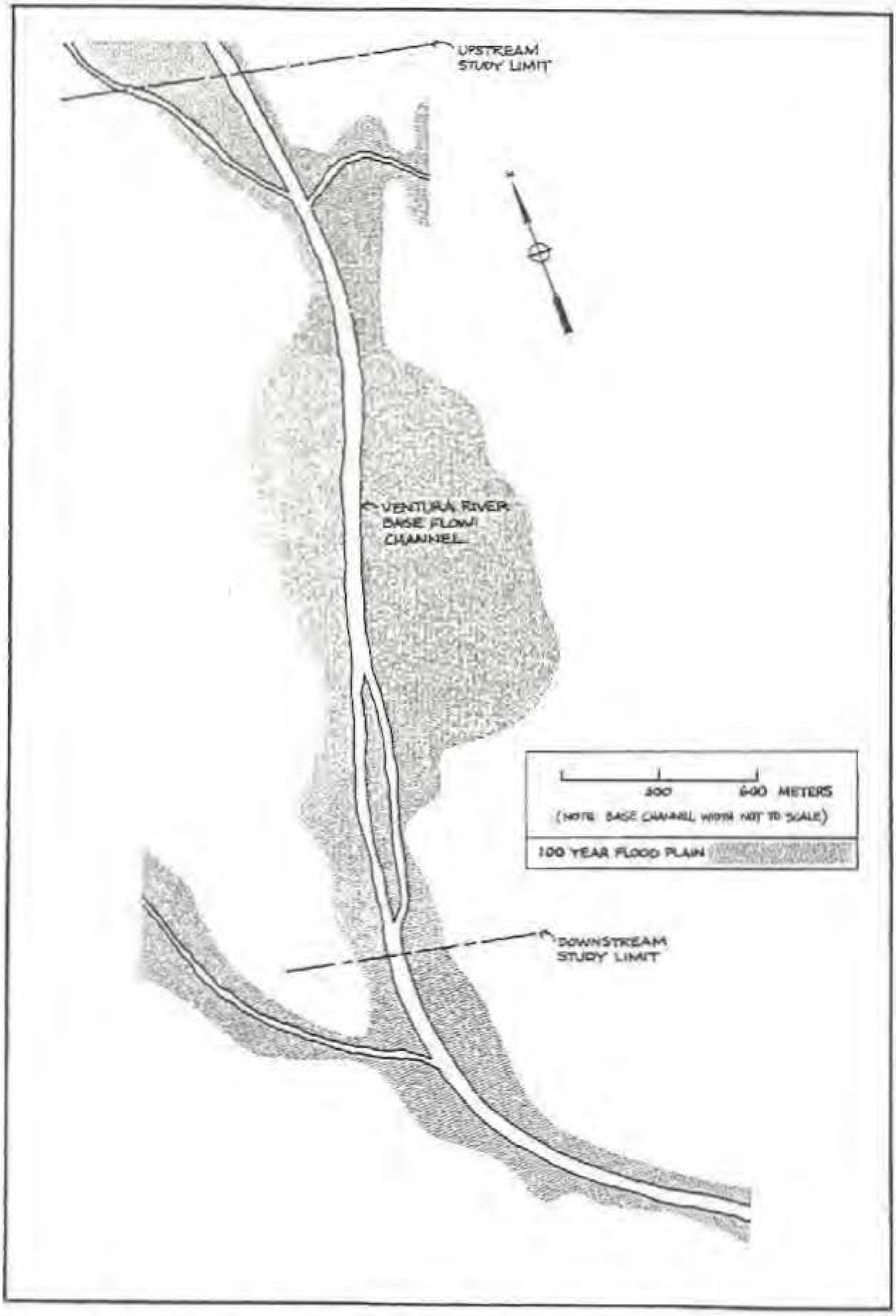

Figure 5. Casitas Springs Study Area Channel Configuration After Floods of 1978

compared to the 22 pools and 26 riffles which existed in June of both years.

Although surface flow increased during the winter of 1977, it was insufficient to scour instream vegetation, other than algae, and resulted in no substrate movement or channel migration. In 1978, high winter flow completely rearranged the pool/riffle make-up in the study area. Surface flow was divided into two channels for approximately .8 kilometers, then re-combined into a single channel at the lower end of the study area. The divided and rearranged channel configuration produced 37 riffles and 36 pools in 1978. the number of pools and riffles between June and October 1978 remained the same.

Although base surface flow ranged from a high of 2.547 cms in June, 1978 to a low of .005 cms in October, 1977, the amount of rearing space available to juvenile steelhead during the summer and fall periods remained relatively constant during the course of the study.

The mean width, depth, and area of the riffles and pools in the study area during June and October, 1976, 1977, and 1978 are presented in Tables 2 and 3. The total rearing habitat available in the study area during June and October, 1976, 1977, and 1978 is presented in Table 4.

Riffle Reductions

The total surface area of riffles in the study area was reduced between June and October, 1976, 1977, and 1978 by 17, 18, and 29 percent respectively. Reductions in riffle area might have been expected to be greater in 1976 and 1977 than in 1978 due to the extreme drought conditions which prevailed in the earlier years. However, the high late spring flow which existed in 1978 caused a greater disparity between the normal June flow level and the October flow level observed previously.

Table 2. Mean Width, Depth, and Area of Riffles at Casitas Springs Study Area, 1976-1978.

Month/Year	$\bar{X}$ Width (m)	$\bar{X}$ Depth (m)	$\bar{X}$ Riffle Area (Hectares)
June 1976	6.4	.25	.049
October 1976	5.8	.18	.041
% Reduction	9.0	28.0	16.1
June 1977	6.3	.23	.045
October 1977	5.2	.10	.36
% Reduction	17.0	57.0	20.0
June 1978	11.6	.33	.085
October 1978	7.9	.25	.061
% Reduction	32.0	24.0	28.0
$\bar{X}$ June all	8.1	.27	.60
$\bar{X}$ October all	6.3	.18	.046
$\bar{X}$ % Reduction all	22.0	33.0	23.0

Table 3. Mean Width, Depth, and Area of Pools at Casitas Springs Study Area, 1976-1978.

Month/Year	$\bar{X}$ Width (m)	$\bar{X}$ Depth (m)	$\bar{X}$ Pool Area (Hectares)
June 1976	8.3	.85	.038
October 1976	5.8	.67	.034
% Reduction	30.0	21.0	11.0
June 1977	7.5	.79	.035
October 1977	4.6	.52	.027
% Reduction	39.0	34.0	23.0
June 1978	14.3	1.0	.069
October 1978	10.7	.88	.053
% Reduction	25.0	12.0	23.0
$\bar{X}$ June all	10.0	.88	.047
$\bar{X}$ October all	7.0	.69	.038
$\bar{X}$ % Reduction all	30.0	22.0	19.0

Table 4. Total Juvenile Steelhead Rearing Habitat at Casitas Springs Study Area, 1976-1978. (Hectares)

Month/Year	Pools	Riffles	Both
June 1976	.846	1.260	2.106
October 1976	.740	1.050	1.790
% Reduction	12.0	17.0	15.0
June 1977	.773	1.157	1.930
October 1977	.587	.947	1.534
% Reduction	24.0	18.0	21.0
June 1978	2.477	3.145	5.622
October 1977	1.906	2.218	4.124
% Reduction	23.0	29.0	27.00
$\overline{X}$ June all	1.364	1.854	3.218
$\overline{X}$ October all	1.077	1.404	2.481
$\overline{X}$ % Reduction all	21.0	24.0	23.0

Riffles were narrower in 1976 and 1977 than in 1978 because high winter flow in 1978 temporarily eliminated channel confining littoral vegetation. Between June and October, 1976 and 1977, riffle depths were reduced by 30 and 50 percent respectively. The reduction in riffle width was nominal, and not considered significant. Established littoral and riparian vegetation influenced base flow width, but did not influence riffle depth.

A marked decline in the utility of the rearing space within the riffles of the study area occurred during the summer and fall periods of each year of the study. In 1976 and 1977, riffles at the lower end of the study area became choked with watercress and water hemlock. This vegetation physically slowed stream flow velocities, occupied space, and accumulated sediment in the riffles, reducing or eliminating riffle living space.

In 1978, the volume and velocity of flow through riffles was greater than the previous two years, but the suitability of the riffles for rearing of juvenile steelhead was limited by their wide, shallow configuration and the lack of littoral and riparian cover. A number of riffle areas were over 30 meters long, with no readily accessible pools or instream cover. As a result, most riffles in the study area during the late summer and fall periods of 1976, 1977, and 1978 were more important as food production substrate than as occupied rearing habitat.

Pool Reductions

The surface area of the pools in the study area was reduced between June and October of 1976, 1977, and 1978 by 12, 24, and 23 percent respectively. The 12 percent decrease in 1976 suggests that the reduction in base flow level had relatively little effect on pool surface area.

In 1977, however, the continued depletion of the groundwater table underlying the study area significantly reduced pool surface areas, particularly in the lower reaches of the study area.

Reductions in pool depths during the summer of 1976 and especially 1977 caused a loss in rearing space within the pools of the study area. In 1976, the mean pool depth dropped from .85 meters to .67 meters, a 21 percent reduction. In 1977, the mean pool depth dropped from .79 meters to .52 meters, a 34 percent reduction. During the summer and fall periods of 1976 and 1977, undercut banks were exposed and littoral vegetation was isolated above the water line, eliminating it as a source of cover for rearing juvenile steelhead. The tail of pools became marginally connected with riffle areas so that juvenile steelhead movement into or through riffles was highly unlikely. In June, 1978, stream flow levels were above normal base flow conditions; consequently, the 23 percent loss in total stream surface area resulted in only a 12 percent reduction in pool depth by October.

During years of more normal rainfall and run-off, reductions in pool areas would be less than those observed in October, 1976, 1977, and 1978.

Figures 6 and 7 show summer base flow conditions in the Casitas Springs study area in June and July, 1976.

Water Quality Characteristics

Water quality in the study area remained within the limits suitable for juvenile steelhead. At base flow, average concentrations of selected critical constituents did not change significantly during the duration of the study. Turbidity at base flow was negligible. Water quality conditions in the lower river below the Oak View Sanitary District's

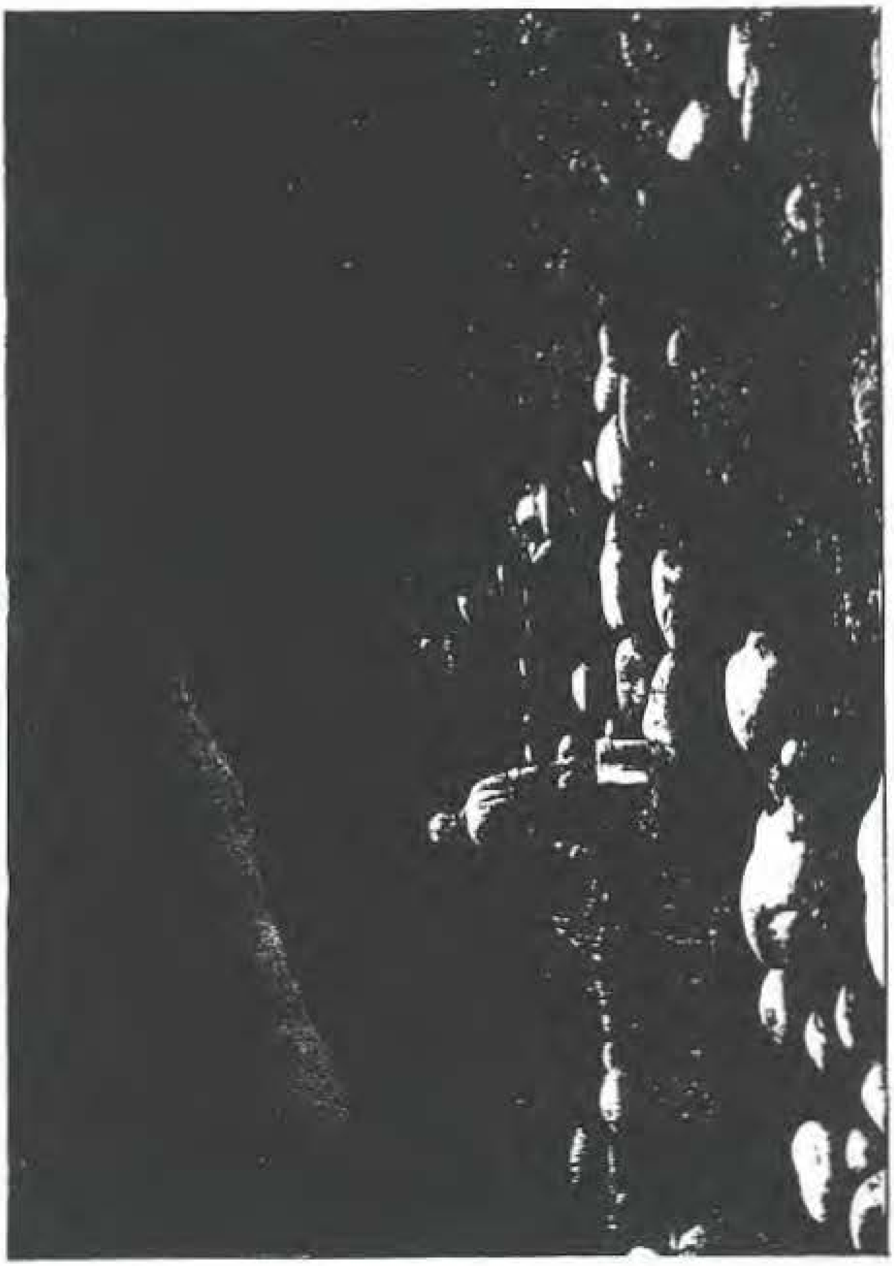

Figure 6. Summer Base Flow Conditions at Casitas Springs Study Area, June, 1976.

Figure 7. Summer Base Flow Conditions at Casitas Springs Study Area, July, 1976.

sewage treatment plant are discussed separately below under "Bioassys". Average values for early summer and late fall water quality factors in the study area are presented in Table 5.

Temperature Observations

Water temperatures in the study area were monitored from June to October of 1976, 1977, 1978. Temperatures from the lower river below the Oak View Sanitary District's sewage treatment plant were also monitored to determine comparable summer thermal suitability during base flow periods. A summary of water temperatures in the study area and the lower river is presented in Tables 6 and 7 respectively.

During June through October, water temperatures in the study area ranged from 14.4^{o} c to 25.5^{o} c, with an average daytime temperature of 19.4^{o} c, an average maximum temperature of 20.5^{o} c, and an average minimum temperature of 16.1^{o} c. High and low temperatures typically occurred for brief periods in the late afternoon and early morning respectively. Extended exposure to high afternoon temperatures was usually limited to three or less hours per day. Thermal stability in the study area was greatest during 1976 and 1977, when springs at the upper limit of the study area constituted the entire flow through the study area. Temperatures in the late summer and fall of 1976 and 1977 were less stable at the lower end of the study area, where stream volume and velocity were significantly reduced by municipal well pumping.

Following the winter flood flow of 1978, water temperatures exhibited greater diurnal fluctuation than in the two previous years. This fluctuation was largely due to the loss of riparian cover and the contributions of surface flow originating in the upper Ventura River and San Antonio Creek. These flows lacked the normal riparian cover as a result

Table 5. Average Values for Summer and Fall Water Quality at Casitas Springs Study Area, 1976-1978. (8 samples/month/constituent)

Constitutent/Characteristic	$\bar{X}$ June	$\bar{X}$ October
Temperature (°C)	20.0	20.0
pH*	7.7	8.0
Dissolved Oxygen (mg/l)	8.2	8.5
Chlorine (mg/l)	< .1	<.1
Chloride (mg/l)	38.0	43.0
Phosphate (PO_4) (mg/l)	<2.0	<2.0
Ammonia Nitrogen (mg/l)	<1.0	<1.0
Nitrate Nitrogen (mg/l)	<1.0	<1.0
Nitrate (mg/l)	<1.0	<1.0
Total Hardness (mg/l)	430.0	450.0
Conductivity (Micromhos/cm)	850.0	940.0

* pH did not change within the month.

Table 6. Average Recorded Water Temperatures at Casitas Springs Study Area, June-October, 1976-1978. (°C) *

Month/Year	$\bar{X}$	$\bar{X}$ High	$\bar{X}$ Low	Range
June 1976	18.9	20.5	17.2	16.1-21.7
July 1976	19.4	21.7	17.2	16.1-25.0
August 1976	20.0	21.1	18.0	16.1-23.9
September 1976	19.4	21.7	17.2	16.1-25.6
October 1976	20.0	21.7	17.8	16.1-23.9
June 1977	18.3	20.5	17.8	15.6-22.8
July 1977	18.9	21.1	17.8	16.1-23.9
August 1977	19.4	21.7	17.2	15.6-25.0
September 1977	18.9	21.1	17.2	16.1-25.0
October 1977	19.4	21.7	17.2	15.0-23.9
June 1978	19.4	22.8	16.1	15.0-25.6
July 1978	19.4	22.8	16.1	15.6-25.6
August 1978	20.0	22.8	16.7	16.1-24.4
September 1978	19.4	21.7	16.7	13.9-22.8
October 1978	19.4	22.2	16.7	14.4-23.9
June 1976-1978	18.9	21.1	17.2	15.0-25.6
July 1976-1978	19.4	20.5	17.2	15.6-25.6
August 1976-1978	19.4	22.2	17.2	15.6-25.0
September 1976-1978	19.4	21.7	16.7	13.9-25.0
October 1976-1978	19.4	22.2	16.7	14.4-23.9

*Ten recordings/month, maximum-minimum thermometer.

Table 7. Average Recorded Water Temperatures at Stations .8 and 4.8 Kilometers above Ventura River Mouth. June-October 1977-78. (°C)*

Kilometers Above Mouth	Month/Year	$\bar{X}$	$\bar{X}$ High	$\bar{X}$ Low	Range
.8	June 1977	19.4	20.5	18.3	16.1-22.2
.8	July 1977	19.4	20.5	18.3	16.7-22.2
.8	August 1977	20.0	21.1	18.9	16.7-22.8
.8	September 1977	19.4	20.5	17.8	15.0-21.7
.8	October 1977	18.9	20.0	16.7	13.9-21.1
.8	June 1978	18.9	20.0	17.8	15.0-24.4
.8	July 1978	20.0	21.1	18.9	16.1-24.4
.8	August 1978	19.4	20.5	18.3	16.1-24.4
.8	September 1978	18.3	19.4	17.2	13.9-24.4
.8	October 1978	18.3	18.3	17.8	14.4-22.2
4.8	June 1977	20.5	22.2	18.9	18.9-22.2
4.8	July 1977	21.7	22.8	20.0	18.3-23.3
4.8	August 1977	22.2	23.3	20.6	18.9-23.9

Table 7 (continued)

4.8	September 1977	20.5	22.8	17.8	17.8-23.9
4.8	October 1977	20.0	22.8	18.3	17.2-24.4
4.8	June 1978	18.9	20.5	17.2	16.1-25.0
4.8	July 1978	20.0	21.1	18.9	16.7-25.0
4.8	August 1978	20.0	20.5	18.9	16.7-24.4
4.8	September 1978	18.9	19.4	18.3	16.1-23.3
4.8	October 1978	18.9	20.0	17.2	13.3-20.6

*Ten recordings/month, maximum-minimum thermometer.

of heavy flooding and were exposed to higher ambient air temperatures because of their origin and passage through an area subject to higher average summer temperatures. The level of surface flow in the study area was not significantly reduced by municipal well operations in 1978, but the loss of riparian cover resulted in higher average temperatures during the spring and summer periods.

Population Observations

The density of the wild steelhead/resident rainbow trout population in the Ventura River below the Robles Diversion was unknown at the outset of the study. In June, 1976, the total living space available in the study area was 2.11 hectares. During the last week of June, 1976, 11,000 marked juvenile steelhead were added to the wild salmonid populations. Fall population estimates were not made until early December, 1976, when electrofishing equipment became available. The December salmonid populations in the study area were estimated at 1,108 marked steelhead and 943 wild steelhead and resident rainbow trout, for a total rearing population of 2,051. The living space in the study area in December, 1976, had been reduced to 1.71 hectares, a reduction of 19 percent. The total salmonid population density in December, 1976, was estimated at 1,200 per surface hectare of rearing space in the study area.

In July, 1977, following the planting of 9,000 marked juvenile steelhead, the planted steelhead and wild salmonid populations in the study area were estimated at 5,409 and 3,458 respectively, for a total rearing population of 8,867. In July, 1977, the total living space available in the study area was 1.87 hectares. The total salmonid population density in July, 1977, was estimated at 4,742 per surface hectare of rearing space in the study area. The October salmonid populations in the study area were estimated at 1,294 marked steelhead and 666 wild salmonids, for a total rearing population of 1,960. The living space in the study area in December, 1977 was reduced to 1.53 hectares, a reduction of 19 percent. The total salmonid population density in October, 1977 was estimated at 1,281 per surface hectare of rearing space in the study area.

In July, 1978, following the planting of 20,000 marked juvenile steelhead, the planted steelhead and wild salmonid population in the study area was estimated at 12,775 and 532 respectively, for a total rearing population of 13,307. In July, 1978, the total living space in the study area was 5.45 hectares. Due to the continuous surface flows above and below the study area, emigration beyond the study area was possible, making additional living space available to planted steelhead and wild salmonids. The total salmonid population density in July, 1978 was estimated at 2,441 per surface hectare of rearing space in the study area. The October, 1978 salmonid populations in the study area were estimated at 5,616 marked steelhead and 423 wild salmonids, for a total rearing population of 6,039. The living space in the study area in October, 1978 was reduced to 4.12 hectares, a reduction of 27 percent. The total salmonid population density in October, 1977 was estimated at 1,466 per surface hectare of rearing space in the study area. Tables 8 and 9 present population estimates of planted and wild salmonids in the Casitas Springs study area between December, 1976 and October, 1978.

Planted juvenile steelhead made up the majority of all salmonids in the study area surveyed between June and October, 1976, 1977, and 1978. A total of 12 marked holdover fish from the 1976 planting were captured

Table 8. Population Estimates of Planted Juvenile Steelhead and Wild Juvenile Steelhead/Rainbow Trout at Casitas Springs Study Area, 1976-1978.

Month/Year	Section of Study Area	Area Shocked (Hectares)	Estimate	95 Percent Confidence Interval	Equivalent Per Hectare
December 1976	Middle	.080	96	65-127	1,198
July 1977	Upper	.040	262	244-280	6,605
July 1977	Middle	.044	167	145-189	3,786
July 1977	Lower	.031	99	90-108	3,178
October 1977	Upper	.038	46	40-52	1,208
October 1977	Middle	.047	79	61-97	1,698
October 1977	Lower	.034	26	21-31	733
July 1978	Upper	.033	97	91-103	2,960
July 1978	Middle	.037	67	62-72	1,799
July 1978	Lower	.036	87	78-96	2,417
October 1978	Upper	.035	72	47-97	2,068

Table 8 (continued)

October 1978	Middle	.052	68	61-75	1,307
October 1978	Lower	.041	42	38-46	1,018

Table 9. Summer and Fall Population Estimates for Planted Juvenile Steelhead and Wild Steelhead/Rainbow Trout at Casitas Springs Study Area, 1976-1978.

Month/Year	Population Estimate For Study Area	95 Percent Confidence Interval	Total Area (Hectares)	Percent Planted	Percent Wild
July 1976	11,000*	---	2.04	---	---
December 1976**	2,051	1,302-2,800	1.71	54	46
July 1976	8,867	8,005-9,729	1.87	61	39
December 1977**	1,960	1,600-2,320	1.53	66	34
July 1978	13,307	12,956-13,658	5.45	96	4
October 1978	6,039	4,943-7,135	4.12	93	7

*No data for wild salmonid population; acclimation mortality of planted steelhead unknown.
**Fall flow conditions prevailed into December of these years.

in the study area between May and October of 1977. In 1978, only one holdover fish from the 1977 planting was captured in the study area. These fish, therefore did not contribute significantly to the rearing populations of subsequent years. The presence of greater numbers of 0^+ wild salmonids in 1977 than in 1976 suggests that some spawning of either steelhead or mature resident rainbow trout had occurred despite the extremely low flow conditions which prevailed during the winter and spring periods of 1977. In 1978, following heavy winter and spring run-off, changes in the pre-existing natural stream morphology and instream flood control activities either physically destroyed redds or caused heavy deposits of silt to accumulate over spawning areas. This resulted in smaller numbers of young-of-the-year wild steelhead and resident rainbow trout than might have been expected given the higher than average surface flows. However, standing crop estimates in the spring and fall of 1978 were higher than either 1976 or 1977.

The population fluctuations observed in the study area during the study reflect the effects of two consecutive drought years followed by a flood year. During years of average rainfall and run-off, it can be expected that early summer and late fall populations of salmonids, including juvenile steelhead, would be greater than those observed during the study. Summer and fall standing crop estimates for planted steelhead and wild salmonids are presented in Table 10.

Growth Estimates

The growth rate of planted juvenile steelhead varied as habitat conditions changed. During 1976 and 1977, summer rearing conditions, including available space, were nearly identical.

Table 10. Standing Crop Estimates of Planted Juvenile Steelhead and Wild Juvenile Steelhead/Rainbow Trout at Casitas Springs Study Area, 1976-1978. (kilograms per hectare)

Date	Planted	% Total	Wild	% Total
June 1976	7.33	---	---	---
December 1976	35.25	43	47.33	57
June 1977	6.52	---	---	---
October 1977	39.50	61	25.71	39
June 1978	4.98	---	---	---
October 1978	105.33	91	10.98	9

In 1976, the planted steelhead grew from 5.0 to 10.8 cm between July 1 and October 15, for an average growth of 1.66 cm per month. The greatest growth gains were made during July and August, while the slowest growth gains occurred during the fall. In 1977, the planted steelhead grew from 4.5 to 11.2 cm between July 1 and October 15, for an average growth of 1.91 cm per month. The greatest growth gains were again made in July and August, while the slowest growth gains occurred during the fall.

In 1978, following a series of heavy winter floods, the stream morphology of the study area changed significantly. As previously indicated, riparian and instream vegetation was removed as a result of the high flows and instream flood control activities. Surface flow was 2.547 cms when the steelhead were planted, or nineteen times greater than the flow at the time of the two previous plantings. Planted juvenile steelhead grew from 4.7 to 14.4 cm by October 15, for an average growth of 2.8 cm per month. As in 1976, the most rapid growth occurred during July and August, while the slowest growth gains occurred during the fall.

The mean fork lengths of planted steelhead during the summer and late fall of 1976, 1977, and 1978 are presented in Table 11.

Summer and fall surface flow during 1976 and 1977 were comparable; following the heavy run-off of 1978, summer and fall flow in the study area remained higher than in 1976 and 1977, resulting in more living space and a potentially more abundant food supply. As a result of more favorable fall habitat conditions, rapid growth continued further into the winter than in 1976 and 1977.

Based upon data collected in 1977, wild juvenile salmonids grew at a slower rate than the planted juvenile steelhead. Length frequencies

Table 11. $\bar{X}$ Fork Lengths of Planted 0^+ Class Juvenile Steelhead at Casitas Springs Study Area, June-December, 1976-1978.

Year/Month	$\bar{X}$ Fork Length (centimeters)	Sample Size	95 Percent Confidence Interval
1976			
June	5.0	75	4.9 - 5.1
July	---	---	---
August	---	---	---
September	10.0	47	9.8 - 10.2
October	10.8	107	10.7 - 10.9
November	---	---	---
December	12.0	38	11.6 - 12.4
1977			
June	4.5	100	4.3 - 4.7
July	7.0	80	6.7 - 7.3
August	9.4	19	9.0 - 9.8
September	10.8	21	10.3 - 11.3
October	11.2	104	11.0 - 11.4
November	11.6	21	11.0 - 12.2
December	---	---	---
1978			
June	4.7	81	4.6 - 4.8
July	7.4	65	7.4 - 7.6

Table 11 (continued)

August	---	---	---
September	13.2	100	12.9 - 13.5
October	14.4	106	14.2 - 14.6
November	15.1	62	14.7 - 15.5
December	15.8	97	15.4 - 16.2

for wild salmonids are available only for June, 1977. Wild salmonids grew from 9.5 to 14.7 cm between June and mid-December, for an average growth of .95 cm per month. Growth data for wild salmonids may have been negatively biased by the inclusion of some small planted steelhead that exhibited a regenerated dorsal fin.

Length frequency histograms of planted juvenile steelhead for October, 1976, 1977, and 1978 are presented in Figures 8, 9, and 10 respectively. Figure 11 compares the October lengths of planted steelhead in 1976 and 1977 (drought years) with those of 1978 (a flood year). Lengths of wild salmonids for December 1976, 1977, and 1978 are presented in Table 12.

Survival Estimates

It was estimated that of the 11,000 juvenile steelhead planted in June 1976, 10.1 percent survived through December, 1976. Of the 9,000 juvenile steelhead planted in June, 1977, it was estimated that 14.4 percent survived through late October. Of the 20,000 juvenile steelhead planted in June, 1978, it was estimated that 28 percent survived through late October. In 1978, emigration was possible both up-stream and downstream from the study area throughout the year. Survival estimates include only those fish within the confines of the study area. Subsequent electrofishing both above and below the study area revealed some marked juvenile steelhead from the 1978 planting. The 1978 survival estimates, therefore, are negatively biased.

Population estimates made after the first month of stream life in July, 1977 and 1978 show a reduction of 40 percent in 1977 and 36 percent through mortality and mortality and emigration respectively. If these ac-

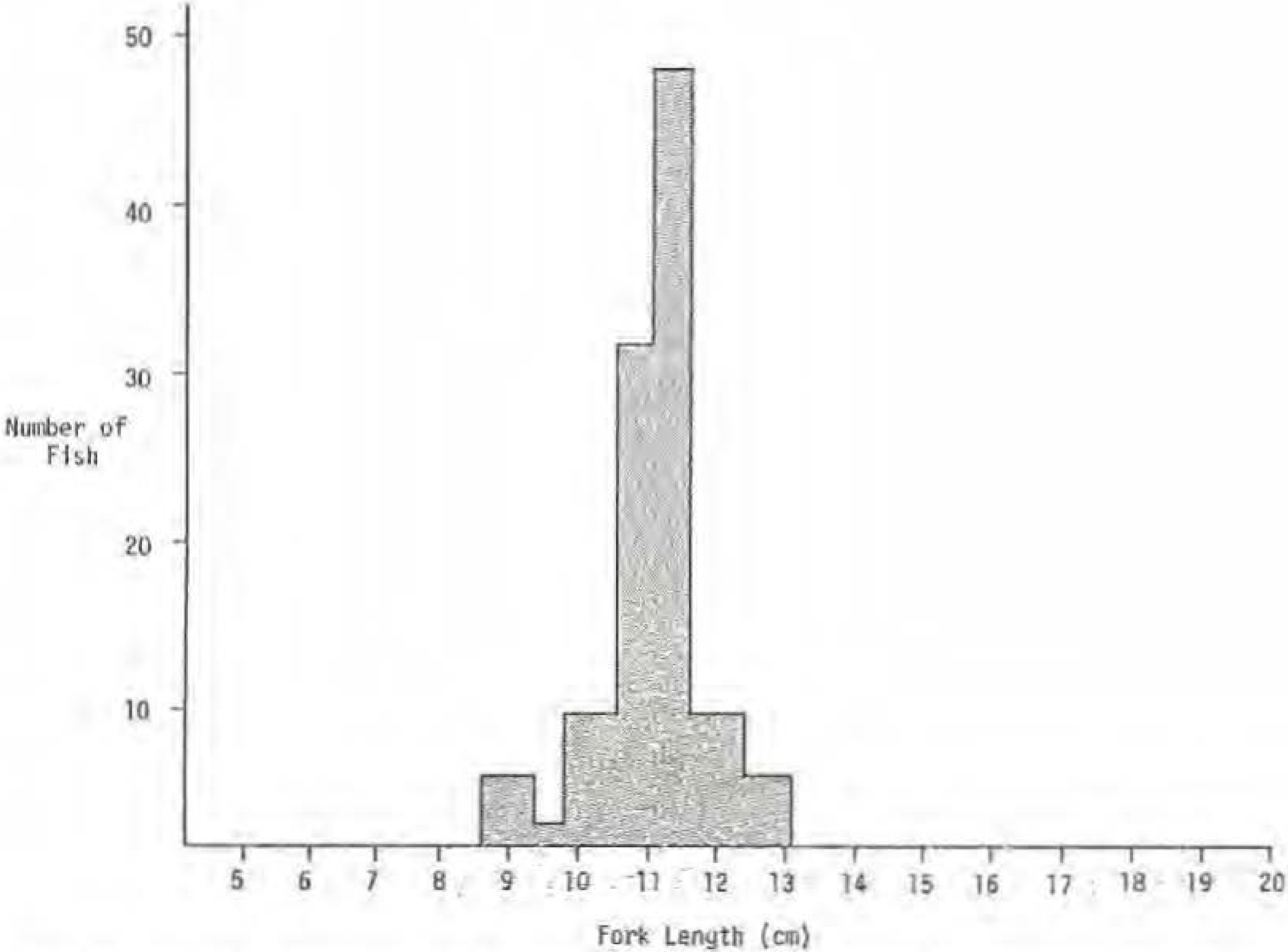

Figure 8. Length Frequency of Planted Juvenile Steelhead at Casitas Springs Study Area, October, 1976.

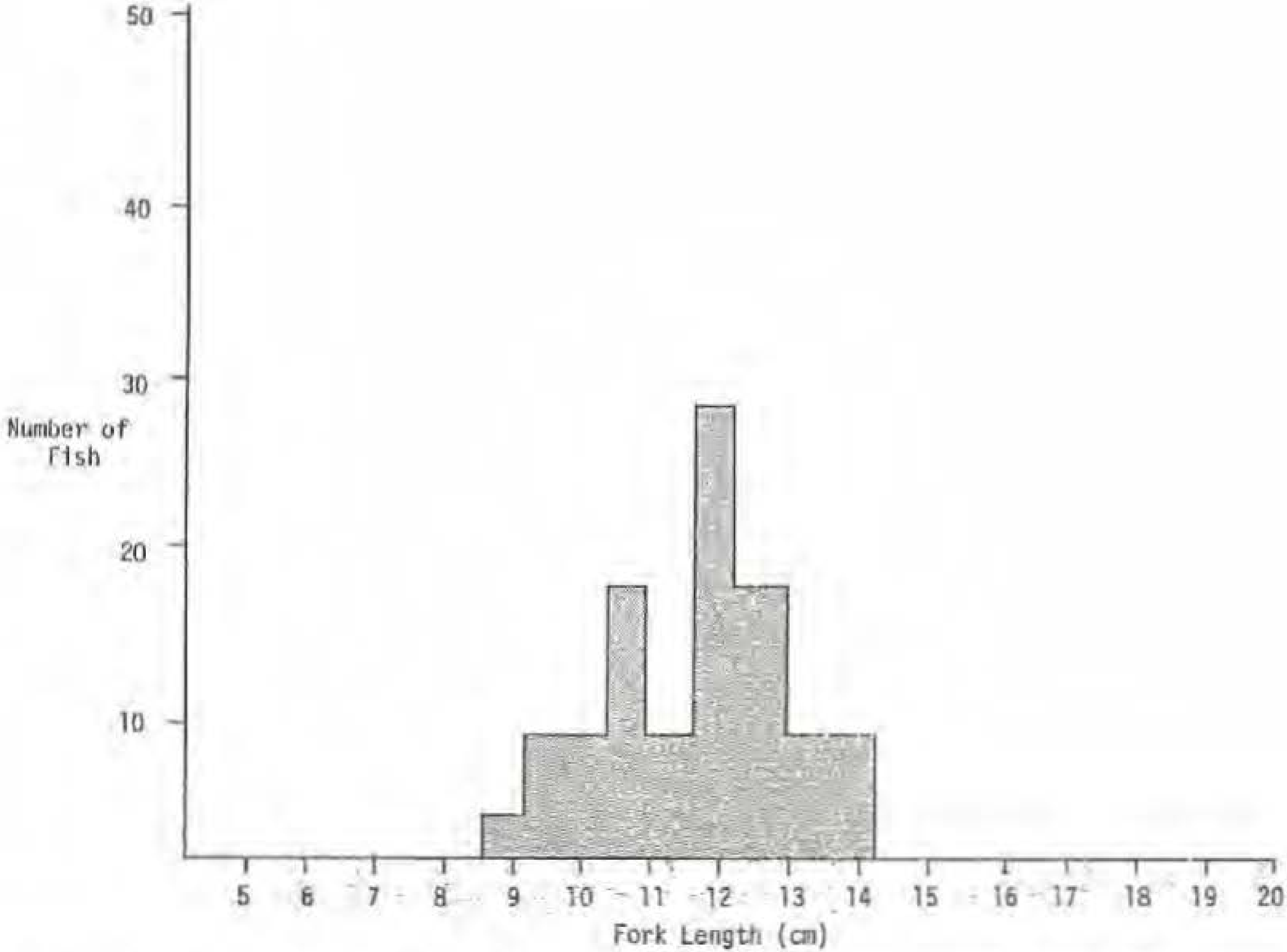

Figure 9. Length Frequency of Planted Juvenile Steelhead at Casitas Springs Study Area, October, 1977.

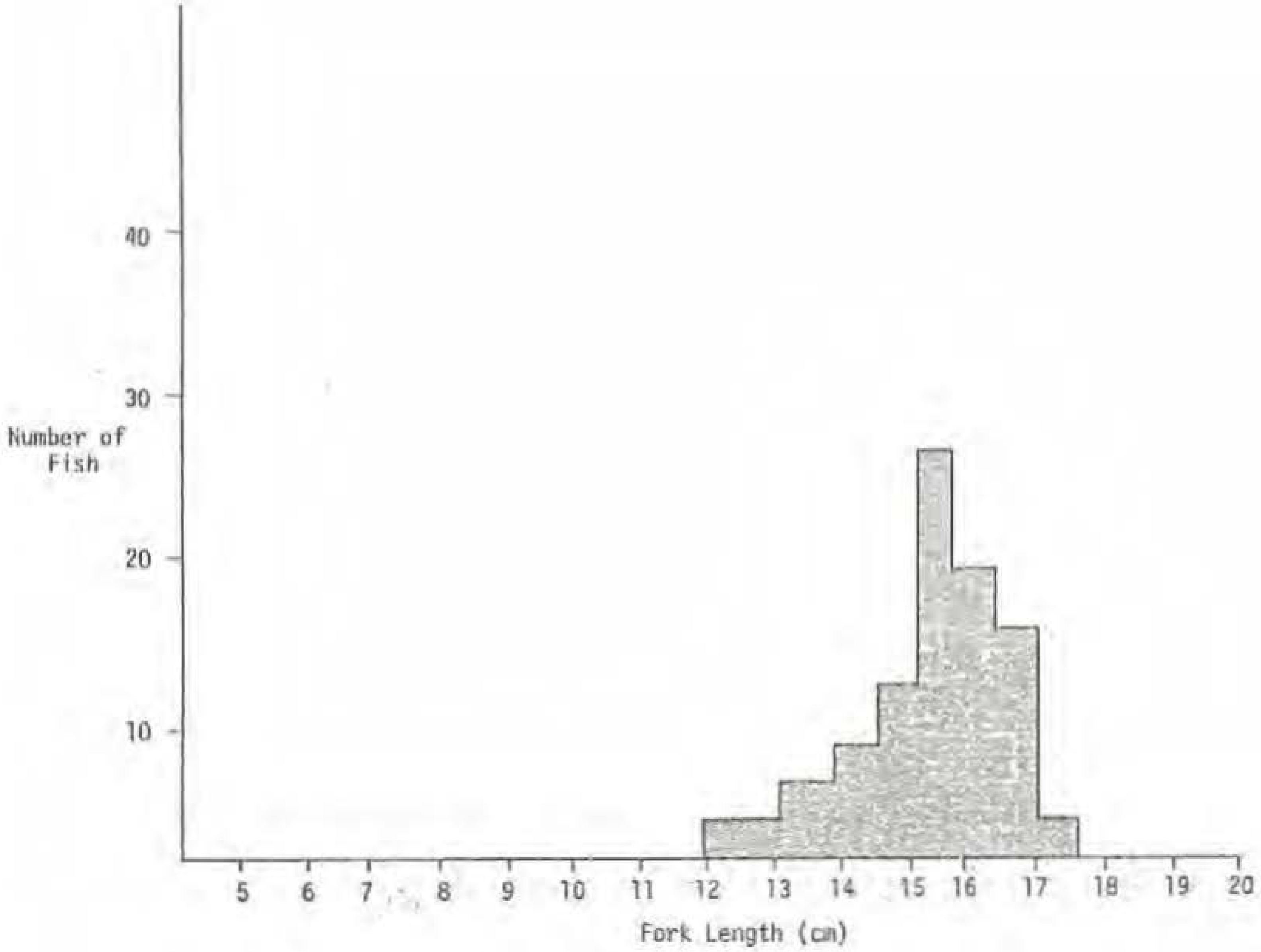

Figure 10. Length Frequency of Planted Juvenile Steelhead at Casitas Springs Study Area, October, 1978.

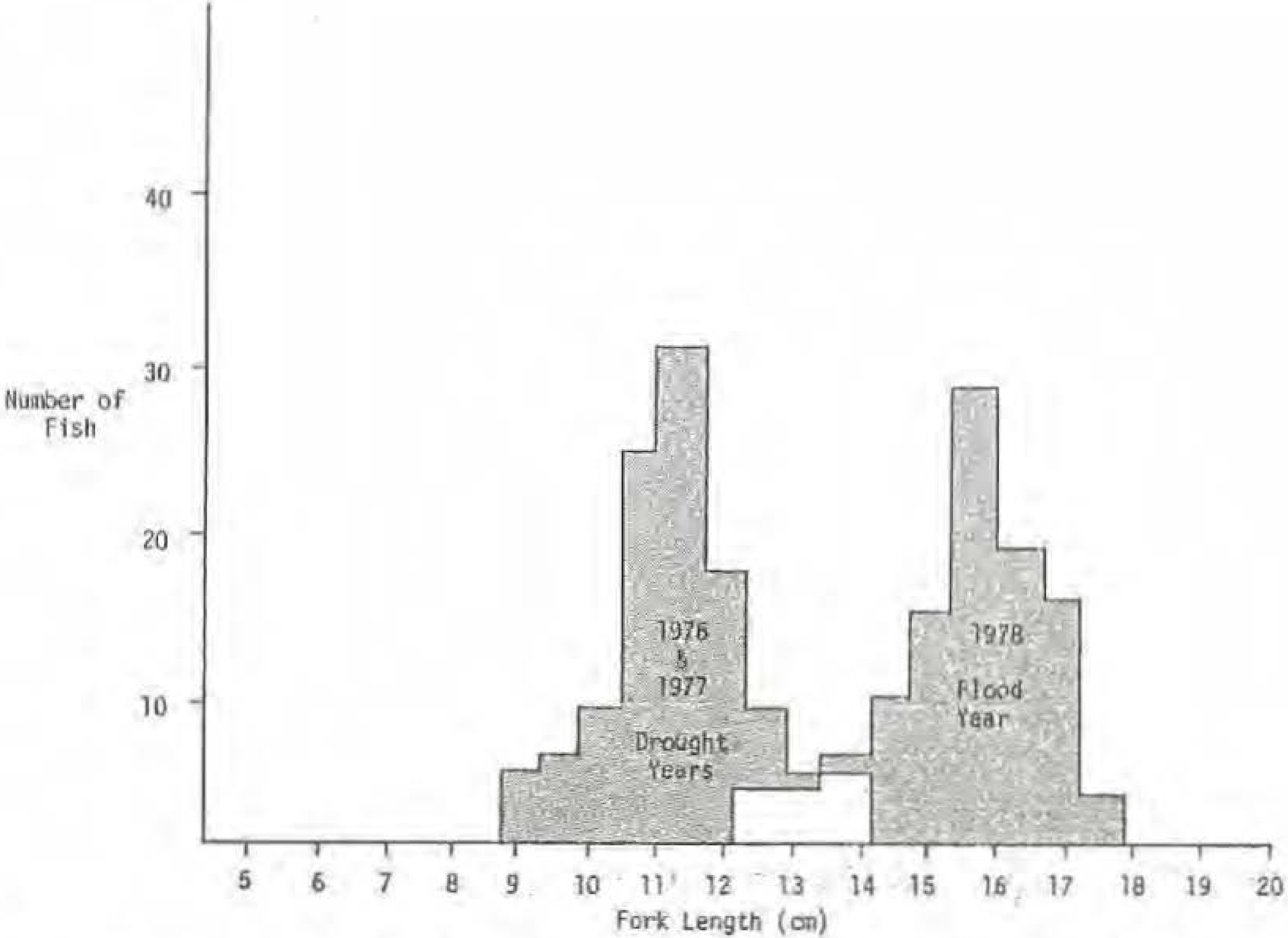

Figure 11. Length Frequency of Planted Juvenile Steelhead at Casitas Springs Study Area, October, 1976-1978.

Table 12. $\bar{X}$ Fork Lengths of Wild Juvenile Steelhead/Rainbow Trout at Casitas Springs Study Area, June and December, 1976-1978.

Month/Year	$\bar{X}$ Fork Length (centimeters)	Sample Size	95 Percent Confidence Interval
June 1976	---	---	---
December 1976	15.3	33	14.2 - 16.4
June 1977	9.5	54	9.1 - 9.9
December 1977	14.7	10	13.7 - 15.7
June 1978	---	---	---
December 1978	19.8	8	19.0 - 20.6

climation losses are discounted, and survival estimates are made for the "adjusted population", the October survival estimates for 1977 and 1978 are 24 percent and 42 percent respectively.

The survival of the wild salmonid populations in the study area between June and October, 1977 and 1978 was estimated at 19 percent and 80 percent respectively. The survival estimate of wild salmonids in 1978 could have been positively biased because immigration into the study area from both upstream and downstream was possible throughout the year. It is more likely, however, that survival of wild salmonids remained high in 1978 because rearing space was not limiting, and the initial density of wild salmonids was lower than normal.

Table 13 presents a comparison of survival estimates of planted juvenile steelhead and wild salmonids in the Casitas Springs study area for 1976, 1977, and 1978.

Bioassays

Bioassays were conducted during September, October, and November, 1977. All rainbow trout test organisms at the Casitas Springs study area station survived the 96-hour bioassays conducted in September, October, and November. Because of the high water quality prevailing in the study area during the bioassays, this station served as a control. Rainbow trout test organisms at the station located 25 meters downstream from the Oak View Sanitary District's sewage treatment plant (2 kilometers below the study area) experienced 100 percent mortality within 24 hours during September, October, and November. At the Shell Road bridge station (2.4 kilometers below the Oak View Sanitary District's sewage discharge), trout test orgnisms experienced 100 percent mortality within 24 hours in September, and October, but survived the November bioassay. At the Main Street

Table 13. A Comparison of Survival Estimates of Planted Juvenile Steelhead and Wild Juvenile Steelhead/ Rainbow Trout at Casitas Springs Study Area, 1976-1978.

Percent of June Population Surviving in October (December, 1976)

Year	Planted Juvenile Steelhead			Wild Juvenile Steelhead/Rainbow Trout		
	June Pop.	October Pop.	% Survival	June Pop.	October Pop.	% Survival
1976	11,000	1,108 (Dec)	10.1	---	943 (Dec)	---
1977	9,000	1,294	14.4	3,458	666	19.0
1978	20,000	5,616	28.0	532	423	80.0
Average	13,333	2,673	20.0	1,995	677	27.7

Percent of July Acclimated Population Surviving in October (December, 1976)

Year	Planted Juvenile Steelhead			Wild Juvenile Steelhead/Rainbow Trout		
	June Pop.	October Pop.	% Survival	June Pop.	October Pop.	% Survival
1976	6,611*	1,108 (Dec)	17.0	---	943 (Dec)	---
1977	5,409	1,394	24.0	3,458	666	19.0

Table 13 (continued)

1978	12,775	5,616	44.0	532	423	80.0
Average	8,265	2,673	32.0	1,995	677	27.7

* Assumes an acclimation mortality comparable to 1977.

bridge station (7.0 kilometers upstream from the ocean), all trout test organisms survived the 96-hour bioassay conducted in September, October, and November, 1977. All surviving trout were released following each bioassay near the stations where they were tested.

In summary, the bioassays conducted at three locations in the lower river reflected a marked decreased in toxicity proportionate to the distance of the bioassay stations downstream from the major dischargers.

DISCUSSION

The major historic spawning and rearing areas in the Ventura River have been rendered inaccessible to migrating adult steelhead by the construction of Matilija Dam, the Robles Diversion, and Casitas Dam. Matilija Dam has removed 28.8 kilometers of stream length in Matilija Creek and Murietta Creek which contain suitable spawning and rearing habitat. Robles Diversion has blocked 3.0 kilometers of stream length in the main stem of the Ventura River, 2.0 kilometers of stream length in Matilija Creek below Matilija Dam, and 6.4 kilometers of stream length in the North Fork of the Ventura River which contain suitable habitat. Casitas Dam has blocked an additional 30 kilometers of stream length in Coyote Creek and Santa Ana Creek which contain suitable spawning and rearing habitat. It should be noted that these estimated reductions in accessible spawning and rearing habitat do not include third and fourth order tributaries which may have also been used by steelhead. Steelhead rearing habitat in the lower Ventura River has been degraded or rendered unsuitable for year-round rearing by inadequately treated waste discharges below the Oak View Sanitary District's sewage treatment plant.

The suitable spawning and rearing habitat presently available to steelhead is generally restricted to a 3.2 kilometer reach of the Ventura River between the confluence of San Antonio Creek and the Oak View Sanitary District's sewage treatment plant. Spawning and rearing habitat of an unknown quality in sections of a 14.4 kilometer reach of San Antontio Creek was beyond the scope of this study.

The observations made during the course of this study indicate that a number of factors influence the survival and growth of juvenile steelhead in the remaining rearing habitat of the Ventura River system. These include water developments and their operation, rainfall and run-off patterns, flood control activities, and waste discharges.

Habitat Characteristics

The spawning and rearing habitat examined during the study proved to be highly productive, despite extreme flow fluctuations. Surface flow in the study area was characterized by high conductivity (800 - 1000 micromhos/cm at base flow), abundant instream vescular plant and algal vegetation, diverse abundant invertebrate and vertebrate food sources, suitable rearing water temperatures, and negligible turbidity. These water characteristics, combined with a prolonged growing season, contributed to high growth and survival rates.

Growth

Mc Fadden and Cooper (1962) found that the growth rates of salmonids are related to the general productivity of the aquatic environment and that differences in water temperature between streams caused significant difference in fish growth rates. Shapovalov and Taft (1954) noted that juvenile steelhead reared in the warmer portions of Waddell Creek, California exhibited a more rapid growth rate than those reared in cooler portions of the Creek. Larger juvenile steelhead found in warmer portions of Waddell Creek were also attributed to a shortened incubation period which increased the length of the growing season.

During the summer and fall periods of 1976, 1977, and 1978, the planted juvenile steelhead and wild salmonids grew rapidly in response to generally favorable conditions. The greater average lengths of marked steelhead observed in October, 1978 compared to those in October, 1976 and 1977, however, suggests that the rate of growth decreased in 1976 and 1977 in response to losses in riffle area, reduced flow velocity, and the consequent reduction in allochthonous food organisms. In 1978, less severe reductions in suitable habitat conditions between June and October resulted in greater average lengths during the fall. Wild salmonid growth rates were slower than planted steelhead, but may have been biased by the inclusion of marked juvenile steelhead that had regenerated the clipped dorsal fin because of their smaller than average size at the time of marking.

Table 14 compares the mean fork length of 0^+ and 1^+ steelhead reared in the study area with steelhead from four more northerly Pacific Coast streams with generally lower average water temperatures (modified from Cross, 1975). A comparison of these growth rates indicates that steelhead reared in the Ventura River obtain smolt size ($\approx 15^+$cm) in the first year of stream life, rather than the second or third year as do most steelhead from more northerly streams. This accelerated juvenile growth could result in approximately twice the smolt production per unit area of rearing habitat than is the case in streams with cooler average water temperatures and shorter growing seasons. This "yearling smolt" phenomenon was further evidenced by the almost total absence of 1976 and 1977 marked 1^+ juvenile steelhead captured during electrofishing surveys conducted in the study area in the summer of 1977 and 1978.

Mc Fadden and Cooper (1962) also found that population regulation of stream resident salmonids was affected primarily by changes in numbers

Table 14. A Comparison of the Mean Fork Lengths of 0^+ and 1^+ Steelhead from the Ventura River and Four More Northerly Pacific Coast Streams. (centimeters)

Date	Ventura River*	Singley Creek	Casper Creek	Yager Creek	Bummer Lake Creek
			0^+ Year Class		
June	4.7	4.5	4.7	---	---
August	9.4	6.5	---	4.8	---
September	11.3	6.5	---	---	6.2
October	12.1	7.5	5.7	---	---
			1^+ Year Class		
June	20.2	11.0	9.2	---	---
August	24.5	12.5	---	12.3	---
September	25.0	12.5	---	---	13.0
October	25.0	13.0	11.0	---	---

*Mean fork length for all three years, 1976-1978.

of individuals, rather than by changes in the growth rate or size of individuals. Growth rates observed during the study remained comparable between individual years, despite the fluctuations in the amount of available rearing area. Additionally, juvenile steelhead survival increased in 1978. It is likely that the growth rates of juvenile steelhead in the study area were largely independent of the density of the salmonid populations, and were determined principally by the condition of the physical habitat and chemical quality of surface flow.

Survival

Mc Fadden (1969) found that physical factors such as floods and droughts periodically cause the death of fish. The Ventura River study was conducted during two consecutive years of severe drought followed by a year of extreme flooding. The effects of both the drought and flood were most severe during the fall periods when surface flow was lowest.

Mortality of the planted juvenile steelhead and wild salmonids in the study area between June and October, 1976, 1977, and 1978 was due primarily to the loss of usable rearing habitat. This loss was the result of severe flow reductions in 1976 and 1977 caused by a prolonged drought and municipal groundwater extraction in the lower end of the study area. In June, 1978, following heavy flooding and extensive instream flood control work, additional mortality resulted from the removal of natural riparian vegetation and the isolation of fishes in separated stream channels. The impacts of the drought and floods which occurred during the study area are discussed in more detail below.

Drought

Drought conditions prevailed during the first two years of the study, 1976 and 1977. As a result, planted juvenile steelhead and wild salmonids were reared in an extremely limited reach of the river, consisting of between 1.7 and 5.6 hectares, which was supplied only by rising groundwater during the summer and fall periods. Low flow conditions also may have resulted in decreased food production, allochthonous drift, and an increase in intraspecific competition, avian predation, and water temperatures.

Havey and Davis (1970) found that stream flow magnitude at critical times of the year was the single most important factor influencing the standing crops of juvenile Atlantic salmon (Salmo salar) at Karrow Stream, Maine. In 1976 and 1977, standing crops in the study area were smaller than in 1978, despite the extensive disruption to the rearing habitat resulting from the flooding and associated instream flood control activity following the 1978 flood. These reduced standing crops were most probably the effect of the extreme low flow conditions which existed from 1976 through 1977. The long term effects of the frequency and duration of droughts on the survival of juvenile steelhead in the Ventura River could not be evaluated within the scope of the study, but it is probable that such natural fluctuations in physical conditions would be a significant determinant in the survival and growth rates of juvenile steelhead, particularly if such conditions are intensified by water developments such as impoundments, diversions, and groundwater extractions.

Flooding

During the winter of 1978, the Ventura River basin experienced extremely heavy flooding. Flows in the study area increased from .566 cms in December, 1977, to over 1,726.3 cms in February, 1978. The February flows were the highest flows recorded since the U.S.G.S. stream flow guages were installed on the Ventura River in 1911.

High winter flow produced correspondingly higher summer and fall flows which resulted in a greater amount of rearing area available to wild salmonids and planted juvenile steelhead. This winter flow, however, also had a number of adverse impacts on the steelhead spawning and rearing capacity of the river (U.S. Fish and Wildlife Service, 1978). The peak flows substantially altered the river morphology, creating a split channel through the study area, new pool riffle patterns, and re-arranging the substrate of the channel bottom. Most significantly, the high winter flow temporarily removed a majority of the instream and riparian vegetation which had provided important summer and fall cover for fish and aquatic invertebrates, and contributed to summer thermal stability.

The loss of thermal stability in streams following the removal of riparian vegetation has been well documented by Burns (1972), Hall and Lantz (1971), Brown and Krygier (1970), Meehan (1970), Swift and Messer (1971), and Gray and Eddington (1969). According to Gray and Eddington (1969) and Karr and Gorman (1975), when vegetation is removed along stream banks and water temperature increases from 6^{o} to 9^{o} c, it may become impossible for species with lower temperature requirements to continue living in the area, regardless of other environmental changes such as sediment load and habitat structure.

In flood prone river systems several adaptive mechanisms serve to minimize the effects of the sudden loss of riparian vegetation. Riparian plant species have adapted to frequent destruction by developing an ability to recover rapidly through sprouting from buried stems, root systems, and through rapid seed dispersal (Stiles, 1978a, 1978b, 1979). A single growing season following moderate flooding is normally sufficient time for the riparian community in the study area to develop a canopy adequate to provide thermal stability during the summer and fall periods.

Under unregualted condtions, the high summer and fall flows resulting from heavy flooding would produce deeper and more extensive pools and riffles which would persist until the riparian canopy had begun to re-establish. Greater sustained summer and fall base flows would, therefore, not only provide additional living space and cover, but would also insulate base stream flows from temperature increases incompatible with juvenile steelhead growth and survival. Thus under natural conditions, a dynamic equilibrium would be maintained between the removal of the riparian canopy and the increase in base summer and fall flows resulting from severe flooding.

The impacts of the natural removal of riparian vegetation by flooding have been compounded by man-made alterations in the watershed. The most important of these alterations are water supply developments and instream flood control activities.

Water developments in the Ventura River basin have been designed principally as water storage, rather than as flood control facilities. Consequently, these facilities have not substantially reduced the magnitude of extreme flood flows which account for the most significant removal of riparian vegetation. Under present operating conditions, however, these facilities substantially reduce the summer and fall run-off which would under unregulated conditions serve to compensate for the periodic loss of riparian vegetation through flooding. The coordinated operation of the Matilija Dam, Robles Diversion, and the Casitas Dam allows the complete control of mid-range flows (0 to 14.5 cms) in most situations. Flows in the main stem of the Ventura River between .556 and 14.5 cms are normally diverted through the Robles Diversion facilities to the Casitas reservoir. Consequently, mid-range flows are reduced instantaneously in the river below the Robles Diversion, disrupting the balance between the natural reduction of summer and base flows and the re-establishment of riparian vegetation following flooding. As a result of the operation of these facilities, the lower river is also deprived of the cooler surface flows orginating in the headwaters of the basin during the winter months.

Several public agencies, including the Ventura County Flood Control District, the Oak View Sanitary District, the City of San Buenaventura, and the City of Ojai, have traditionally engaged in instream flood control activities (such as pilot channeling and bank re-construction) following heavy flooding. These activities have resulted in additional disturbance of the natural stream morphology, removal of riparian vegetation and disruption of its natural recovery, and heavy sedimentation downstream of the flood control activity.

The study area experienced significant changes as a result of the unusually heavy flooding in 1978. The river channel migrated laterally and split into two separate channels. Heavy equipment was employed to shore up failing banks, and protect residential properties and public utilities. This work was performed without specific consideration for the impacts on fish and wildlife and utlized no techniques to mitigate these impacts. Consequently, planted steelhead and wild salmonids, particularly wild young-of-the-year salmonids, experienced additional stress stemming from instream flood control activities.

Johnson (1964) found that channel alterations of the Shields River, Montana resulted in a 90 percent reduction in the weight and number of game fish. Congdon (1971) observed an 83 percent reduction in total standing crop per acre following channelization of the Chariton River in Missouri. Bayless and Smith (1967) reported a 90 percent reduction in fish over 15 cm per acre in twenty-three channelized streams compared to thirty-six streams in a more natural condition.

While flooding often temporarily removes riparian vegetation and contributes to higher average water temperatures, instream flood control activities results in more severe and long term degradation of stream habitat (Council on Environmental Quality, 1973; Emerson, 1971; Esler, 1968). Major effects of channelization noted by Karr and Schlosser (1977) include a reduction in habitat complexity through destruction of riffles, pools, meanders, and instream cover, and the formation of an unnaturally uniform substrate. Karr and Schlosser (1977) conclude that one result of these physical alterations is a drastic reduction in both fish and invertebrate populations.

Although more rearing space was available in the Casitas Springs study area in June, 1978 than was available in June, 1976 and 1977, the quality of the habitat was significantly reduced as evidenced by the relative abundance of planted juvenile steelhead occurring in artifically and naturally altered stream sections following the winter flood of 1978. Electrofishing surveys conducted on September 14 and 15, 1978 showed more than four times as many fish in a naturally altered stream section than in a stream section which had been artificially altered by instream flood control activities. Table 15 presents the relative abundance of planted steelhead in an artificially and naturally altered stream section in the study area following the 1978 flood.

The depressed number of young-of-the-year wild salmonids observed in June, 1978 reflected poor early life history conditions which existed following heavy flooding and subsequent instream flood control activity in the study area and upstream in San Antonio Creek. This activity resulted in prolonged heavy sedimentation throughout the spring months when eggs would have been incubating in and alevins emerging from spawning gravels. The instream flood control activities probably also resulted in the direct physical destruction of redds. Cordone and Kelley (1961) found that when sediments settle out of suspension, they frequently cover essential spawning sites, cover eggs, or prevent emergence of recently hatched young. Mc Crimmon (1954) concluded that the degree of bottom sedimentation in pools and especially riffles determined the amount of shelter available and consequently the survival of Atlantic salmon fry in Duffin Creek, a tributary to Lake Ontario.

It is likely that the heavy sedimentation of pool and riffle areas in the study area during the spring of 1978 significantly reduced the shelter available to wild salmonid fry that hatched and survived to emergence, and that high post-emergence mortality occurred prior to the population sampling conducted in July, 1978. The loss of riparian vegetation in combination with less favorable stream morphology (i.e., extensive wide and shallow riffle areas) may have caused an increase in fish density in other more favorable portions of the study area, or an increase in up or dowstream emigration from the study area.

Table 15. Relative Abundance of Planted Juvenile Steelhead in an Artificially Altered and Naturally Altered Stream Section at Casitas Springs Study Area, 1978.*

	Artificially Altered Stream Section	Naturally Altered Stream Section
Distance sampled**	579	274
Numbers captured	36	78
Equivalent per kilometer	62	284

*Figures represent numbers captured by electrofishing with one pass through each section.
**Meters

Waste Discharges

All point waste discharges are located below the Casitas Springs study area and therefore could not directly influence the rearing capacity of the study area. However, there are a number of private industrial and public domestic discharges made to the lower 8 kilometers of the Ventura River. Bioassays conducted at three locations in the lower river reflected a marked decrease in toxicity proportionate to the distance of the bioassay stations downstream from the major discharges.

The 100 percent mortality within 24 hours of test trout organisms at the station located 25 meters downstream from the Oak View Sanitary District's sewage treatment plant can be partially attributed to the drought conditions during the fall of 1977 which resulted in no surface flow from upstream reaching and therefore diluting the effluent discharged from the treatment plant. A comparison of the bioassay results from the four stations and a review of the discharge records of the Oak View Sanitary District (Oak View Sanitary District, 1977) suggests that the presence of unionized ammonia and/or chromate in lethal concentrations was one of the principal causes of test trout mortality at the Oak View Sanitary District and Shell Road bridge stations. During September and October, 1977, the concentration of ammonia nitrogen at the Shell Road bridge station was comparable to the concentration observed at the Oak View Sanitary District station. The concentration of ammonia nitrogen observed at the Shell Road bridge station was substantially less in November, 1977, when all trout test organisms survived the 96-hour bioassay. Because levels of critical chemical constituents were tested at 24 hour intervals (or four times during each bioassay), however, not all fluctuations in concentrations of potentially toxic substances originating in waste discharges to the river may have been detected.

During the fall of 1977, water quality improved below the Shell Road bridge station. A zone of biological recovery was observed as the river's flow approached the mouth at the Pacific Ocean. This condition was probably the result of contact with stream substrate, water agitation through riffles, and vegetation contact, which together combined to effectively nitrify and dechlorinate the surface flow in the lower river. As a consequence, a 1.9 kilometer reach of the lower river has the potential, under existing conditions, to provide suitable juvenile steelhead rearing habitat, even during periods of extreme drought.

Predation

There was no evidence during the study of predation on planted juvenile steelhead or wild juvenile salmonids by 1^+ or older steelhead or resident salmonids, though the potential existed. Evidence of such predation has been observed in other studies, including Shapovalov and Taft (1954).

A number of avian predators, including the great blue heron (Ardea herodias), green heron (Butorides virescens), western belted kingfisher (Megacerle alcyon), and common egret (Casmerodius albus) were regularly observed throughout the study area. Mc Fadden (1966) states that avian predators are known to have important effects on stream salmonids. Avian predation on the planted juvenile steelhead was probably most extensive in June, 1976, 1977, and 1978 immediately following planting and prior to the establishment of territories. It is likely that the avian predation was principally focused on the more abundant non-game fish populations in the study area which consist of arroyo chub (Gila orcutti) and the partially armored three spined stickleback (*Gasterosteus aculeatus*).

Additional potential predatory species include the aquatic west-tern garter snake (*Thamnophis elegans*), and the western pond turtle (*Clemmys marmorata*). Anglers engaging in the spring through fall sport fishery also account for a small percentage of the mortality of the rearing salmonid population in the study area.

None of the predatory populations appeared to pose a substantial threat to the survival of the rearing juvenile steelhead population in the Ventura River system.

CONCLUSIONS AND RECOMMENDATIONS

The quantity and quality of the steelhead rearing habitat in the Ventura River has been severely restricted by water supply developments which have blocked access to major spawning and rearing areas in the river's tributaries, and altered the run-off pattern in the remaining accessible rearing areas. Reduction of mid-range flows, waste discharges, and instream flood control activity appears to be the major factors affecting the rearing capability of the remaining habitat accessible to spawning adult steelhead in the Ventura River system.

The reach of the river between the confluence of San Antonio Creek and Foster Park remains the most important accessible steelhead spawning and rearing habitat in the Ventura River. An assessment of the quantity and quality of the rearing habitat in San Antonio Creek, the only major tributary remaining accessible to ascending adult steelhead in the Ventura River system, was beyond the scope of the study.

Though the amount of rearing habitat in the main stem of the river is quite limited, it proved to be highly productive. Rapid growth rates were observed during the study under summer and fall base flow conditions. This growth occurred in response to generally favorable habitat conditions which were the result of stable base flow augmented by rising groundwater, warm (though not limiting) water temperatures, water quality conducive to rapid growth (800 - 1000 micromhos/cm at base flow), an abundance of food organisms, and a prolonged growing season.

Survival of the planted juvenile steelhead and wild salmonids in the study area was adversely impacted by two consecutive years of severe drought followed by a winter of unusually heavy flooding. Drought conditions acclerated the loss of living space available to salmonids between June and October, 1976 and 1977. Flood conditions during the winter of 1978 resulted in the removal of most of the riparian vegetation, and subsequently, the pilot channelization of a major portion of the study area.

During years of less extreme rainfall and run-off patterns, summer and fall conditions would be at least as favorable, and probably more favorable than those observed during the three years of the study. Base flow would not be influenced as strongly by municipal groundwater extraction and the riparian canopy would not be subjected to natural and artificial disturbance, providing a more favorable channel configuration, less sedimentation, and greater thermal stability.

The following resource management policies and programs should be implemented to protect and enhance the steelhead resources of the Ventura River:

1. Develop a set of management practices for routine maintenance and emergency flood control activities to reduce the impacts of such activities on riparian vegetation, water quality, base flow channel morphology, and associated aquatic fauna. Such practices should include, though not necessarily be limited to: a) reducing flood control activities to the minimum necessary to protect life and property based upon the hydrological and fluvial characteristics of the Ventura River system; b) wherever possible, limit the removal of riparian

vegetation during the course of performing flood control work necessary to protect life and property through the employment of hand rather than mechanical means; c) maintain a single, confined, sinuous base flow channel inside pilot channels, and avoid a broad, shallow, straight channel configuration; d) to the extent practicable, restrict routine flood control maintenance activities to the period of the year when the majority of the vegetation is in a dormant or non-reproductive phase; e) wherever possible, avoid direct contact with the base flow channel; f) where flood control activities are necessary in the base flow channel, route the base flow around the areas where instream work is to be performed; g) when flood control work is performed in a live stream, utilize effective silt curtains or other means to reduce sedimentation downstream.

2. Regulate surface and groundwater extractions for out-of-stream uses to ensure an adequate flow regimen to meet the migratory and rearing requirements of adult and juvenile steelhead. Such a flow regimen should provide adequate flows to facilitate periodic flushing, attraction and migration of adults upstream, aeration of spawning and incubation areas, and emigration of smolts to the ocean.

3. Upgrade the treatment of all point discharges into the lower Ventura River, including the discharge from the Oak View Sanitary District's sewage treatment plant, to protect instream beneficial uses, including the passage of adult and juvenile steelhead through the lower river and the rearing of juvenile steelhead in the entire reach of the lower river on a year-round basis.
4. Develop a steelhead smolt rearing facility to mitigate the loss of the historical steelhead spawning and rearing habitat rendered inaccessible to adult migrating steelhead by the construction of the Matilija and Casitas water supply projects. Such a facility could be located at the base of either the Matilija or Casitas Dam. Major components of a smolt rearing facility would include adult trapping facilities, adult holding and juvenile rearing ponds, and spawning and incubation facilities. A small scale facility could produce a sufficient number of smolts to increase the present run to 2000 adults annually.
5. Retain the current sport fishing regulations restricting the winter fishing season to the lower Ventura River below Foster Park and limiting the method of take to the use of artificial lures with single barbless hooks until the current run of adult steelhead can be augmented by a smolt rearing facility.

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