An Evaluation of Steelhead Habitat and Population in the Gabilan Creek Watershed

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Bachelor of Science

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Preface

This is an under-graduate student report. The opinions and conclusions presented do not necessarily reflect the final material to be presented as the outcome of the Salinas Sediment Study (2000-1 contract). Nor do they necessarily reflect the opinions or conclusions of the Central Coast Regional Water Quality Control Board, who funded the work, or any of its staff.

Having said that, I hope you enjoy the report. It is the product of an extra-ordinary level student dedication to the science of bettering the environment of the Central Coast while recognizing the social and economic importance of its agriculture and industry.

Dr. Fred Watson
Project leader.
Student Capstone Advisor

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1 Abstract

South-Central Coast Steelhead have recently been listed as threatened by the National Marine Fisheries Service. As a result, many studies are being undertaken to examine habitat, populations, and the effects of land use on steelhead (*Oncorhynchus mykiss irideus*) throughout the central coast of California. The primary aim of this study was to conduct and inventory of steelhead habitat and population within the Gabilan Creek watershed in Monterey, California. The specific objectives of this study were to address the following questions: Is there suitable habitat for steelhead in the Gabilan Creek watershed? Have populations existed there in the past? Do populations currently exist, and if not, why?

This was accomplished by researching the life cycle and characteristics of steelhead, performing a reconnaissance survey, assessing rearing and spawning habitat, and conducting a population survey. The purpose of the reconnaissance survey was to locate perennial water, note important features related to the survival and spawning of steelhead, and to map accessible portions of the creek. The survey was conducted along much of the length of the creek and grouped into three reaches totaling approximately 21 km. The habitat assessment involved using a Rearing Index for Young-of-the-Year Method to measure the quality and quantity of surveyed rearing habitat and to then calculate a rearing index. The rearing index was used to predict steelhead young-of-the-year population density per unit length of stream. This method was performed for five sections located within the headwaters of Gabilan Creek. Additionally, selected sites throughout the watershed were monitored for stream factors such as temperature, dissolved oxygen concentrations, total dissolved solids, and suspended sediment concentrations. Finally, population assessment involved visually observing adult steelhead, if present, during upstream migrations. Interviews were also conducted with several local residents regarding historical anecdotal steelhead sightings.

The results of this study indicated that suitable rearing and spawning habitat does exist in the headwaters of Gabilan Creek. It was also determined lower reaches of Gabilan creek could be problematic for the migration of adults due to lack of cover, woody debris, and uniform flow structure. It remains inconclusive as to whether or not steelhead currently exist in Gabilan creek. However, rainbow trout were observed in the headwaters. Rainbow trout have a polymorphic life-history structure enabling them to assume anadromy. Therefore, even if steelhead do not currently exist in Gabilan creek, there is a potential for a steelhead run during years with adequate rainfall and stream flow.

2 Introduction

Steelhead, *Oncorhynchus mykiss irideus*, are a member of the *Salmonidae* family, spending their adult years at sea and then returning to freshwater streams to spawn. As human population continues to grow, so to does urbanization and pollution, resulting in degradation of natural lands, streams, and wildlife. In order to ensure that populations of steelhead persist in the future it is extremely important that they are protected and suitable habitat is maintained.

In August 1997, South-Central Coast Steelhead Evolutionarily Significant Unit (ESU) was federally listed as "threatened"(NMFS 1997). As a result of this listing, many studies are being undertaken to examine habitat, populations, and the effects of land use on South-Central Coast Steelhead. The South-Central Coast Steelhead ESU extends from the Pajaro River in Santa Cruz County, CA to San Luis Obispo County, CA (NMFS 1997). In August 1997 and July 2000, the National Marine Fisheries Service published the final protective regulations regarding steelhead. Activities that may adversely affect steelhead such as logging, farming, grazing, road construction, removal of large woody debris, and altering stream channels may be in violation of Section 9 of the Endangered Species Act unless previously authorized by a Section 7 consultation with NMFS or a Section 10 permit (NMFS 1997).

South Central Coast Steelhead are unique because of the varying climatic conditions that they must face and to which they have evolved. The mediterranean climate of the south central coast of California creates variable climatic and hydrological conditions. As many of the streams in this region are ephemeral, populations can become isolated, thus preventing migration. Steelhead not only must cope with inhabiting a region that naturally poses these harsh environmental conditions, but must also survive amongst human population growth, increased urbanization, the conversion of natural lands to other land uses, and the accompanying anthropogenic effects.

If populations of this threatened central coast species are to exist in the future, land use management and policy decisions must take into account the requirements that are necessary to maintain a viable steelhead habitat and population. Some studies on South Central Coast Steelhead have been conducted. For example, agencies such as the California Department of Fish and Game, the US Forest Service, and the Monterey Peninsula Water Management District have worked on rivers such as the Salinas, the Carmel, and the Arroyo Seco. However, many of the small tributaries to these drainages have not been studied.

2.1 Objectives

The objective of this project was to examine steelhead habitat and to determine if populations of this species exist in the Gabilan Creek watershed located in Monterey County, California. The specific objectives of this study were to address the following questions:

- ❖ Is there suitable habitat for steelhead in the Gabilan Creek watershed?
- ❖ Have populations existed there in the past?
- ❖ Do populations currently exist, and if not, why?

This study is important due to the lack of information and previous studies on *O. mykiss* in this watershed. The only intensive steelhead study to date in this watershed was a habitat inventory conducted by Michelle Gilroy of the California Department of Fish and Game in the summer 2000, which has not yet been published.

The Watershed Institute at California State University Monterey Bay provides technical assistance to the Central Coast Regional Water Quality Control Board in the development of Total Maximum Daily Load (TMDL) management measures for sediment in the Salinas Valley. Part of this study involves a comprehensive review of the status of steelhead in the Salinas River Valley. In collaboration with the TMDL study, an inventory of steelhead habitat and population for the Gabilan Creek watershed was conducted. This was accomplished by researching the life cycle and characteristics of steelhead, performing a reconnaissance survey, assessing rearing and spawning habitat, and conducting a population survey.

2.2 Steelhead Life Cycle and Characteristics

Historically, the range of steelhead extended from the Kamchatka Peninsula in Eastern Siberia to the northern Baja Peninsula in Mexico. However, today their range extends from the Gulf of Alaska and the Kamchatka Peninsula to southern California around Malibu Creek (Schmitten 1997).

Steelhead are anadromous. Their life cycle consists of four major stages: spawning, incubation, juvenile rearing, and adult (Hunter 1991). Anadromous fish begin their life cycle in freshwater. *O. mykiss* lay their eggs in gravel-cobble substrate nest called "redds", in which they incubate for one to four months. Redds are often located in the transition zone between the slow moving water of deep pools or runs and the more turbulent water of riffles. This location maximizes the flow of well-oxygenated water to the incubating eggs. Following yolk sac absorption, young fry emerge from the redd and begin feeding. After rearing for up to two years in freshwater, physiological changes occur during the process of smoltification, which allows fish to adjust to seawater (Hagar, 1996). The smolt then migrate to the ocean. Steelhead typically spend one to two years at sea, where they feed and attain most of their size, they return to their natural streams to spawn. Freshwater streams provide protection for egg and larval development.

Steelhead exist in two behavioral forms. Stocks that return to their natal streams during autumn and winter are known as winter steelhead; whereas, those that migrate to freshwater in spring and summer are classified as summer steelhead. The variety that exists in the Salinas River Valley, California, are winter steelhead (Pennell and Barton 1996).

Steelhead and rainbow trout are of the same genus and species, *Oncorhynchus mykiss.* Resident rainbow trout reach sexual maturity in freshwater and spawn without entering the ocean. They typically lay fewer eggs and mature at smaller sizes (Hagar 1996). Steelhead and resident rainbow trout occupying the same waterway lack significant morphological and genetic differences. Evidence suggests that steelhead and resident rainbow trout within the same stream can form single interbreeding populations. One life history form is capable of spawning with an individual of the opposite form (Thorpe 1987; as cited in Calfed 1998). "It is possible that offspring of resident fish may migrate to the sea, and offspring of steelhead may remain in streams as resident fish" (Burgner et al. 1992; as cited in Busby et al. 1996).

Several physical and environmental factors exist that can limit or enhance the survival of steelhead. For example, the metabolism of steelhead is directly controlled by temperature. The preferred temperature range for steelhead is 7.3 to 14.6° C. The suggested optimum temperature is 10.1° C, whereas the upper lethal temperature is 24.1° C (Bell 1973; as cited in Reiser and Bjornn 1979). Another factor that can be limiting to *O. mykiss* is ambient dissolved oxygen (DO). Low dissolved oxygen concentrations can affect embryo development and hatching, alter the swimming performance of migrating adults, and may cause migration to cease (Reiser and Bjornn 1979). A criterion of >7.8 mg/L (69% saturation at 10 degrees Celsius) has been suggested for salmonids (Pennel and Barton 1996). The suggested pH range for aquatic life is 6.5 to 9.0 (Pennel and Barton 1996).

Suspended sediment can also influence the migration and rearing of steelhead. Reiser and Bjornn (1979) cited a study in which migration ceased in a stream with a suspended sediment content greater than 4,000 mg/L. The study also suggested that streams with sediment concentrations less than 25 mg/L can be expected to support healthy fisheries (Bell 1973). Another factor influencing steelhead reproduction is size of available substrate for spawning. The substrate diameter range suitable for steelhead spawning is .6-10.2 cm (Reiser and Bjornn 1979).

Other environmental factors that can influence steelhead survival are the availability of escape cover and abundance of aquatic insects for food. Escape cover can exist in the form of boulders, logs, undercut banks and trees, root wads, and overhead riparian vegetation (Hunter 1991). Overhead riparian vegetation also contributes to maintaining optimum temperatures, especially in the warmer areas of the southern steelhead range. Preferred food items for steelhead, while in freshwater, include: ephemeropterans (mayflies), trichopterans (caddisflies), and dipterans (Pennel and Barton 1996). Steelhead also depend on sufficient water velocity, depth, and flow for survival (Hunter 1991).

Successful migration and passage also require the absence of barriers. Steelhead generally migrate upstream at an average speed of 2.14 km/hour. When migrating upstream steelhead use up to 80% of their energy reserve. Therefore, any major changes in steelhead energy expenditure, such as the additional energy use needed to overcome barriers may prevent the success of migration and spawning. Steelhead are capable of leaping 6 to 10 feet, however this requires adequate pools for resting above and below the obstacle (Evans 1974).

2.3 Factors Contributing to Decline

Steelhead populations in coastal California have been declining throughout the past several decades. Several natural and human factors have contributed to this decline (NMFS 1997). For instance, various types of land use such as agriculture, grazing, logging, and an increase in urbanization have degraded the habitat of *O. mykiss* by reducing riparian vegetation, increasing erosion and sediment loading, altering flow regimes, and increasing pollution (NMFS 1996). Although these effects have been studied in the past, much more information is needed to completely understand the linkages between anthropogenic activities and their effects on steelhead population and habitat.

Urbanization and agricultural activity can lead to a loss of large woody vegetation as agricultural field boundaries and housing developments replace and encroach upon riparian zones (Fig. 3-1). Some grazing practices can also contribute to the loss of riparian grasses and forbs and can increase erosion rates (Fig. 3-2).

Figure 3-1. Artichoke field in the Salinas Valley showing drastically altered riparian habitat, erosion, and sedimentation (Photo: Fred Watson)

Figure 3-2. Grazing site along Gabilan Creek showing removal of riparian vegetation (Photo: Julie Hager)

Loss of riparian vegetation reduces shade, cover, food supply, and streambank stability (Hardy and Andrews 1989). The reduction of shade and canopy can lead to significant increases in temperature. In areas such as the southern central coast of California, this can be detrimental as temperatures are already near the lethal limit. Riparian vegetation also provides habitat for insects upon which steelhead feed, detritus providing nutrients to the streams, and cover for predator avoidance. Riparian vegetation prevents erosion by slowing runoff rates and reducing soil loss by binding soil to root mass. In addition, bank sediments reinforced by roots of riparian vegetation can be 20,000 times more resistant to erosion than bare banks (Smith 1976; as cited in Abernethy and Rutherford 1998).

According to the National Marine Fisheries Service (1997), "Sedimentation from land use activities is recognized as the primary cause of habitat degradation in the range of west coast steelhead." An excess of sediment can be damaging to steelhead in several different ways. Turbidity, the scattering of light and reduction of light penetration, is primarily due to high concentrations of suspended silts and clays. This can reduce aquatic plant life by limiting photosynthetic growth, therefore reducing the number of aquatic invertebrates, which are the primary food source for steelhead (NMFS 1996). High turbidity can affect the foraging patterns of steelhead while also leading to a disruption in social behavior (NRC 1996). Furthermore, it has been determined that an excess in fines (<.83mm -clay, silt, and fine sand) in spawning gravels can fill the interstitial spaces preventing water and therefore preventing oxygen from entering the redd. This can lead to increased mortality as metabolic wastes accumulate and eggs are smothered. Wickett (1957) found that rate of survival increases with permeability, and McNeil and Ahnell (1964) determined that permeability was low when gravels contained more than 15% fines (Borok and Jong 1997). A final effect of high suspended solid concentrations is the clogging and abrasion of gills (NMFS 1996).

Flow regimes can be altered when channel adjustments are made to prevent damages caused by flooding. Adjustments may consist of straightened channels and banks armored by rip-rap such as concrete, boulders, or sandbags often used to prevent erosion. Although rip-rap may provide some habitat for steelhead, in general adjustments such as these reduce physical complexity by reducing roughness and eliminating eddies and pools which are beneficial for rearing and protection (NRC 1996).

Finally, land use such as agriculture and urban development can increase pollution. For instance, sewage can alter dissolved oxygen concentrations leading to near anaerobic conditions (NRC 1996). Agricultural runoff can also alter the chemistry of the water and may destroy aquatic life by adding pesticides, herbicides, and fertilizers to the water (NMFS 1996).

Many natural processes can also affect the habitat and populations of steelhead. Natural events such as drought and landslides that may affect steelhead cannot be prevented. However, anthropogenic disturbances are avoidable. With proper land use management and policy, many of the previously mentioned problems can be avoided. However, this requires education, incentive, planning, and support.

3 Study Area

The Gabilan Creek watershed encompasses the city of Salinas (Fig. 4-1) and covers approximately 316 km^2 above the confluence with Tembladero Slough (Watson et al. 2001). It is a relatively isolated drainage that flows from its headwaters near Fremont Peak, through the city of Salinas, and then finally to Tembladero Slough from the south (Fig. 4-1). The gradient is very steep in the headwater section, moderate to steep once it reaches the valley, and then relatively flat throughout the city of Salinas on to the slough (Day 1959). The lower portion, known as the Reclamation Ditch, is a 13 mile system of ditches that were constructed in 1917. The Reclamation Ditch system begins near Carr Lake in the city of Salinas. Carr Lake is a storage system that captures the drainages of Gabilan, Natividad, and Alisal creeks. The Reclamation Ditch System was constructed to route waters from the city of Salinas and nearby agricultural fields into Tembladero Slough and finally into Moss Landing Harbor through the Potrero tide gates (RDIPAC 2001).

The watershed is characterized by a mediterranean climate with temperatures ranging from approximately 0° C in the winter to 21° C in the summer (Jackson et al, 1993; Mulitsch 2000). The geology of the watershed is predominantly granitic-based rock type derived from the Salinian Block. The primary natural ecosystem types are Coast Live and Blue Oak woodland, grassland, valley oak savannah, and chaparral (Day 1959). The primary species within the riparian corridors include: willow, sycamore, big leaf maple, oak, alder, and some additional aquatic plants and grasses.

The headwaters encompass natural lands with grazing as the primary land use. The upper most portion of the watershed is owned and managed by the Gabilan Cattle Company. The ranch is very active in the conservation and protection of natural resources and works with the U.S. Fish and Wildlife Service and California Department of Fish and Game to improve potential native steelhead runs in Gabilan Creek (Gabilan Creek Cattle Company 1999). The land uses for the lower portion of the watershed are primarily row crop agriculture (lettuce, strawberries, artichokes, and broccoli) and urban (residential and industrial).

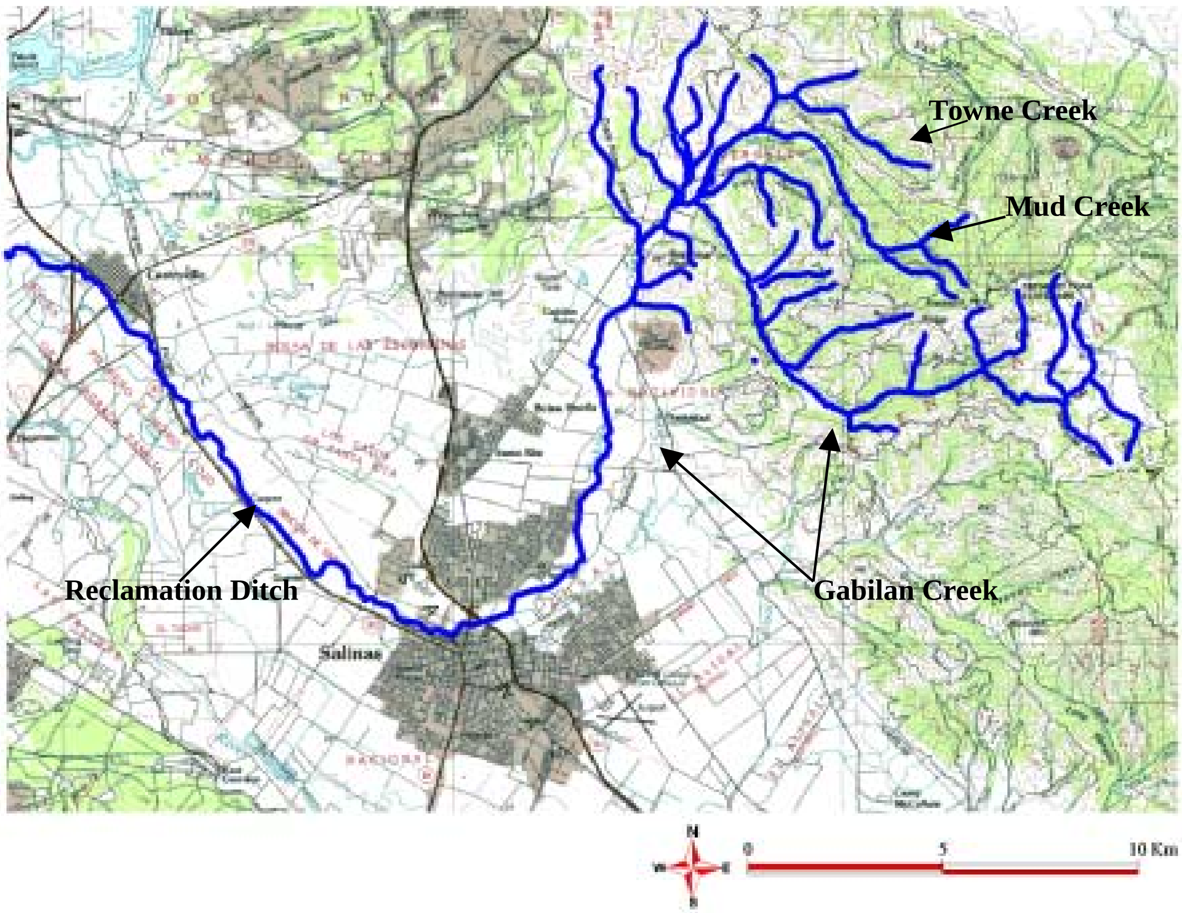

Figure 4-1. Gabilan Creek drainage, topography, and infastructure (circa 1995)

4 Methods

The study was divided into three different phases:

A. Reconnaissance Survey

B. Detailed Habitat Assessment

C. Population Assessment

4.1 Reconnaissance

The reconnaissance phase of this study consisted of a detailed survey of Gabilan Creek. Portions of the creek from the confluence of Tembladero Slough to the headwaters located within Rancho Cienega Del Gabilan were walked and surveyed with the exception of the portion that runs through downtown Salinas (due to concerns with safety). The main goal of this survey was to locate perennial water and any obstructions that may prevent the migration of steelhead.

The exact location of the portion of the creek to be surveyed and the adjacent land ownership were determined. If necessary, land owners were contacted in order to gain permission to access the creek. The first step of the field survey involved assembling the necessary field equipment (Table 5). Next, teams (usually of two) conducted the survey. The survey included walking and mapping portions of the creek using GPS, while also taking detailed field notes. These notes included general descriptions of the creek pattern (for example meandering, braided, or straightened), creek profile, and roughness. Dominant substrate (boulder, cobble, gravel, sand, or silt) within each section was also determined. Estimates for average percent overhead cover were made. If perennial water was present, width and depth measurements were taken for the low flow channel. In addition, estimates were made for bankfull width and depth. Water temperatures were periodically taken throughout the survey. For major pools encountered, length, width, and depth measurements were taken. In sections with an abundance of pools and large woody debris, counts were made. Important features such as pools, riffles, bank condition, riparian vegetation, obstructions, possible pollution sources, and adjacent land use were noted. All fish, frog, and major plant species encountered were also noted.

4.2 Detailed Habitat Assessment

Habitat assessment was conducted using the Rearing Index for Young-of-the-Year Method (Dettman and Kelley 1986). This method was originally developed by D. W. Kelley and Dave Dettman, a fishery biologist for the Monterey Peninsula Water Management District. The method uses measures of quality and quantity of rearing habitat to calculate a rearing index. The rearing index can then be used to predict steelhead young-of-the-year population density per unit length of stream.

The original Rearing Index for Young-of-the-Year program was revised and updated by Dr. Fred Watson, Adjunct Faculty at California State University Monterey Bay. The new program is operated using *Microsoft Access* Software. It was tested by entering data provided and previously analzyed by Dave Dettman using the older method. The results of updated version were comparable to the original Dettman/Kelley program with less than 3% error.

Habitat assessment was performed for five representative reaches located in the headwaters of Gabilan creek. They were selected based on their suitability for rearing, determined by the reconnaissance phase of this study. Each reach was delineated according to character type (pool, glide, riffle, or run). Each character was then divided into homogenous sections based on factors such as apparent depth, velocity, and dominant substrate. For each section, length and width measurements were taken. Five depth measurements were then taken for each section. The surface water velocity was measured using a stopwatch, a dowel, and a 2 meter measuring stick. Next, percent embeddedness of the section was measured for five randomly chosen cobbles. Abundance of cobbles was determined by estimating the percent of cobbles per total substrate. Roughness and cover were rated from 0 to 3 (0-poor, 3-excellent). Table 5 lists the necessary field equipment to conduct this type of assessment.

The data was then entered into the updated Rearing Index for Young-of-the-Year program, which calculated a rearing index for each reach. The rearing capacity, number of young-of-the-year per unit length of stream, was also determined.

Apart from the Rearing Index for Young-of-the-Year Method, selected sites throughout the watershed were monitored for stream factors such as temperature, dissolved oxygen concentrations, total dissolved solids, and suspended sediment concentrations. Temperatures were measured in September and October 2000 at sites located in three reaches of Gabilan creek. Measurements for dissolved oxygen concentration were also taken at sites within the three reaches during the winter 2000/2001. The Salinas Sediment Study (SSS) monitored Gabilan

Creek, at sites within two reaches, during four winter storm events. The SSS field campaigns involved taking measurements of stream flow and collecting water samples which were processed for suspended sediment concentration and total dissolved solids using the protocol determined by the SSS. This involved approximately 200 site visits throughout the winter months.

Table 5. Field Equipment List

Field Equipment	
GPS: *Trimble's GeoExplorer and Pro XR*	Optical range finder
YSI Dissolved Oxygen Meter	Reel measuring tape
Digital Camera	2 meter measuring stick
Topographic maps	Ruler and grain size card
Plant and fish guides	Thermometer
Waterproof field book	Stopwatch
Boots and Waders	Small dowels

4.3 Population Assessment

The third phase of the study involved conducting a steelhead population assessment. The original intent of this assessment was to estimate the abundance of steelhead by electrofishing and/or netting. These counts were intended to estimate the population size of steelhead, if they in fact exist in Gabilan creek. However, this portion of the study has not yet been completed due to the pending status for the required National Marine Fisheries Service Section 10 Permit.

An alternative method for population assessment consisted of visual adult steelhead observations, if present, during upstream migrations. Interviews were also conducted with several local residents regarding historical anecdotal steelhead sightings.

5 Results

5.1 Reconnaissance

The reconnaissance portion of this study involved an initial survey of Gabilan Creek. The purpose of this survey was to locate perennial water, note important features related to the survival and spawning of steelhead, and to map accessible portions of the creek. The survey was conducted along much of the length of the creek and grouped into three reaches totaling approximately 21 km (Fig. 6-1).

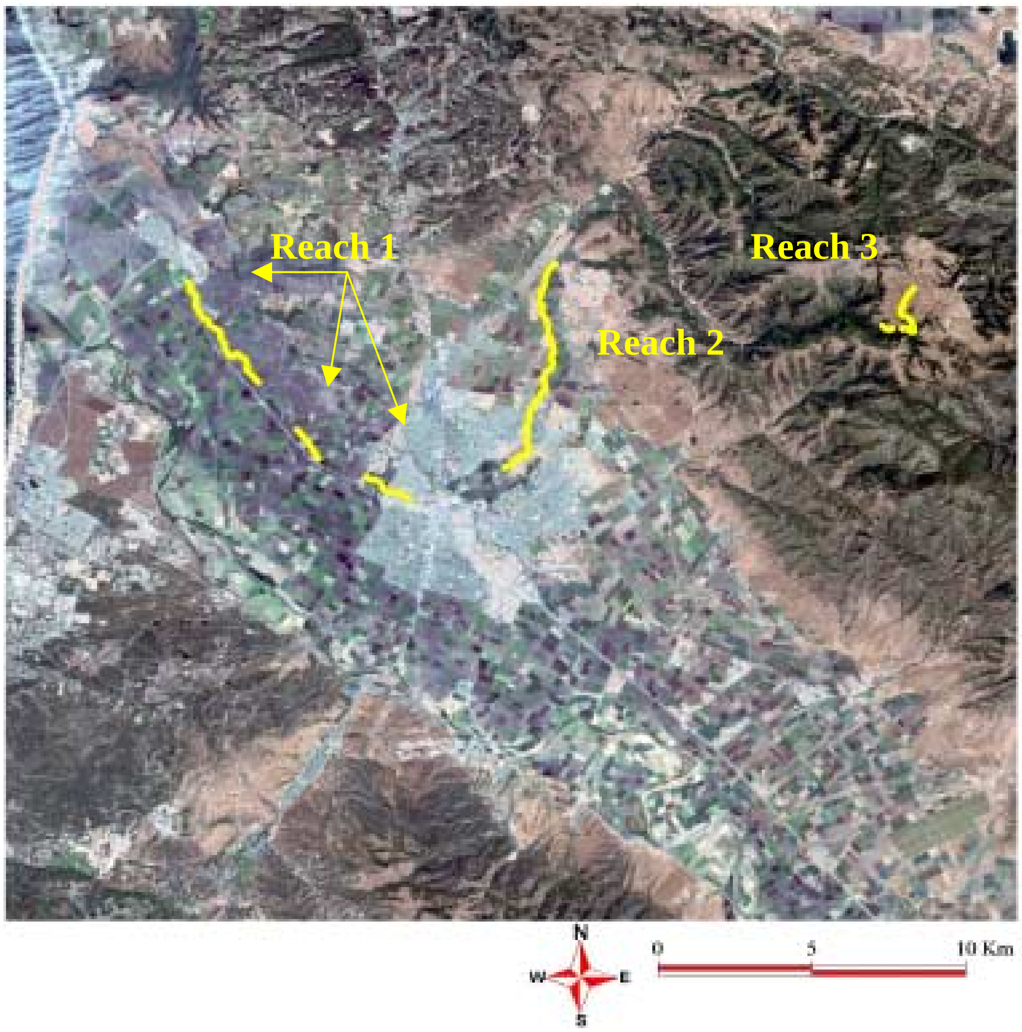

Figure 6-1. Map of Gabilan Creek illustrating 3 surveyed reaches.

Reach 1 was located along the Reclamation Ditch. The reach was divided into four sections. For a detailed map showing the four sections and the noted features see Figure 6-2. The results of the reconnaissance work along Reach 1 are summarized in Table 6-1, and photographs illustrating sites within each of the four sections are presented Figures 6-3 to 6-6.

The channel within Reach 1 was straight and incised. The flow was uniform, lacking significant roughness. All sections within the reach displayed almost no redeeming habitat features such as an abundance of pools, sufficient cover, and presence of large woody debris. The channel substrate was primarily silt and clay. The banks were relatively unstable with visible erosion, and also lacked riparian vegetation.

Reach 2 was located along lower Gabilan Creek. This reach was divided into three sections. Figure 6-7. illustrates the three sections and important features that were noted during the survey of this reach. A summary of the results of reconnaissance work for this portion of Gabilan Creek are found in Table 6-2. Figures 6-8 to 6-11 present photographs at sites within each of the three sections.

Reach 2 was still channelized and fairly straight, but perennial water was only present in the first half of the reach. Riparian vegetation, cover, and large woody debris were more abundant than in Reach 1. The channel substrate was predominantly coarse sand.

Reach 3 was located in the headwaters of Gabilan Creek. This reach is comprised of three sections. Figure 6-12 is a map of Reach 3 illustrating the three sections and important feature noted features of the survey. The results of reconnaissance work in this upper Gabilan Creek reach are summarized in Table 6-3. Photographs at sites within each of the three sections are presented in Figures 6-13 to 6-15.

Reach 3 was characterized by step/pool and pool/riffle sequences, and perennial water was present throughout this entire portion of the creek. The gradient was much steeper than in the previous two reaches. Channel substrate was a combination of bedrock, boulder, cobble, and gravel. The quality of habitat also changed drastically. For instance, the abundance of pools, overhead cover, and large woody debris increased. Additionally, on one field day, 16 rainbow trout were observed in various pools.

The only major obstruction to migration found within the three reaches was located in Reach 3. A large waterfall, approximately 4 meters in height was located with Section 2 of this reach. Other detailed field data for the three reaches is included in Appendix A.

Reach 1: Reclamation Ditch

- Incised ditch
- flat gradient
- lacking roughness
- little to no riparian vegetation
- rip-rap in some areas

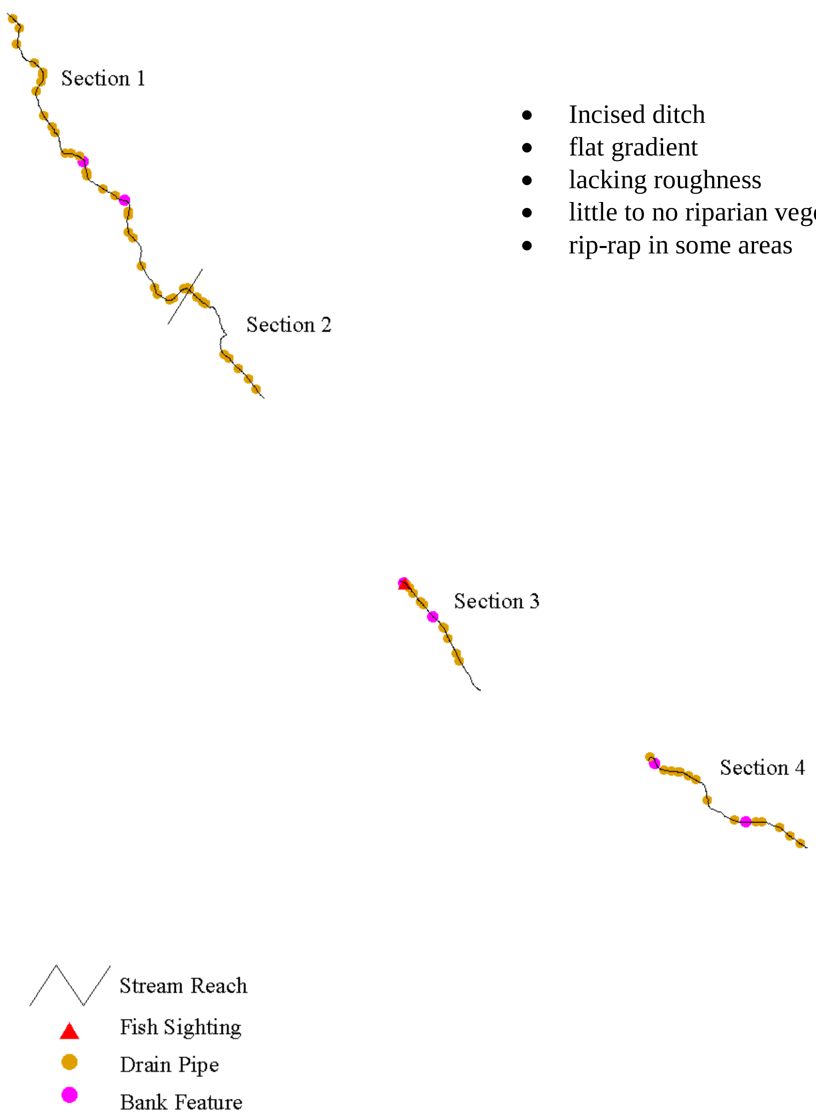

Figure 6-2. Reclamation Ditch

Table 6-1. Reach 1: Reclamation Ditch Reconnaissance Summary

Location	***Perennial Water***	***Pools***	***LWD***	***Overhead Cover***	***Erosion***	***Bank Vegetation***	***Substrate***	***Fish & Amphibian Sightings***	***Adjacent Land Use***
Section 1	Yes	-	-	-	+	-	sand, silt	Common Carp	row crop agriculture
Section 2	Yes	-	-	-	+	✓	sand, silt	California Roach	row crop agriculture
Section 3	Yes	-	-	-	+	-	silt, clay	Common Carp	row crop agriculture
Section 4	Yes	-	-	-	+	✓	silt, clay	California Roach	row crop agriculture, industrial

(-) very little to none **(✓) moderate** **(+) abundant**

Figure 6-3. Location: Reach 1 Section 1, showing confluence with Tembladero Slough, incised channel, and lack of riparian vegetation (Photo: JulieHager)

Figure 6-4. Location: Reach 1 Section 2, showing deeply incised channel with lack of riparian vegetation (Photo: Joel Casagrande)

Figure 6-5. Location: Reach 1 Section 3, showing incised channel, bank erosion, and agricultural drainage pipe (Photo: Joel Casagrande)

Figure 6-6. Location: Reach 1 Section 4, showing deeply incised channel, lack of riparian vegetation, and rip-rap with sand bags (Photo: Julie Hager)

Reach 2: Lower Gabilan

- incised channel in some areas
- relatively flat gradient
- moderate amount of riparian vegetation

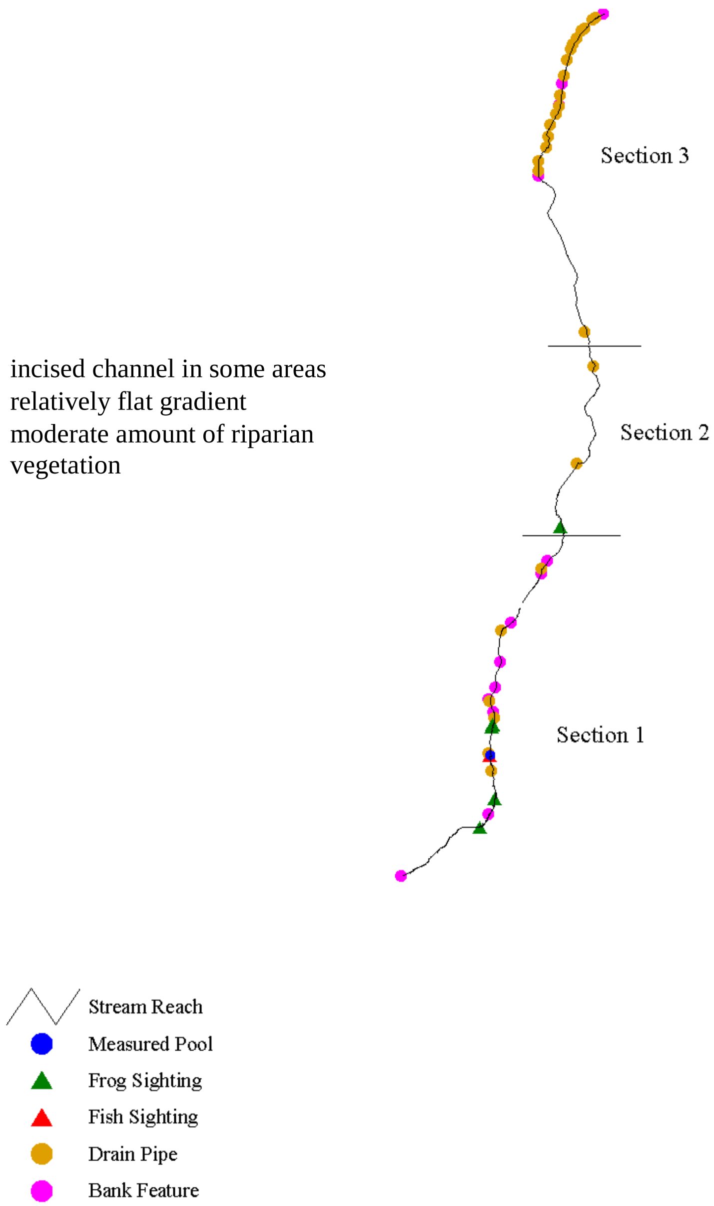

Figure 6-7. Reach 2: Lower Gabilan Creek

Table 6-2. Reach 2: Lower Gabilan Creek Reconnaissance Summary

Location	***Perennial Water***	***Pools***	***LWD***	***Overhead Cover***	***Erosion***	***Bank Vegetation***	***Substrate***	***Fish & Amphibian Sightings***	***Adjacent Land Use***
Section 1	Yes	-	✓	✓	-	+	sand	Pacific Treefrog	residential
Section 2	No	-	✓	+	✓	✓	sand	Western Toad	row crop agriculture, grazing, residential
Section 3	No	-	-	-	+	-	sand	none	row crop agriculture residential

(-) very little to none **(✓) moderate** **(+) abundant**

Figure 6-8. Location: Reach 2 Section 1, showing abundant riparian vegetation (Photo: Julie Hager)

Figure 6-9. Location: Reach 2 Section 2, showing riparian vegetation and sand substrate (Photo: Joel Casagrande)

Figure 6-10. Location: Reach 2 Section 3, showing lack of riparian vegetation, incised channel, and visible erosion (Photo: Julie Hager)

Reach 3: Upper Gabilan

- step/pool and pool/riffle sequences
- steep gradient
- abundant riparian vegetation

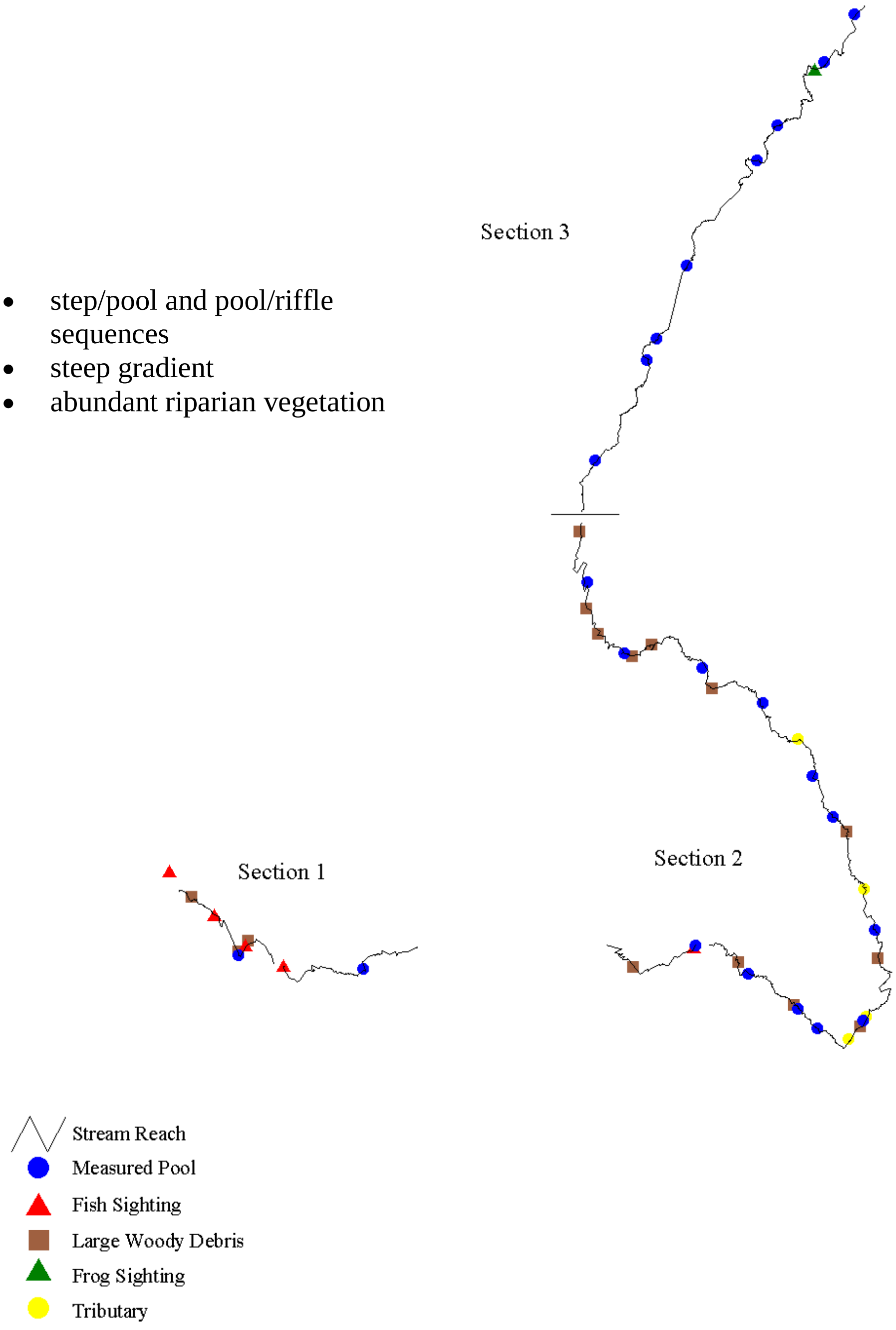

Figure 6-11. Reach 3: Upper Gabilan Creek

Table 6-2. Reach 3: Upper Gabilan Creek Reconnaissance Summary

Location	***Perennial Water***	***Pools***	***LWD***	***Overhead Cover***	***Erosion***	***Bank Vegetation***	***Substrate***	***Fish & Amphibian Sightings***	***Adjacent Land Use***
Section 1	Yes	+	+	+	-	+	cobble boulder	Rainbow Trout	grazing
Section 2	Yes	+	+	+	-	+	bedrock boulder	none	grazing
Section 3	Yes	+	+	+	-	+	cobble boulder	Bullfrog	grazing
(-) very little to none **(✓) moderate** **(+) abundant**									

Figure 6-12. Location: Reach 3 Section 1, showing boulder/cobble substrate, woody debris, and steep gradient (Photo: Julie Hager)

Figure 6-13. Location: Reach 3 Section 2, showing bedrock substrate, small pools, and steep gradient (Photo: Joel Casagrande)

Figure 6-14. Location: Reach 3 Section 3, showing cobble substrate (Photo: Julie Hager)

5.2 Detailed Habitat Assessment

From the reconnaissance work it was determined that the most appropriate location to perform habitat assessment was within Reach 3 (Upper Gabilan). Five sites were selected, within a wide riparian corridor in the steep country surrounded by grazed grasslands. Within each of the five locations, there was the presence of large woody debris, undercut banks and trees, and abundant overhead canopy providing adequate shade and cover. Habitat assessment was conducted for these five sites using the Rearing Index for Young-of-the-Year Method (Dettman and Kelley 1986). Figure 6-15 illustrates the locations of these five sections in Reach 3. A rearing index was calculated for each of the five habitats and then used to determine the predicted steelhead young-of-the-year population density per unit length of stream.

The results are summarized in Table 6-3. The five sections surveyed totaled 117 meters, and have the capacity to support approximately 180 steelhead young-of-the-year. Throughout all five of the sections, cover was abundant and received high ratings (usually 2 on a 0 to 3 scale). Roughness varied throughout the reaches depending on the amount of pools and riffles within each section. Pools generally received lower ratings, as they often lacked significant roughness. The average cobble abundance within the five habitats was 22%, and the average embeddedness was 26%. The average pool depth was 0.25 meters. Appendix B presents the complete field data.

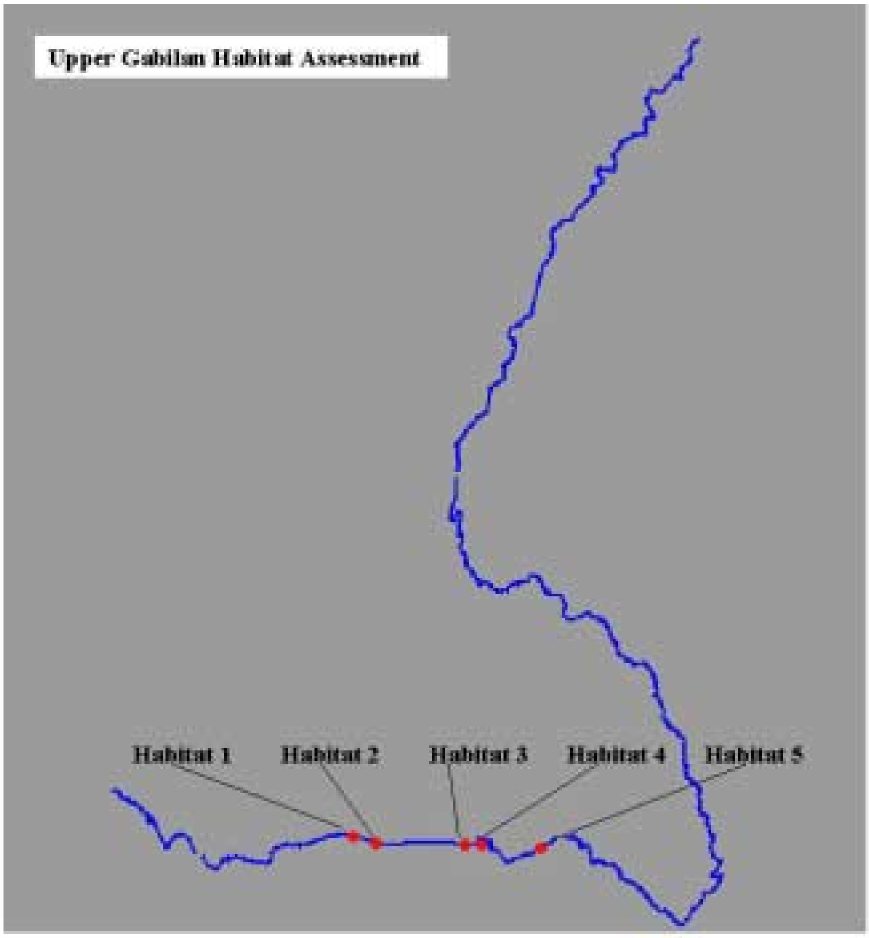

Figure 6-15. Upper Gabilan (Reach 3) Habitat Assessment Map

Table 6-3. Habitat Assessment Summary

Section ID	*Length (m)*	*Avg. Cobble Abundance*	*Avg. Cobble Embeddedness*	*Average Pool Depth (m)*	*Rearing Index*	*Density (fish per meter)*
Habitat 1	44.00	18%	21%	.24	4182	**1.58**
Habitat 2	14.00	14%	30%	.16	1767	**2.02**
Habitat 3	12.85	23%	35%	.34	1121	**1.47**
Habitat 4	21.90	33%	26%	.22	1300	**1.08**
Habitat 5	24.60	24%	18%	.31	2525	**1.72**

The next portion of the habitat assessment involved monitoring sites along Gabilan Creek for temperature, suspended sediment, total dissolved solids (TDS), and dissolved oxygen. Summer water temperature and dissolved oxygen measurements were recorded at various sites within the three reaches and are summarized in Table 6-4. Measurements for suspended sediment and TDS were taken during four winter (2001) rain events. A total of six sites, three within Reach 1 and three within Reach 2, were monitored during these winter events. Reach 3 was not monitored during these events due to time constraints and poor road conditions during the intense rains. The results of this monitoring are summarized in Table 6-5.

Table 6-4. Water Temperature and Disssolved Oxygen Summary

Location	*Mean Temp (C)*	*DO (mg/L)*
Reach 1	20.75	11.28
Reach 2	21.0	8.23
Reach 3	12.93	10.25

Table 6-5. Suspended Sediment Concentration and Total Dissolved Solids Summary

Rain Event	*Range of Suspended Sediment Concentration (mg/L)*		*Range of Total Dissolved Solids (μS)*	
	Reach 1	**Reach 2**	**Reach 1**	**Reach 2**
Jan 7-13	29 to 913	0-1904	145-1443	370-995
Jan 23-26	47 -1928	7.8-6714	76-1360	148-1016
Feb 9-12	No Data	302-5884	No Data	121-1066
Feb 18-19	33-1321	2.5-6812	107-1355	133-1067

The mean summer temperatures measured for Reach 1 and Reach 2 were above the preferred temperature range for steelhead rearing, 7.3 to 14.6° C (Bell 1973; as cited in Reiser and Bjornn 1979). The average temperature for Reach 1 was 20.75° C and 21.0° C for Reach 2, which were both approaching the lethal limit of 24.1° C. However, temperatures within Reach 3 were within the preferred temperature range. The dissolved oxygen levels recorded for the three reaches were all within the suggested criterion of >7.8 mg/L dissolved oxygen for salmonids (Pennel and Barton 1996).

For three of the four monitored winter storm events, the upper limit of the suspended sediment concentration range for Reach 2 was greater than 4,000 mg/L. Suspended sediment concentrations greater than 4,000 mg/L have been found to cause migration to cease (Bell 1973; as cited in Reiser and Bjornn 1979).

5.3 Population Assessment

Due to the pending status of the NMFS permit, electrofishing was not conducted. However, Gabilan creek was monitored during 4 winter storm events. During that time zero migrating steelhead were observed. However, resident rainbow trout were observed in the headwaters (Reach 3). On one field day, 16 trout were observed in various pools and riffles.

The second part Phase C involved interviewing several individuals for historical anecdotal steelhead sightings within the watershed. The first person contacted regarding steelhead in the region was Darrell Boyle, the ranch manager at Rancho Cienaga Del Gabilan (Gabilan Cattle Company). Darrell Boyle wrote,

> “Our caretaker on the ranch for 15 years until two years ago reported seeing steelhead several times at the headwaters. The house he lived in is on Gabilan Creek, on the basin just below Fremont Peak. He called them "egg eaters" indicating to me juveniles (I thought he was talking about half-pounders). He reported his daughter caught one that was 20 or so inches in the pool below his house. I would guess this was about 10 years ago.”

The second person interview was with Bill Tarp, a life-long resident of Monterey County. He recalled that he, his father, and his grandfather used to fish in the headwaters of Gabilan Creek near Fremont Peak in the 1940’s. However, they did not recall ever catching or observing steelhead. The largest fish that he ever caught within the watershed was a 7-9 inch rainbow trout.

6 Discussion

6.1 Reconnaissance

Based on the substrate compositions of the three reaches examined in this portion of the study, only Reach 3 could serve as a spawning area for potential steelhead populations. However, a potential barrier to migration was detected at the beginning of Section 2. The cobble size substrate found along this reach is suitable for the construction of redds, whereas both Reach 1 and Reach 2 were dominated by coarse sand and silt. During higher flows, sand and silt are frequently transported as bedload along the bottom of the channel resulting in an unstable substrate, which is not optimal for redd construction.

The results of the reconnaissance work also indicated that Reach 3 could provide rearing habitat for steelhead young. This indication was based on the presence of pools of sufficient depth, substantial cover, and abundance of large woody debris. Reach 1 and 2 lacked sufficient overhead cover, woody debris, and pool/riffle structuring. These parameters help to control temperature and provide cover and food, which are essential for productive rearing. Although Reach 1, the Reclamation Ditch, did have water throughout the summer, the flow was uniform and lacking the hydraulic roughness that creates pools and riffles. Reach 2 did not have perennial water.

6.2 Detailed Habitat Assessment

The results of the habitat assessment that was conducted in Reach 3 reiterates the conclusions made from the reconnaissance results; Reach 3 does provide potential rearing habitat for steelhead. The average potential population density for steelhead young-of-the-year within the five surveyed sections was 1.6 fish per meter. The same Rearing Index for Young-of-the-Year Method has been conducted on several streams throughout the region. For instance, on the main stem of the Carmel River above the Los Padres dam, the average young-of-the-year rearing capacity was estimated as 5.7 fish per meter (Dettman and Kelley 1986).

The five sections surveyed were representative of all of Reach 3. The total length of stream in Reach 3 below the potential barrier detected during the reconnaissance work is approximately 770 meters. Therefore, Reach 3 has the potential to support approximately 1,230 steelhead young-of-the-year. The length of the stream not surveyed between Reach 2 and Reach 3 is approximately 16 km. If this stretch of stream is similar to the sections that were assessed, then the entire Gabilan creek may have the potential to support up to 25,800 steelhead young-of-the-year. In addition, some of the small tributaries to Gabilan creek such as Vierra, Towne, and Mud creek may also have similar habitat. If so, the entire watershed may have the potential to support more than 30,000 steelhead young-of-the-year.

The results of the summer temperature monitoring suggest that the Reclamation Ditch (Reach 1) and portions of lower Gabilan creek (Reach 2) are not suitable for steelhead rearing. The average summer temperatures of both of these reaches exceeded the preferred temperature range for *O. mykiss* (7.3 to 14.6° C).

The results of the winter monitoring suggested that the sediment concentrations measured for Reach 2 could inhibit the migration of adult steelhead. Concentrations greater than 4,000 mg/L have been found to cause migration to cease (Bell 1973; as cited in Reiser and Bjornn 1979). For three of the four monitored events, the maximum sediment concentrations were greater than 4,000 mg/L. Sediment concentrations may have been much lower between storms, thus permitting successful migration. However, a few portions of the stream only flowed during the major winter storm events.

6.3 Population Assessment

Gabilan creek was monitored during four storm events that occurred within the steelhead migrating season. During that time, zero steelhead were observed. The rains of the season were more than likely not abundant enough to provide sufficient flow for successful migration. Flow was only strong enough to connect the entire Gabilan creek system for two days, once during the February 9-12 event and once during the February 18-19 event (Watson et al. 2001).

The results of one of the interviews suggested that steelhead have existed in Gabilan creek in the past. However, this is only one anecdote, and more research on this is needed.

7 Conclusion

In conclusion, reconnaissance work was conducted in three reaches within the Gabilan creek watershed. This was followed by a detailed habitat assessment using a Rearing Index for Youn-of-the-Year Method, which estimated potential steelhead population density per unit length of stream. Environmental and water quality criteria such as summer temperature, dissolved oxygen, suspended sediment, and total dissolved solids were also measured. Finally, a population assessment was performed including adult steelhead observations and interviews regarding historical anecdotal steelhead sightings.

7.1 Is there suitable habitat for steelhead in the Gabilan creek watershed?

The results of the reconnaissance portion of this study indicated that suitable rearing and spawning habitat does exist in the headwaters of Gabilan Creek. It was also determined that sections in the Reclamation Ditch and lower reaches of Gabilan creek could be problematic for the migration of adults due to lack of cover, woody debris, and uniform flow structure.

From the habitat assessment, it was determined that the surveyed sections (117 meters) in the headwaters can potentially support up to 180 steelhead young-of-the-year. Additionally, the entire Gabilan creek watershed may have the potential to support up to 30,000 steelhead young-of-the-year. However, the monitoring for water quality criteria suggested that suspended sediment concentrations and high temperatures for lower portions of the creek may be problematic for migrating adults.

7.2 Have populations existed there in the past?

One of the two interviews suggested that steelhead have existed in Gabilan creek in the past. However, this is only one account of a steelhead sighting in this watershed and does not absolutely confirm that a substantial run ever existed.

7.3 Do populations of steelhead currently exist?

The first portion of the population assessment resulted in zero steelhead observations, which was primarily accounted to the lack of rainfall and flow. Therefore, it remains inconclusive as to whether or not steelhead currently exist in Gabilan creek. However, rainbow trout were found in the headwaters. Rainbow trout have a polymorphic life-history structure enabling them to assume anadromy. Therefore, even if steelhead do not currently exist in Gabilan creek, there is a potential for a steelhead run during years with adequate rainfall and stream flow.

7.4 Policy and Ethical Implications

The results of this study raise several ethical and policy related issues. Since suitable rearing and spawning habitat exists, and there is the potential for a current steelhead run based on the polymorphism of rainbow trout, should land use management and policy decisions place more emphasis on habitat protection? Should problematic areas in the lower reaches be restored in order to enhance the successful migration of steelhead?

Currently management and local agencies may not be aware of the possibility of a current or future steelhead run due to lack of previous studies on habitat and population within this watershed. Therefore, it is important that community awareness on the this issue increases. The lower reaches of Gabilan Creek had high suspended sediment concentrations and summer temperatures which have been proven to adversely affect steelhead migration. Ideally, it would be beneficial to reduce these levels by restoring these portions of the creek and promoting land use practices that reduce sediment loads. This would require addressing other issues such as human use and finance. However, with proper land use management and policy it is possible to restore the habitat along lower Gabilan Creek. This requires education, incentive, planning, and support.

7.5 Future Work

There is need for additional studies in order to understand the relationships between land use, water quality, and aquatic habitats. More steelhead habitat and population analyses on Gabilan creek are also needed, as several portions of the creek were not monitored due to accessibility and time constraints. The use of alternative methods for assessing rearing and spawning habitat in the headwaters would serve as an excellent source for comparison of the methods used in this study.

Future surveys regarding historical anecdotal accounts would also be extremely helpful toward confirming whether or not steelhead ever existed in Gabilan Creek. In order to preserve this threatened south central coast species, it is essential to have a complete understanding of the abundance, distribution, and quality of habitat and population. Policy decisions must aim at enhancing the existing habitat while also supporting the needs of the landowners and community.

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10 Appendices

10.1 Appendix A: Reconnaissance Data

Reach ID	Sect ID	Date	Reach Length	Perennial water?	Est Bkf width	Est Bkf depth	Low-flow width	Low-flow depth	Median class size	Large Woody Debris	Pools	Notes
1	3	8/16/00	1308	Yes	-	-	3	0.75	MUD	0	0	abundance of algae, crop-lettuce and broccoli, stage .89m, bed is silt, clay, boulders
1	3	8/16/00	168	Yes	-	-	3	0.75	MUD	0	0	abundance of algae, power station on R bank, crop-broccoli
1	4	8/16/00	694	Yes	-	-	3	0.75	MUD	0	0	abundance of algae, litter
1	4	8/16/00	998	Yes	-	-	3	0.5	MUD	0	0	abundance of algae, ended at victor bridge
2	2	8/17/00	701	No	-	-	8	0.08	SAND	-	0	coarse sand and gravel substrate, concrete spillway~2M high, rip-rap under bridges
2	2	8/17/00	1025	No	-	-	0	0	SAND	-	0	coarse sand and gravel substrate, grazing present, observed 1 'western toad'
2	2	8/17/00	785	No	-	-	0	0	SAND	-	0	dirt road crosses creek
1	1	8/21/00	3560	Yes	-	-	8	0.3	SAND	0	0	abundance of algae, sand, silt, and mud substrate, observed 'common carp'
1	2	8/21/00	1459	Yes	-	-	0	0	SAND	0	3	small area with good vegetation, some pool-riffle sequences (not well defined), higher velocity than normal
2	1	8/22/00	3477	Yes	-	-	10	0.1	SAND	-	0	rip-rap not continuous, water source from urban drain at lexington bridge
2	3	8/31/00	3097	No	-	-	-	-	SAND	0	0	pollution and litter present (pvc pipe and psuedoephedrine hydrochloride bottles)
3	3	9/27/00	288	Yes	5	1	3.1	0.3	COBBLE	1	9	bull frog sighting
3	3	9/27/00	349	Yes	2	2	0.7	0.3	COBBLE	3	22	confluence with small tributary
3	3	9/27/00	211	Yes	6	1	2.3	0.05	COBBLE	-	12	pool/riffle sequences
3	3	9/27/00	223	Yes	4	1	1.4	0.1	COBBLE	1	16	meandering
3	3	9/27/00	125	Yes	6	1	2.7	0.2	BOULDER	-	9	gradient increased, channel straightened, riffles shorter, pools deeper
3	2	11/3/00	367	Yes	6	2	2.6	0.15	BOULDER	6	28	fencing present to prevent cattle access to creek
3	2	11/3/00	555	Yes	6	2	1.5	0.2	BOULDER	8	34	gradient increased, more exposed bedrock
3	2	11/3/00	395	Yes	9	1	2.95	0.05	BOULDER	4	26	pool temperatures 8° C
3	2	11/3/00	533	Yes	11	2	2	0.3	BOULDER	6	37	possible obstruction (waterfall) at end of reach
3	1	11/17/00	216	Yes	20	2.5	1.5	3	BOULDER	5	17	observed 3 rainbow trout, length ~6 inches
3	1	11/17/00	296	Yes	10	2.5	1.5	0.3	BOULDER	4	23	observed 2 rainbow trout, length~6-8 inches
3	1	11/17/00	258	Yes	20	2	1.5	0.3	BOULDER	8	22	observed 7 rainbow trout, length ~6-8 inches

Appendix A: Reconnaissance Data (cont.)

Reach ID	Sect ID	Date	Reach Length	Eroded bank	Rip-rap	Plant species	Cover	Land use (left bank)	Land use (right bank)
1	3	8/16/00	1308	Both	Both		-	ROW	ROW
1	3	8/16/00	168	Both	None	Hemlock, Nettle	-	ROW	ROW
1	4	8/16/00	694	Both	None	Hemlock, Nettle, Willow	-	ROW	ROW
1	4	8/16/00	998	Both	None	Hemlock, Nettle	-	RESID	INDUS
2	2	8/17/00	701	None	None	Sycamore, Cottonw, Willow, Grass, Mustard, Hemlock, Nettle, Watercress, Cape Ivy	-	RESID	RESID
2	2	8/17/00	1025	Both	None	Willow, Nettle, Watercress, Sycamore	-	ROW	ROW
2	2	8/17/00	785	None	None	Oak, Cat tail, Cape Ivy, Sycamore, Willow, Arundo	-	ROW	ROW
1	1	8/21/00	3560	Both	None	Willow, Nettle, Hemlock, Watercress	-	ROW	ROW
1	2	8/21/00	1459	Both	None	Willow, Nettle, Hemlock, Watercress	-	ROW	ROW
2	1	8/22/00	3477	None	Both	Cottonw, Sycamore, Willow, Cape Ivy, Watercres, Coyote, Arundo, Thistle, Hemlock, Cat tail	-	RESID	RESID
2	3	8/31/00	3097	Both	None	Willow, Sycamore, Arundo, Hemlock, PampasGrs	-	ROW	ROW
3	3	9/27/00	288	None	None	Oak, Maple, Psn Oak, Madrone, Ferns, Willow	80%	GRAZE	GRAZE
3	3	9/27/00	349	None	None	Wild Berr, Rush, Oak, Maple, Willow	50%	GRAZE	GRAZE
3	3	9/27/00	211	None	None	Psn Oak, Wild Berr, Thistle, Oak, Willow, Nettle, Maple	40%	GRAZE	GRAZE
3	3	9/27/00	223	None	None	Rush, Willow, Madrone	40%	GRAZE	GRAZE
3	3	9/27/00	125	None	None	Alder, Maple, Ferns, Psn Oak	70%	GRAZE	GRAZE
3	2	11/3/00	367	None	None	Madrone, Maple, Psn Oak, Oak, Nettle, Ferns	80%	GRAZE	GRAZE
3	2	11/3/00	555	None	None	Madrone, Maple, Psn Oak, Oak, Nettle, Ferns	70%	GRAZE	GRAZE
3	2	11/3/00	395	None	None	Madrone, Maple, Psn Oak, Oak, Nettle, Ferns	70%	GRAZE	GRAZE
3	2	11/3/00	533	None	None	Madrone, Maple, Psn Oak, Oak, Nettle, Ferns, Sycamore	65%	GRAZE	GRAZE
3	1	11/17/00	216	None	None	Madrone, Alder, Psn Oak, Oak, Nettle, Ferns, Sycamore	50%	GRAZE	GRAZE
3	1	11/17/00	296	None	None	Madrone, Alder, Psn Oak, Oak, Nettle, Ferns, Sycamore	60%	GRAZE	GRAZE
3	1	11/17/00	258	None	None	Madrone, Alder, Psn Oak, Oak, Nettle, Ferns, Sycamore	70%	GRAZE	GRAZE

10.2 Appendix B: Habitat Assessment Data

Juvenile Steelhead Habitat Survey

Stream: Gabilan Creek
Location: Habitat 1
Date: 12/9/00 & 12/21/00

CHAR	LENGTH (m)	WIDTH (m)	DEPTH (m)					EMBEDDEDNESS (%)					VELOCITY (m/s)	CbAb (%)	ROUGH	COVER	Distrif (m)
PL	7.4																
	3.2	2	0.2	0.07	0.13	0.1	0.07	0	0	0	0	0	0	0	1	2	0
	3.2	2.5	0.37	0.32	0.33	0.35	0.18	0	0	0	0	0	0	0	1	2	0
	2	2.5	0.18	0.25	0.19	0.25	0.07	0	0	0	0	0	0	0	0	1	3
	2.2	1.5	0.13	0.25	0.12	0.12	0.23	20	0	0	0	0	0	1	0	1	5
	2.2	2.1	0.25	0.42	0.37	0.22	0.3	0	0	0	0	0	0	0	2	2	5
RN	2.2	1.4	0.1	0.15	0.17	0.18	0.11	45	50	35	35	10	.13	65	1	2	7
	2.2	1.5	0.22	0.28	0.21	0.21	0.2	60	2	25	25	5	.20	20	1	2	7
RF	7.2																
	5.5	1	0.11	0.03	0.07	0.14	0.18	10	35	60	50	5	0.3	25	2	2	15
	2	0.5	0.06	0.09	0.06	0.02	0.05	50	2	10	60	60	0	2	2	1	18
	1.7	0.5	0.12	0.15	0.22	0.09	0.1	50	5	40	70	60	0.18	10	2	2	20
PL	4.5																
	2	2	0.3	0.34	0.42	0.3	0.3	55	45	10	35	50	0.03	5	1	2	0
	2.5	2	0.28	0.3	0.15	0.23	0.17	40	60	35	15	10	0	2	1	2	1
RN	3.2																
	2	1.3	0.11	0.21	0.13	0.1	0.11	20	5	30	50	25	0.06	35	1	2	4
	1.2	2	0.1	0.05	0.04	0.03	0.1	20	15	40	10	35	0.27	50	1	2	6
RF	19.5																
	8	0.7	0.16	0.12	0.09	0.1	0.12	30	20	7	5	10	0.31	45	2	2	8
	11.5	0.8	0.12	0.11	0.03	0.1	0.1	50	20	8	55	40	0.44	35	2	2	16

Juvenile Steelhead Habitat Survey
Stream: Gabilan Creek
Location: Habitat 2
Date: 12/30/00

CHAR	LENGTH (m)	WIDTH (m)	DEPTH (m)					EMBEDDEDNESS (%)					VEL (m/s)	CbAb (%)	ROUGH	COVER	Distrif (m)
PL	3.8																
	3.8	2	0.26	0.17	0.25	0.15	0.18	50	20	65	40	20	0	2	1	2	2
	2	1.9	0.11	0.14	0.13	0.04	0.18	20	45	50	10	5	0	2	1	2	2
RN	10.2																
	2.6	1.4	0.08	0.11	0.13	0.1	0.05	20	35	55	10	40	0.23	40	1	2	6
	2	2	0.09	0.15	0.15	0.18	0.11	10	50	20	50	55	0.07	15	1	1	8
	3.2	2.8	0.08	0.1	0.03	0.03	0.03	45	5	5	10	10	0.14	25	2	2	10
	2.4	2.7	0.11	0.12	0.18	0.1	0.12	20	15	30	45	50	0.19	2	1	2	14

Juvenile Steelhead Habitat Survey
Stream: Gabilan Creek
Location: Habitat 3
Date: 12/30/00

CHAR	LENGTH (m)	WIDTH (m)	DEPTH (m)					EMBEDDEDNESS (%)					VEL (m/s)	CbAb (%)	ROUGH	COVER	Distrif (m)
PL	3.75	1.4	0.19	0.4	0.48	0.3	0.32	50	60	45	45	65	0	1	1	2	0
RF	9.1																
	3.2	2	0.1	0.06	0.05	0.06	0.05	10	15	65	65	60	0.24	30	1	2	4
	1.7	1.8	0.11	0.07	0.1	0.1	0.09	5	45	15	20	35	0.25	15	2	2	7
	4.2	1.2	0.12	0.16	0.11	0.1	0.12	15	5	30	50	5	0.38	45	2	2	9

Juvenile Steelhead Habitat Survey
Stream: Gabilan Creek
Location: Habitat 4
Date: 12/30/00

CHAR	LENGTH (m)	WIDTH (m)	DEPTH (m)					EMBEDDEDNESS (%)					VEL (m/s)	CbAb (%)	ROUGH	COVER	Distrif (%)
PL	4.3																
	1.5	1	0.36	0.3	0.29	0.25	0.24	5	5	10	15	5	0.07	5	2	2	2
	2.8	2	0.09	0.25	0.25	0.2	0.15	15	10	2	25	30	0	2	0	2	3
RF	4.5	0.25	0.15	0.05	0.01	0.01	0.06	45	0	30	15	50	0.34	60	2	2	4
PL	0.7	1.7	0.13	0.2	0.2	0.16	0.12	10	70	15	5	75	0	15	1	2	0
RF	8.4																
	2.3	0.07	0.02	0.03	0.04	0.03	0.07	45	0	25	45	50	0.23	75	1	2	1
	2	1.3	0.11	0.1	0.02	0.09	0.04	60	15	10	20	5	0.14	80	1	2	3
	4.1	0.9	0.13	0.11	0.19	0.11	0.11	5	60	20	0	30	0.24	55	2	2	5
PL	4																
	2.1	1.3	0.31	0.27	0.35	0.18	0.29	15	20	45	55	40	0.08	1	2	2	0
	1.9	0.7	0.19	0.18	0.13	0.11	0.2	20	55	40	35	15	0.09	0	1	2	2

Juvenile Steelhead Habitat Survey
Stream: Gabilan Creek
Location: Habitat 5
Date: 12/30/00

CHAR	LENGTH (m)	WIDTH (m)	DEPTH (m)					EMBEDDEDNESS (%)					VEL (m/s)	CbAb (%)	ROUGH	COVER	Distrif (m)
PL	4.0																
	4.0	0.8	0.11	0.28	0.2	0.11	0.07	35	65	70	5	40	0	2	1	3	0
	4.0	1.5	0.35	0.44	0.42	0.5	0.22	0	0	0	0	0	0	0	0	1	4
	1.6	1.5	0.48	0.43	0.33	0.32	0.42	0	0	0	0	0	0.13	0	2	3	4
RF	11.2																
	4.8	0.95	0.3	0.2	0.25	0.21	0.21	15	20	5	75	20	0.59	25	2	2	9
	4.4	0.8	0.19	0.25	0.26	0.21	0.25	5	10	40	10	40	0.45	40	2	2	14
	3.5	1.0	0.1	0.08	0.16	0.22	0.25	30	2	20	35	45	0.18	2	1	1	13
	2	1.3	0.17	0.18	0.31	0.28	0.3	15	10	30	10	40	0.26	25	2	3	16
RN	9.4																
	4.3	0.8	0.22	0.2	0.32	0.28	0.26	0	0	0	0	0	0.29	0	0	0	0
	4.3	0.8	0.2	0.31	0.31	0.36	0.41	10	35	25	35	15	0.12	25	2	2	0
	5.1	0.6	0.21	0.09	0.15	0.18	0.14	15	20	5	45	40	0.09	75	0	2	4
	4.3	0.8	0.2	0.1	0.04	0.09	0.12	20	20	15	5	10	0.37	65	0	0	4

10.3 Appendix C: Temperature and Dissolved Oxygen Data

Location	Temperature (C)	Location	Dissolved Oxygen (mg/L)
Reach 1	19.5	Reach 1	8.2
Reach 1	24	Reach 1	8.8
Reach 1	20	Reach 1	15.8
Reach 1	19.5	Reach 1	14.7
Reach 2	21	Reach 1	8.9
Reach 2	21	Reach 2	6
Reach 2	21	Reach 2	8.6
Reach 3	12	Reach 3	10.4
Reach 3	13	Reach 3	10.4
Reach 3	14		
Reach 3	13		
Reach 3	12		
Reach 3	14.5		
Reach 3	12		
Reach 3	8		
Reach 3	8		
Reach 3	8		
Reach 3	8		
Reach 3	8		
Reach 3	9		
Reach 3	8		